On the Taxation of Private Retirement Wealth*

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Abstract

Private retirement plans have become an increasingly important component of household wealth in the United States, with nearly two-thirds of Americans having access to employer-sponsored defined contribution plans. These plans have significant tax advantages, as both employee and employer contributions are tax-exempt, while the returns remain untaxed until their withdrawal during retirement. We develop a quantitative life-cycle model that incorporates both private and public pension systems, the life-cycle profile of homeownership, as well as a detailed tax-transfer system. Our model is able to replicate key empirical regularities, such as the observed distribution of private retirement wealth by age and income and the age and income dependence of pickup rates. We show that these subsidies lead to "new" savings in the long run, as they do not crowd out savings in other assets, while there is some crowding out in the short run. At the same time, eliminating these tax advantages leads to a wider tax base in the short run, which allows the government to reduce taxation, generating substantial redistribution towards current generations.

Keywords: Private Pensions; Tax Exemptions; Redistribution; Life-cycle Savings.

JEL codes: E2, E6, H2, H3.

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1 Introduction

During the last decades, many developed countries have introduced and promoted private retirement plans, mostly through significant tax advantages. The United States is a leading example, as these plans have become a common benefit for employees, with almost two-thirds of Americans currently accumulating funds in these accounts, and private retirement wealth constituting the second most prominent part of total wealth for most households. One of the reasons why these plans have gained considerable popularity is their large fiscal advantages, especially the fact that both employees and employers can make contributions that are exempt from income taxation, while the asset returns are shielded away from taxation until retirement. Despite the importance of this type of household saving, its specific tax treatment, and the wide heterogeneity across households in terms of their usage and volume, there is almost no macroeconomic literature studying how the preferential tax treatment of private retirement accounts affects savings and labor supply distortions and what the redistributive effects of the regressive subsidies embedded in these accounts are.

This is important for two reasons. First, given the vast share of private retirement accounts (PRAs) in the U.S. household asset portfolio and the very distinct incentives and constraints associated with this type of savings, any assessment of life cycle household saving behavior or wealth inequality that abstracts from them may miss this significant and distinct channel. Second, and equally important, the tax advantages of PRAs are deeply embedded in the US income tax-transfer system. Employee contributions, employer matches, and accrued returns all interact directly with the progressive income tax schedule, with Social Security taxation, and with the timing of tax liabilities over the life-cycle. As a result, any analysis of income tax or public pension reforms that treats any income taxation in isolation from PRAs, no matter whether it is motivated by redistribution, efficiency or revenue considerations, is likely to misrepresent both the effective tax base and the true incidence of the tax system across cohorts and income groups. Our paper's main objective is to provide a unified framework in which retirement saving behavior and the income tax-transfer system are modeled jointly, filling an important gap in the literature.

To achieve this, we construct a quantitative life-cycle model that can capture key empirical facts regarding both regular and private retirement life-cycle savings. Both assets complement public pensions to achieve the desired level of old-age consumption and enable households to leave the desired level of bequests to their offspring. Given that the fiscal advantages of private pension accounts are part of the overall tax-transfer system, one of our main contributions is to model carefully all the relevant interactions between private retirement accounts and savings in regular assets (including housing) with the progressive income tax system. In addition, we introduce homeownership through mortgage financing (in a reduced form way), which we show to be critical to generate the right balance between regular and private pension savings at younger ages. Our aim is to first capture the key channels of distortions and redistribution caused by the subsidization of private retirement plans. In turn, this analysis lays the foundation for investigating when and whether these subsidies should be increased, reduced, or eliminated.[1]

We model private retirement plans as an additional asset with characteristics that closely resemble the regulations in the U.S. In particular, we allow all households to contribute to their individual retirement accounts (up to a predetermined limit) each period. In addition, for a set of households, their individual contributions can be matched by the employer (again, up to a limit). Employee and employer contributions are both exempt from taxation until withdrawal during retirement. Moreover, while returns on regular savings are subject to income taxation immediately when they are realized, returns on private pension assets are not taxed directly. Note, however, that households will "eventually" need to pay income taxes on both the contributions and on the returns, as all withdrawals during retirement are subject to the same progressive income tax system as labor and asset income during working life. In this sense, these tax advantages allow households only to defer taxation. As their total income is expected to be lower when they retire, the progressivity of the income tax system implies that these assets have clear advantages in terms of (after-tax) returns. At the same time, they are assumed to be fully illiquid during the working phase, implying that investing in these accounts will not help to smooth consumption in the presence of idiosyncratic labor productivity shocks. Finally, we assume that, upon retirement, agents can withdraw funds from their retirement accounts to supplement their public pensions (and regular savings). As in U.S. law, these withdrawals face age-dependent minimum distribution requirements.[2]

To the best of our knowledge, this is the first paper that introduces a fully micro-founded modeling of private pension plans and the tax-transfer system into a state-of-the-art quantitative life-cycle model with uninsurable idiosyncratic shocks. The first im-

[1]For example, Spain has recently reduced the tax advantages of individual contributions while encouraging the wider availability of employment (or occupation) based plans to provide wider access, and our framework can be used to study the potential effects of such a reform.

[2]We abstract from annuities since their use has considerably declined over time, with most U.S. households choosing instead to keep their funds in the retirement plans until the minimum distribution requirement hits. As documented by Brown et al. (2019), who studied the recent trends in retirement income choices of U.S. TIAA participants, the fraction of first-time retirement income claimants who selected a life-contingent annuitized payout stream dropped from 54% in 2000 to 19% in 2017.

portant contribution of our paper is the quantitative evaluation of our model in terms of its ability to generate key empirical regularities of private pension access, contributions, and savings, together with all the key statistics regarding the age profiles and dispersion of earnings and wealth. To do this, we use data from the Survey of Consumer Finances to document key patterns in private pension savings in the US data. Consistent with the existing literature documenting these patterns, we highlight the importance of private retirement wealth and reveal substantial heterogeneity across households in terms of private retirement savings as well as across employers in terms of access and copays.

When the model is calibrated to the US economy, the model is able to deliver empirically plausible age profiles and distributions of labor earnings, wealth, lifetime earnings, and bequests. In particular, the model can capture substantial heterogeneity in the life-cycle accumulation of both regular and retirement assets. Remarkably, the calibrated model can match the life-cycle pattern of retirement wealth quite accurately both at the aggregate and by income types, even though it was not targeted. The fit is similarly good for regular wealth during the working age for the top and bottom quartiles. However, the model overstates the wealth decumulation after retirement, possibly because we abstract from health expenditure shocks, stronger bequest motives, or marital shocks, which we leave for further research. In addition, the model has a remarkably good fit of individual contribution rates (intensive margin) across income levels and age. At the same time, the model somewhat overstates the age profile of the extensive margin (i.e., the probability of contributing to the plans among those who are offered matched employer contributions), especially at young ages. This implies that the model has a somewhat slower accumulation of private retirement wealth at young ages and a faster accumulation afterwards.

Nevertheless, we view the good fit of the asset accumulation profiles as a contribution by itself, as we are not aware of a quantitative model that is able to capture private retirement wealth accumulation in a similarly rich quantitative environment. In fact, a related contribution of our paper is to show that the relative shares of private pensions and regular wealth can be matched only if the life-cycle profile of homeownership is incorporated into our quantitative life-cycle model. This is because the utility boost associated with homeownership makes savings in regular assets more attractive during the earlier part of the life-cycle, as a "down payment" is required to purchase a home. In addition, the mortgage debt associated with homeownership also slows down private retirement wealth accumulation at earlier stages of the life-cycle. To quantify these effects, we show that a (recalibrated) version of our model without the explicit modeling of homeownership would feature more than 50% (as opposed to 22% in the data and in the benchmark) of total wealth invested in private pension accounts.

Next, we study the effects of the tax advantages on aggregate distortions, namely, on overall asset accumulation and labor supply. The first key finding is that, although all the tax advantages matter for investment in PRAs, most of the effect is coming from the deferred taxation of individual and employee contributions (in roughly equal shares). The fact that taxes on returns can be deferred has a very small effect. Overall, the elimination of all tax advantages drives retirement wealth to zero in the long run, and it generates a considerable reduction in total wealth, while regular wealth does not change significantly. In other words, the beneficial tax treatment of private retirement accounts does not crowd out regular savings, at least in the long run. In terms of hours, there are several opposing effects. On the one hand, removing the tax advantages eliminates the tax advantages of accumulating extra savings and, hence, reduces saving incentives for those who tend to use them, which tends to reduce labor supply. This is the dominant effect in the short run, and the effective labor supply drops. On the other hand, in the long run, as total wealth is significantly lower, consumption also drops considerably, creating a positive wealth effect on labor supply that roughly offsets the previous effect, resulting in roughly the same labor supply as in the status quo. Both the progressivity of the tax system and the unequal access to employer copayments effectively create higher after-tax return on savings for many high income households, and we show that in the long-run this leads to a significantly higher concentration of wealth in the top half of the wealth distribution. In fact, we show that eliminating all the tax advantages would considerably lower the wealth share of the top 10% while raising that of the middle quintile. Unlike most of the literature on return heterogeneity, which focuses on the very top of the distribution, our channel operates across a much broader segment of households in the upper half.

Interestingly, the short-run effects on consumption and regular savings are quite different from the long-run effects. To understand this, note that the elimination of the advantages expands the tax base and hence facilitates the reduction of average income taxes in the short run. At the same time, as total wealth is decumulated over time, the tax base erodes and taxes must increase. These dynamics allow currently living households to both increase consumption and regular asset accumulation in the few years after the reform but not in the long run. In this sense, the preferential tax treatment of private retirement savings actually crowds out some regular savings in the short run. Note also that the previous effects imply that eliminating the subsidies on PRAs induces a significant intergenerational welfare redistribution towards current cohorts at the expense of future ones. At the same time, the reform generates only small effects on within-cohort inequality between education types. These results constitute another key contribution of the paper, as the redistributive and efficiency-enhancing roles of private pension tax exemptions have been largely ignored by quantitative models studying tax or pension reforms.

Finally, motivated by the fact that eliminating the tax advantages associated with private pensions is increasing the tax base (at least in the short run), we analyze as an application whether the elimination of these tax advantages can be, in principle, used to fill budget gaps ("fiscal consolidation").[3] In particular, we study a fiscal reform in which the government has to finance a permanent increase in government expenditures by either raising average income taxes or by eliminating some of the tax advantages on private retirement accounts (and adjusting average income taxes as necessary). Consistent with the findings above, we find that a fiscal consolidation that relies on the elimination of tax advantages needs a considerably lower increase in income taxes in the short run, but it leads to significantly lower total wealth and somewhat higher average taxes in the long run. Hence, to a large extent, this policy shields current generations against the negative welfare consequences of increased government expenditure but hurts future generations significantly. At the same time, if the reform is financed through increased average income taxes, the welfare costs are distributed much more equally across current and future generations. Hence, if governments need political support to implement this type of reforms, they may find that eliminating the tax advantages is more viable or attractive, even though this will have severe consequences for future generations.

Literature review

Our paper bridges several strands of literature. First, there is a large literature studying portfolio choice over the life-cycle using dynamic quantitative macroeconomic models. The work by Guiso et al. (2002), Cocco et al. (2005), Curcuru et al. (2010), and Fagereng et al. (2017) focuses primarily on the determinants of stock market participation decisions. Portfolio allocation in the presence of liquid and illiquid assets has been studied by Kaplan et al. (2014). While the previous papers establish important frameworks for understanding household portfolio decisions, they do not explicitly model the choice between tax-advantaged private retirement accounts and regular taxable savings, an important distinction that we introduce in the present paper. Similarly to our paper, Brendler et al. (2024) study portfolio choice in a setting with private retirement wealth accumulation with a focus on the unequal access. In contrast, we focus on the tax treatment of these accounts and their interaction with the income tax system.

Second, our work also connects to the empirical literature examining the effects of tax-advantaged retirement accounts on savings behavior and wealth accumulation. Among

[3] This is relevant since the U.K. Treasury, for example, has considered considerable reductions of the tax advantages of private retirement contributions to expand the tax base as part of the 2026 budget

others, Poterba et al. (1995), Attanasio and DeLeire (2017), Attanasio et al. (2004), Benjamin (2003) and Pence (2002) analyze whether 401(k) contributions represent largely new savings or substitution from other assets. Interestingly, Poterba et al. (1995) find that private retirement accounts mostly generate new savings while Attanasio and DeLeire (2017), Attanasio et al. (2004), and Pence (2002) find that they largely crowd out other forms of savings. Benjamin (2003) stands somewhere in the middle showing that around half of savings in these accounts constitute new savings. Our counterfactual model-based analysis complements their purely empirical approach. While our results are more in line with the results of Poterba et al. (1995) in the long run, we also find some crowding out in the short run, similarly to Benjamin (2003).

Third, a critical dimension of retirement policy is its distributional effects. Poterba et al. (2007) document substantial heterogeneity in retirement wealth accumulation across income, Gustman and Steinmeier (2001) analyze how pension wealth affects the distribution of wealth and Catherine et al. (2023) examine how 401(k) plans affect wealth inequality over the life-cycle. Most recently, Choukhmane et al. (2024) use linked employee-employer data to document substantial gaps in who benefits from retirement saving incentives, showing that tax advantages disproportionately benefit higher-income households, and revealing significant disparities by race and parental income. Also, Brendler et al. (2024) document large heterogeneity in access to employer-sponsored retirement plans (and to housing) in the U.S., and they study how unequal access affects portfolio choice and wealth accumulation. Our paper provides a rich characterization of PRAs, based on the Survey of Consumer Finances, which both confirms and complements the results in these papers. This empirical evidence serves as input to our quantitative analysis, and it allows us to contrast the key implications of our model with the data.

Fourth, we also contribute to a large macroeconomic literature on the sources of wealth inequality. In particular, to match the high degree of wealth concentration at the very top of the distribution in the data, existing research has extended the standard incomplete markets model by including return heterogeneity (Hubmer et al., 2021; Bach et al., 2020; Fagereng et al., 2020; Benhabib et al., 2019), preference heterogeneity (Krusell and Smith, 1998), rich income dynamics (Castaneda et al., 2003), entrepreneurship (Cagetti and De Nardi, 2006; Quadrini, 2000), bequests (De Nardi, 2004), medical expense risk (De Nardi et al., 2010), or non-homothetic preferences (Straub, 2019; De Nardi, 2004). Instead, we focus on how institutional features of PRAs shape differences in wealth accumulation across the population and we show that the combination of uneven access to employment copayment opportunities and the progressivity of the tax system create endogenously heterogeneous (after-tax) returns on total savings for a significant proportion of households concentrated in the top half of the income distribution. Given this, PRAs contribute significantly to the wealth concentration at the top half of the asset distribution.

Finally, most closely related to our work are papers that explicitly model the institutional features of private retirement accounts in calibrated life-cycle settings. Gomes et al. (2009) analyze the impact of tax-deferred retirement accounts on consumption and wealth accumulation with preference heterogeneity. Horneff et al. (2020) investigate the benefits of annuitization choices within employer-sponsored plans, highlighting how Required Minimum Distribution (RMD) rules have affected the decline in annuity demand. More recently, Choukhmane (2024) uses a dynamic life-cycle model with the inertia/passive behavior vs. active savings decisions to study the effects of default contribution rates and auto-enrollment on savings decisions, and Choukhmane and de Silva (2024) introduces a portfolio choice in a model with default contributions to study the allocation between risky/safe assets in retirement accounts. The previous analyses typically study retirement savings in partial equilibrium or focus on specific features in isolation. In contrast, we embed a detailed modeling of the institutional features of retirement accounts within a general equilibrium framework that incorporates many of the relevant margins that pension or income tax-transfer system reforms could distort, such as endogenous labor supply, human capital accumulation and endogenous retirement.[4] Using this framework, we then study the redistributive, efficiency and budgetary consequences of private pension plan subsidization.

The paper is organized as follows. Section 2 presents empirical evidence related to private retirement accounts. Section 3 presents the model. Section 4 discusses the calibration. Our main findings are discussed in Section 5, and Section 6 concludes.

2 Empirical evidence

This section presents empirical evidence on wealth accumulation, with an emphasis on private retirement wealth. We document several facts on its relative share over total wealth, its distribution across age and income groups, and some important characteristics of active ESRPs, including offer rates, participation (pickup) rates, copayment levels, and contribution rates. This empirical evidence will serve three main purposes. First, some observations directly inform us about how to model private pension accounts. Second, we use several empirical facts as calibration targets, as we will parameterize the model to repli-

[4] Our modeling framework is related to Ábrahám et al. (2025), where we offer a detailed modeling of the U.S. public pension and tax-transfer systems, but we do not consider private retirement accounts. Here, we simplify greatly the public pension component in our previous work and extend the framework by modeling private retirement accounts in detail, together with a reduced form modeling of housing.

cate some of these moments. Finally, another set of findings will be used to validate the model's performance.

Our analysis is based on publicly available data from the Survey of Consumer Finances (SCF), covering five survey waves during 2010–2022. Our unit of measurement is a household, since asset accumulation is typically determined at the household level. Our sample includes household heads aged 25–85 who are in dependent employment or self-employed, as well as all households with heads up to age 100 who report being retired. *Earnings* include income from wages, salaries, sole proprietorships, farms, and other businesses. We define *income* as the sum of earnings, capital interest income, public pensions, and withdrawals from private pension plans. We exclude capital gains from total income to align the definitions in the data and the quantitative model. Moreover, we adopt the SCF definition of net worth for *total wealth*, which is the value of all financial and real assets net of all debts. We split total wealth into *private retirement wealth*, which includes pension plans accumulated in individual retirement and thrift accounts net of any loans taken against pensions, and the remaining net wealth, which we refer to as *regular wealth*.

Figure 1 depicts the average of total wealth, regular wealth, and private retirement wealth across 5-year age groups, expressed in nominal terms (2022 U.S. dollars). The figure shows that both the average regular and private retirement wealth increase considerably over the life-cycle up to the retirement age, adding up to about 1.6 million dollars by age 60 in total wealth. We find that retirement wealth is a nontrivial component of total wealth, amounting to about 23% of total wealth around the time of retirement. This is consistent with Catherine et al. (2023), who show that retirement and Social Security wealth together constitute nearly half of the total wealth of the bottom 90% of the wealth distribution.

Figure 2 decomposes the two components of total wealth in the previous figure by income quartiles within each age group. The figure shows that there is substantial heterogeneity in the accumulation of retirement savings across income, with higher-income agents accumulating significantly more in their private pension accounts. In fact, both regular and pension wealth are largely concentrated in the top income quartile. Other papers in the literature have also documented income-based disparities in retirement wealth accumulation. For example, Choukhmane et al. (2024) use a large-scale employer-employee-linked panel dataset to identify the mechanisms behind income-based disparities in DC plans, showing that the benefits of the current system accrue disproportionately to higher-income households.

In the quantitative section, we will calibrate our model to match aggregate total wealth in the economy and the average life-cycle path of regular wealth accumulation. At the

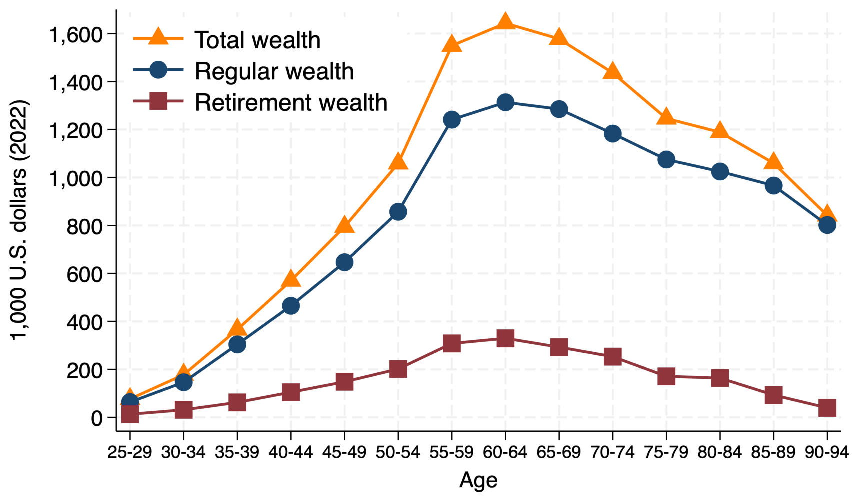


Figure 1: Regular wealth and private retirement wealth by age (SCF).

Notes: Regular wealth is the total net worth net of retirement wealth. The values are expressed in 2022 U.S. dollars.

same time, we will not target the life-cycle pattern of pension wealth and total wealth or the distribution of each wealth component by age and income. One of the important questions we ask in this paper is whether a standard quantitative life-cycle model can replicate these moments.

We now turn to the analysis of the "supply" and "demand" for the ESRPs. The SCF provides detailed information on contributions to private retirement accounts, both those made directly by households and those made through an ESRP. We begin by analyzing saving behavior within ESRPs and then turn to non-employer-based retirement accounts.

The left panel of Figure 3 displays the *offer rate*, which is the average fraction of employees whose employer offers a retirement plan and who are eligible to enroll in this plan among all households. Moreover, the right panel of the figure displays the *pickup rate*, defined as the share of employees who enroll in an ESRP out of the pool of all employees who have access to such a plan. Panels (a) and (b) show the average offer rates and pickup rates by 5-year age groups, respectively, while panels (c) and (d) decompose these variables by income quartiles for each age group.

To construct these figures, we impose the following restrictions. First, we naturally restrict our sample to the working age population with household heads aged 25–64. To ensure consistency with Figure 2, which includes regular and private wealth by age and income quartiles for the full sample, we maintain the same income quartiles when examining offer and participation (pickup) rates by income. Second, since the unit of observation in the preceding analysis is the household, we assume that a household has access to an

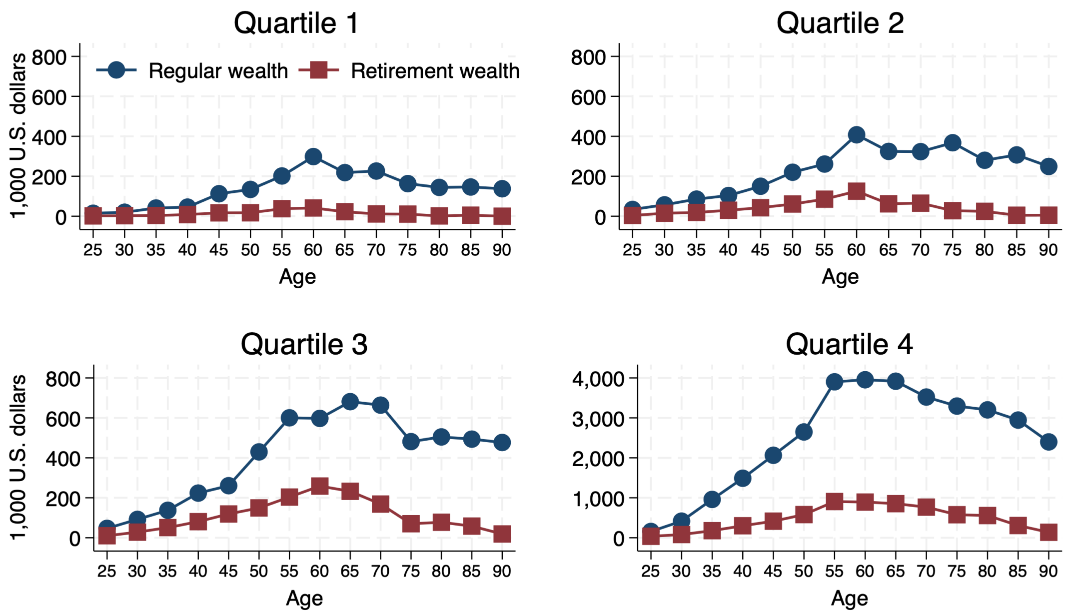
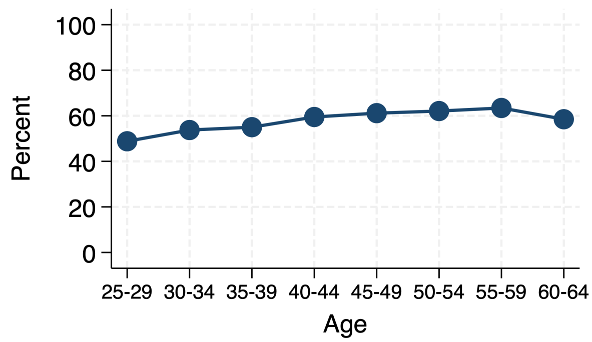


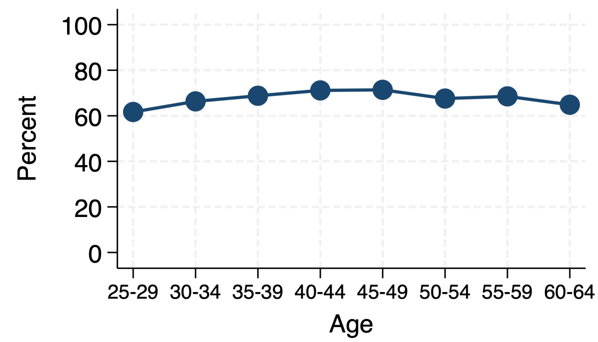
Figure 2: Regular wealth and private retirement wealth by age and income quartiles (SCF).
Notes: Regular wealth is the total net worth net of private retirement wealth. Income quartiles are defined within each 5-year age group. *Income* is the sum of earnings, capital interest income, and income from public and private pension plans. The values are expressed in 2022 US dollars.

ESRP if either (i) the plan is offered to the household head, or (ii) it is not offered to the head but is offered to the spouse and the spouse earns more than 50% of the couple's combined labor income. In all other cases, the household is assumed to have no access to an ESRP. Furthermore, we also categorize a household as not having access to an ESRP if, under the aforementioned assumptions, the employer copay rate is zero even if the employee has positive contributions. In other words, we define the participation (pickup) rate as the proportion of households who report enrollment in any job-related plan where both the employee and the employer are making positive contributions, among all households that have access to an ESRP.

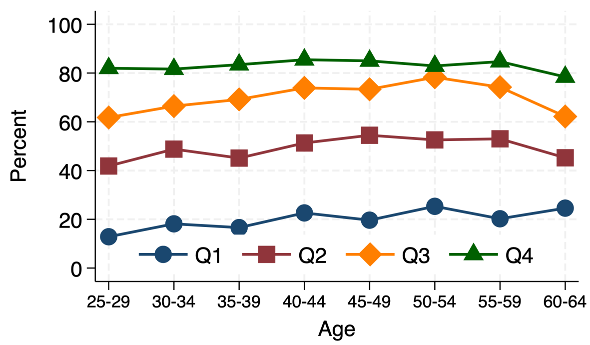
Turning to Figure 3 (Panels (a) and (b)), we see that both the offer and pickup rates do not vary significantly by age, with around 58% of employees on average being offered ESRPs, and about 68% of employees with access to such plans enrolling in them. As shown in the lower panels, however, the aggregate patterns hide a substantial heterogeneity in both the offer and pickup rates by income. This heterogeneity is especially striking when looking at the offer rates. While 83% of workers (on average) have access to employer plans in the top income quartile, the plans are offered only to around 20% of households in the lowest quartile. As discussed earlier, this could be an important factor explaining why



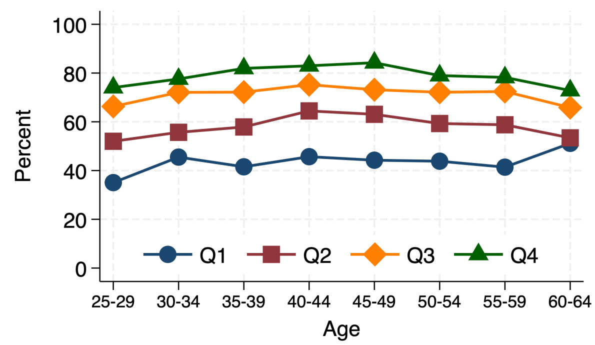
(a) Average offer rates by age.



(b) Average pickup rates by age.



(c) Offer rates by age and income.



(d) Pickup rates by age and income.

Figure 3: Offer rates and pickup rates for employer-provided retirement accounts (SCF).

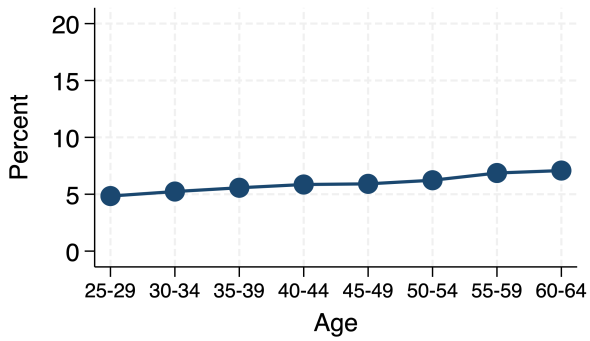
Notes: Offer rate denotes the fraction of employees whose employer offers a retirement plan with a positive copay rate and who are eligible to participate in this plan. *Pickup rate* is defined as the proportion of employees who enroll in the ESRP and both employee and employer actively contribute to the plan out of the total pool of employees who have access to such a plan. Panels (a) and (b) show the average offer rates and pickup rates within each age group, while Panels (c) and (d) plot average offer rates and pickup rates within each income quartile/age group. Income quartiles are defined within each 5-year age group on a full sample and are the same as in Figure 2.

poorer households accumulate substantially lower wealth in private retirement accounts. Observe that there is also large heterogeneity in the pickup rates. Among higher-income workers, a much higher fraction (79% on average) decides to contribute to retirement accounts (and hence benefits from the employer copayment), while this ratio drops to only 44% on average for the lowest-income quartile, contributing further to the lower accumulation of retirement wealth among lower-income households. In our quantitative analysis, we will impose the income dependence of offer rates observed in Panel (c) to capture the unequal access to ESRP (assuming that offer rates do not vary by age, consistent with our evidence), and we will check ex post whether the model can replicate the income dependence of the pickup rates in Panel (d).

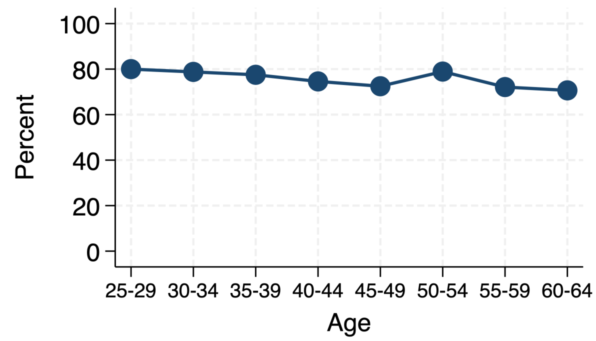
Note that the unequal access we have shown above is consistent with the findings of Brendler et al. (2024), who document large heterogeneity by income in access to employer-sponsored retirement plans in the U.S., and Poterba et al. (2007), who document that 401(k) eligibility rises sharply with income, and that participation given eligibility exceeds 60% at all income levels. Next, we show that households make extensive use of ESRPs, while employers typically offer generous copayments by constructing the average employee contribution and employer copayment rates for ESRPs across age groups. To construct these variables, we restrict the sample to households enrolled in an employer-based plan, namely, those with positive participation (pickup) rates as shown in Figure 3(d). Moreover, the contribution and copayment rates at the household level are computed by weighting each of the spouses' individual rates by their respective annual labor income.

Figure 4 (Panels (a) and (b)) displays the average employee contribution and employer copayment rates for ESRPs across age groups. Panel (a) illustrates that individual contributions rise slightly with age and are high–around 6% on average. This, combined with a substantial employer copayment, which averages 76% (Panel (b)), implies that these plans represent an important savings vehicle, accounting for roughly 10.5% of household income saved in private retirement accounts. Panels (c) and (d) in the same figure display the same variables by age and income quartiles. Panel (c) shows that the life-cycle increase in contribution rates are mostly driven by high-income households, whose contributions increase from 5% to 8%, while the lower-income groups have a more stable profile. Employer copayments, shown in Panel (d), are also stable across age, but they decline with income. The average copayment rate is roughly 100% for the lowest-income workers and about 66% for the highest-income group, possibly reflecting that wealthier households tend to reach the employer-matching cap more often.

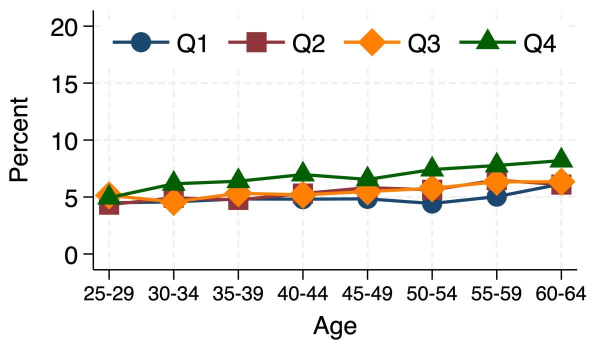
While the last two figures focus on contributions to ESRP, it is important to note that



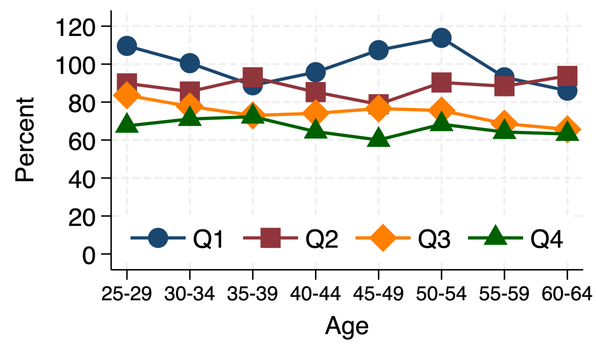
(a) Average contribution rates by age.



(b) Average copay rates by age.



(c) Average contribution rates by income.



(d) Average copay rates by income.

Figure 4: Copay and contribution rates for employer-provided retirement plans, conditional on participation (SCF).

Notes: Panels (a) and (b) show the average contribution and copay rates within each 5-year age group, while Panels (c) and (d) plot average rates within each income quartile/age group. Income quartiles are defined within each 5-year age group on a full sample and are the same as in Figure 2.

these plans are the most relevant, as fewer than 10% of households in our sample report contributing to non-employer-based private retirement accounts, such as IRAs. The average contribution rate to these accounts is about 7%, slightly higher than the 6% average contribution rate observed for employer-sponsored plans. Among households that do not have access to an ESRP, around 10% contribute to a non-employer-based account. Our quantitative model will allow for this option, and some high-income agents will choose to contribute individually to these accounts when they do not have access to employer contributions. Also, since households are able to transfer private retirement funds across different employers and across individual accounts in the real world, we will only have a single private retirement account for each agent, and some workers will be able to receive employer copayments into this account, while others will not.[5]

As stated earlier, a key contribution of our paper is to assess how well a quantitative life-cycle model can replicate the empirical regularities discussed above by allowing agents to jointly choose labor supply and savings in both regular and retirement assets to balance current and old-age consumption.

3 Model

This section lays out the quantitative model that we will use later on for our policy analysis. Throughout the section, all the aggregate variables, prices, and policy variables are indexed by time. Also, to simplify notation, individual variables are indexed only by those characteristics that appear necessary in a given context, but they also depend on time and the agent's characteristics.

3.1 Overview

We assume an open economy setting that is populated by overlapping generations of agents. Each period, a continuum of agents is born. Agents enter the economy as workers at age $j = 1$ (real-life age 25) and continue working until they retire. Mandatory retirement occurs at age J^R, but agents can pay a penalty and retire early at the age of $J^E < J^R$. At age 1, agents draw an educational level z from the invariant distribution P_z. Agents can be either college graduates ($z = z_H$) or non-college graduates ($z = z_L$), and their education remains constant throughout their life. Each educational level is associated with an

[5]Note that, among households that do have access to an ESRP, around 7% also contribute to a non-employer-based account. Most of this is due to the fact that, in the data, one spouse may contribute individually, while the other members of the household contribute through an ESRP. However, this cannot be captured by our unitary household model.

initial amount of skill, denoted by $h_{1,z}$, and an immutable learning ability denoted by θ_z. At age $j = 1$, agents also draw a fixed effect v that represents unobserved productivity and can also take two values (v_H or v_L). Agents live up to a maximum of $J > J^R$ periods, but they may die earlier due to stochastic mortality. We denote by $\psi_j^{z,v}$ the probability that a type (z, v) agent survives up to age $j + 1$, conditional on surviving up to age j. Population grows at an exogenous rate of n and, in the initial period ($t = 0$), the population size is normalized to 1. The model economy is assumed to be on a balanced growth path (with a growth rate of n). Throughout the model description, aggregate variables in period t (except for prices) are divided by $(1 + n)^t$ to express them in per capita terms.

Financial markets are incomplete due to the fact that there is no insurance against idiosyncratic mortality and labor productivity shocks. Agents can self-insure against the shocks by accumulating two types of risk-free assets: private retirement accounts a_p and regular assets a_r. To take into account that housing equity constitutes a major share of the asset portfolio for the majority of households, we assume that a wealth-dependent proportion of regular wealth is home equity. In addition, we assume that homeownership provides utility benefits that are increasing in the home value, and it is financed through regular savings and mortgages, while unsecured borrowing is ruled out. Most agents enter the economy with no assets, but a fraction of them receive bequests from their parents.

Both private pension accounts and (non-housing) regular assets earn the same pretax return. However, there are some important differences between the two, since they are subject to different tax treatment and contributions to private retirement plans are subject to particular constraints and regulations. One key contribution of the paper is the detailed modeling of the institutional framework surrounding private retirement plans. To do this, we use a model set-up based upon Ábrahám et al. (2025) with some important differences. On the one hand, the present paper introduces a detailed modeling of private pension plans, and it explicitly differentiates housing wealth from other assets. In contrast, the previous paper has only one form of privately accumulated assets. On the other hand, the previous paper models the public pension system in more detail, with individual accumulated lifetime earnings directly influencing public pensions. In contrast, the current paper sets public pensions to type-dependent constants that do not respond to individual labor supply, for tractability reasons.

3.2 Households

Households have time-separable preferences over consumption c, housing services c_h and leisure $1-l$, given by:

$$u(c, c_h, 1-l) = \log(c) + \varsigma_h \log(c_h) + \varsigma_l \frac{(1-l)^{1-\eta}}{1-\eta}, \tag{1}$$

where ς_h is the relative utility weight on housing services, ς_l is the relative utility weight on leisure, and η governs the intertemporal elasticity of substitution in labor supply. Agents also derive a ("warm glow") utility from leaving a bequest in case of death, which we will specify later.

For an agent that works l hours, the pre-tax earnings are given by

$$e = w_{z,t} h_{j,z} v y_j l. \tag{2}$$

In the previous equation, the deterministic part of the hourly wage is $w_{z,t}h_{j,z}v$ and it is governed by the wage rate $w_{z,t}$ (determined in equilibrium), the skill level $h_{j,z}$ and the fixed effect v, while the stochastic part is given by an idiosyncratic shock y_j, which varies over the life-cycle.

As for the evolution of the skill level, we assume that human capital is formed endogenously through a learning-by-doing mechanism. As discussed earlier, upon entering the model, workers draw their educational level z, which arrives with a fixed initial amount of skill denoted by $h_{1,z}$ and a learning ability θ_z. During subsequent periods of the working stage, the agent's skills evolve according to:

$$h_{j+1,z} = (1-\delta_h)h_{j,z} + \theta_z (h_{j,z} l)^{\gamma_h}, \tag{3}$$

where $h_{j,z}l$ is the total effective time the agent spends acquiring new skills on the job, $\gamma_h \in (0,1)$ is the speed at which the agent builds up human capital, and δ_h is the rate at which skills depreciate. This human capital technology will allow us to model endogenously the distinct age-earnings profiles for low- and high-skilled households in a parsimonious way. Note that the learning-by-doing human capital accumulation formulation brings a strong dynamic component to labor supply decisions, and it will make any form of explicit or implicit labor income taxation more distortionary.[6]

Finally, the stochastic part of the worker's productivity is driven by the idiosyncratic

[6] Badel et al. (2020) follows a different approach by applying the Ben-Porath (1967) human capital production technology. Holter et al. (2019) discusses the effect of income taxation under each approach.

productivity shock y_j, which follows an AR(1) process:

$$\log y_j \quad = \quad \rho_y \log y_{j-1} + \epsilon_j \text{ with } y_1 = 1 \text{ and } \epsilon_j \sim \mathcal{N}(0, \sigma_\epsilon^2). \tag{4}$$

3.3 Saving alternatives

Workers allocate their assets between *private* retirement accounts a_p and *regular* wealth a_r, part of which is allocated to housing.

3.3.1 Regular wealth and housing

As mentioned earlier, housing is a crucial part of the household's portfolio, and we will show later that including homeownership in the asset portfolio is critical to explain the patterns of regular and pension wealth accumulation. At the same time, for computational tractability (to reduce the number of continuous state variables), we have opted for a reduced form way of modeling housing that matches some key empirical observations. First of all, we assume that households with regular wealth holdings below a certain level $\hat{a}_r$ ($a_r < \hat{a}_r$) do not own a house but rent instead. In contrast, if $a_r \geq \hat{a}_r$, all households own a house in our model, and the value of their house $a_h(a_r)$ is solely determined by their regular wealth, namely $a_h(a_r) = \xi_h(a_r)a_r$, where $\xi_h(a_r)$ is the exogenous wealth-dependent share of the house value in regular wealth.

Renters enjoy a minimal amount of housing services which we denote by $\underline{c}_h$. At the same time, the consumption of housing services for homeowners is given by $c_h(a_r) = a_h(a_r) > \underline{c}_h$. To summarize, housing services are given by

$$c_h(a_r) = \begin{cases} \underline{c}_h & \text{if } a_r < \hat{a}_r \\ a_h(a_r) & \text{otherwise.} \end{cases} \tag{5}$$

Note that this implies that homeownership leads to a jump in utility but can only be possible if the household accumulates a sufficiently high amount of wealth $\hat{a}_r$ (to finance "down payments"). As pension wealth is illiquid during the working life, this provides more incentives for accumulating regular wealth.

In the data, homeownership is largely financed by mortgages, and the higher the household's regular wealth, the higher the proportion of the house value that constitutes home equity (i.e., the lower the mortgage debt and leverage). Hence, we express both the value of home equity $a_e(a_r)$ and the outstanding mortgage $a_m(a_r)$ as an exogenous wealth-dependent proportion of the house value, namely, $a_e(a_r) = \xi_e(a_r)a_h(a_r)$ and $a_m(a_r) = (1-\xi_e(a_r))a_h(a_r)$, where $\xi_e(a_r)$ is the wealth-dependent share of home equity in the value of the home. Given this, the home equity and the mortgage value can be expressed as:

$$a_e(a_r) = \xi_e(a_r)\xi_h(a_r)a_r \quad \text{and} \quad a_m(a_r) = (1 - \xi_e(a_r))\xi_h(a_r)a_r. \tag{6}$$

Note that, for renters ($a_r < \hat{a}_r$), we have $\xi_h(a_r) = 0$, implying that $a_e(a_r) = a_m(a_r) = 0$. As discussed earlier, only non-housing regular wealth earns financial returns. However, housing equity translates into housing services that bring direct utility but no financial benefits. However, this comes with the cost of mortgage debt, further reducing the resources households are willing to put into private retirement funds at younger ages.

3.3.2 Retirement accounts

To model private retirement accounts, we follow closely the actual legal framework in the U.S. (i.e., the regulations related to 401(k) retirement plans and other Individual Retirement Accounts), but introduce some simplifications. While retirement account assets can only be accessed (penalty-free) upon entering retirement, regular wealth can be adjusted at any time, and it therefore helps agents better smooth consumption in response to negative income shocks. However, retirement accounts offer three key advantages for life-cycle wealth accumulation compared to regular savings. First, contributions to retirement accounts reduce the worker's current taxable income and, hence, their current income tax liability. Second, employers may match a portion of the employee's contributions also tax-free, significantly accelerating wealth accumulation. Third, the return on private retirement accounts is not taxed until retirement.

In our model, each worker has access to a private retirement account, towards which the worker can contribute a proportion $0 \leq \kappa \leq 1$ of total earnings $e = \tilde{w}l$ every period, where $\tilde{w}$ is the worker's hourly wage $\tilde{w} \equiv w_{z,t}h_{j,z}vy_j$. As in the U.S. tax law, the worker's contribution amount per period is capped by a limit of χ_w, which is established by the IRS. Hence, the worker's per-period contribution has to satisfy $\kappa\tilde{w}l \leq \chi_w$. In any given period, the worker may decide not to contribute at all to the private retirement account, in which case $\kappa = 0$, and the account only grows by the accrued interest income.

In addition, some workers are employed by firms that offer ESRPs, matching the employer contributions up to a proportion χ_f of earnings. Access to the employer-provided plans is not universal. If the individual has access to an ESRP, then $\psi_e = 1$ and the employer provides a matching contribution. In contrast, if $\psi_e = 0$, the worker contributes to the retirement plan unilaterally without receiving matching employer contributions.

Hence, the law of motion for retirement wealth during the working stage is given by:[7]

$$a_p' = (1+r)a_p + \tilde{w}l[\kappa + \psi_e \cdot \min(\kappa, \chi_f)]. \tag{7}$$

Although we allow for a full match by employers, note that this does not imply that we will see 100% copayment rates for everybody, since the maximum employer contribution rate χ_f could be binding for some households. Given that average contribution rates in the data (Figure 4, Panel (a)) exceed χ_f, this will allow us to replicate the copayment rates that are below 100% in the data (Figure 4, Panel (a)). In addition, as higher-income households tend to contribute more to private retirement wealth (Figure 4, Panel (c)), this will allow us to also replicate the fact that they have a lower average copayment rate (Figure 4, Panel (d)), as the upper bound constraint is more likely to bind for them.

Each period, the worker faces a fixed probability ν of a new draw in ψ_e, which could be interpreted as the worker switching employers or as changing circumstances of the employer. Moreover, conditional on a switch, they will have access to an ESRP with probability $\pi_p(z, v)$, which we assume to be type-dependent to replicate the uneven access to these retirement plans in the data.

Contributions to private retirement plans, $\kappa\tilde{w}l$, are tax-deductible. Specifically, a fraction $\tau_\kappa \in [0, 1]$ of these contributions can be deducted from the worker's taxable income, where τ_κ is a policy variable that represents the tax-deductible portion of the contributions. Together with the fact that the return on pension wealth is not taxable during the working stage, the deductibility of pension contributions provides an additional incentive for agents to save through these plans during their working years.

Upon retirement, agents are allowed to withdraw funds from their private pension accounts. These withdrawals, which we denote by ω, are treated as taxable income and are subject to income taxation at the prevailing tax rates. Hence, while contributions reduce taxable income during the working years, withdrawals increase taxable income during retirement, effectively deferring taxation until funds are accessed. The same deferred taxation principle holds for employer contributions and returns earned on the account during the working life: taxes are fully deferred until funds are withdrawn, in which case full income taxes are levied on them. The law of motion for retirement wealth during retirement

[7]This law of motion implicitly assumes that agents cannot withdraw from their retirement account during the working stage. While this is allowed in reality, it is subject to a large penalty, as income taxes are levied on all cumulated interest income associated with the withdrawn amount. For this reason, early withdrawals happen fairly infrequently. We abstract from this possibility, as it would require the introduction of an additional continuous state variable: the accrued interest income on the retirement account.

reads:

$$a'_p = (1+r)a_p - \omega. \tag{8}$$

The withdrawal amount is subject to the following restriction: $\omega \geq S_j(1+r)a_p$, where $S_j \geq 0$ for all j represents a minimum proportion of the accumulated wealth $(1+r)a_p$ that the agent has to withdraw every period. In line with the U.S. tax code, this minimum proportion is age-dependent for two reasons. First, it starts at age 73 (age 48 in the model), so that $S_j = 0$ if $j < 48$. Second, for $j \geq 48$, the proportion depends on the average life expectancy of a given cohort. Note also that the restriction above prevents pensioners from contributing to their retirement accounts, i.e., ω cannot be negative. This is without loss of generality, as the actual U.S. tax law does not allow retirees to make tax-free contributions to retirement accounts.

If the household passes away, the remaining balance on their private retirement account is part of their estate, together with the regular wealth they have accumulated. Consistent with the U.S. tax code, deferred taxes on private retirement wealth must be paid before the balance can be transferred to the respective heir.[8] In this sense, the balance is treated similarly to the withdrawals ω during retirement.

In Section 4, we will discuss in detail how we use the tax code and other regulations to determine the parameters that drive the key frictions and constraints associated with private retirement accounts.

3.4 Government policies

In order to set up the households' decision problem, we need to discuss the main policy tools the government will use to provide insurance and to redistribute (lifetime) income. The government administers the public pension system and the general income tax-transfer program, which are described in detail below.

3.4.1 Social Security

Households belonging to each type are entitled to receive a constant and type-dependent public pension $\bar{p}_g(z, v)$ if they retire at the mandatory retirement age J^R. Through the type-dependence, we are able to incorporate (on average) the progressivity of the U.S. pension system (i.e., higher income types face a lower replacement rate relative to their

[8] To avoid an additional state variable (inherited retirement wealth), we assume that deferred taxes on inherited private pension wealth are paid in separation by the "estate" and not combined with the other income of the recipient.

average lifetime earnings).[9] All workers pay a proportional Social Security tax $\tau_{SS,t}$ on their taxable earnings (for social security), which are given by $\min(e, cap)$, where cap is an exogenous maximum taxable earnings threshold and e are the total pre-tax earnings in equation (2).

Workers must retire once they reach the mandatory retirement age J^R, but they already become eligible to receive pension benefits at age $J^E < J^R$ and, therefore, may choose to retire early. Since the timing of retirement affects the benefit amount, an individual state variable j^R is introduced, which equals the age at which the agent retires. For workers, the convention is to set this variable at $j^R = 0$.

During retirement, the agent receives a pension benefit of $p_g = p_g(\bar{p}_g(z, v), j^R)$. When the agent retires early, the pension annuity is reduced proportionately to the number of years prior to the mandatory retirement age. The penalty function for early retirement is specified as:

$$p_g(\bar{p}_g(z, v), j^R) = (1 - \delta_g) \cdot \bar{p}_g(z, v) + \left(\frac{j^R - J^E}{J^R - J^E} \right) \cdot \delta_g \cdot \bar{p}_g(z, v). \tag{9}$$

If retirement occurs at the earliest age ($j^R = J^E$), the agent loses (permanently) a fraction δ_g of the full pension amount.[10] When the agent retires at the mandatory retirement age ($j^R = J^R$), the expression above boils down to the full pension amount.

We model the social security budget independently of the federal budget. This is in line with the U.S. legislation. In addition, we assume that the budget is balanced period by period. Given that our economy has a stable demographic structure (i.e., it does not feature demographic transition), this assumption is also consistent with the pay-as-you-go nature of the U.S. social security system.[11]

3.4.2 Income tax-transfer program

Income is taxed non-linearly according to the income tax function Ψ, which potentially allows for negative income taxes (transfers similar to the Earned Income Tax Credit (EITC) in the U.S.). Following Benabou (2000) and Heathcote et al. (2017), the net tax liability is

[9] In Ábrahám et al. (2025), we model the progressivity of the U.S. system in more detail in a setting where there is an explicit link between *individual* lifetime earnings and pensions.

[10] The specification of the penalty function approximates quite accurately the penalty in the current Social Security legislation.

[11] We can introduce demographic transition and social security asset/debt accumulation without conceptual difficulty in the future.

specified as

$$\Psi_t(\iota; \boldsymbol{\lambda}_{I,t}, j^R) = \begin{cases} \iota - \mathcal{I}_t \cdot (1 - \bar{\lambda}_{I,t}) \cdot (\iota/\mathcal{I}_t)^{1-\lambda_{I,t}} & \text{if } j^R = 0 \\ \max\{0, \iota - \mathcal{I}_t \cdot (1 - \bar{\lambda}_{I,t}) \cdot (\iota/\mathcal{I}_t)^{1-\lambda_{I,t}}\} & \text{otherwise,} \end{cases} \tag{10}$$

where ι denotes the agent's taxable income (defined below), $\iota/\mathcal{I}_t$ is the agent's taxable income normalized by the economy-wide average taxable income $\mathcal{I}_t$, and $\boldsymbol{\lambda}_{I,t} = (\lambda_{I,t}, \bar{\lambda}_{I,t})$ are the policy variables associated with the income tax and transfer program. The agent's income after taxes and transfers is then equal to $\mathcal{I}_t \cdot (1 - \bar{\lambda}_{I,t}) \cdot (\iota/\mathcal{I}_t)^{1-\lambda_{I,t}}$.

The variable $\bar{\lambda}_{I,t}$ controls the average income tax level, while $0 < \lambda_{I,t} < 1$ determines the income tax progressivity. Note that the tax liability $\Psi_t(\iota; \boldsymbol{\lambda}_{I,t})$ can be negative for low levels of income, implying that households with low income are entitled to transfers. This feature reflects the negative income tax many low-income households face through the EITC program in the U.S. Finally, note that, for retirees, their sources of income are not subject to the EITC that targets labor income. This restriction implies that retirees with low total income will not pay income taxes but are not entitled to transfers either.[12]

The agent's taxable income is given by

$$\iota = \begin{cases} r(a_r - a_e(a_r)) - ra_m(a_r) + e - \tau_\kappa \kappa \tilde{w} l - 0.5\tau_{SS,t} \min(cap, e) & \text{if } j^R = 0 \\ r(a_r - a_e(a_r)) - ra_m(a_r) + \omega + p_g(\bar{p}_{g,t}(z, v), j^R) & \text{otherwise.} \end{cases} \tag{11}$$

The first line in the previous equation is the taxable income of workers, where $r(a_r - a_e(a_r))$ is the return on the non-housing part of regular wealth, $ra_m(a_r)$ is the interest rate due on mortgages, which reduces taxable income, and e are pre-tax earnings defined in (2). Since the part of labor income that is paid by the employee as Social Security contributions (50%) is not subject to income taxes, a corresponding portion is deducted from the worker's taxable income. As discussed earlier, $\tau_\kappa \in [0, 1]$ is the fraction of contributions to the private retirement plan, $\kappa \tilde{w} l$, that can be deducted from the taxable income up to the level of total labor earnings e. Observe that the return on saving through the retirement plan is not subject to income taxation for workers. The second line of the expression above corresponds to the taxable income of retired agents. Consistent with the US tax code, both public pensions and withdrawals ω from the private retirement account are taxable. This implies that deferred taxes are paid at the time of the withdrawals.

[12]This assumption allows us to use a single income tax-transfer function for both workers and retirees.

3.5 Household's problem

This subsection spells out the optimization problems at different stages of a household's life cycle.

Problem of workers of age $1, ..., J^E - 1$

Workers become eligible for early retirement benefits once they reach the age of J^E. During the first J^E-1 periods, they decide on the amount they want to contribute to the retirement plan, the allocation of regular wealth, and how to divide their unitary time endowment between leisure and work. Given these decisions, the agent's consumption follows from the agent's budget constraint, and their housing consumption c_h is solely determined by their total regular wealth a_r. In each period, agents draw the labor productivity shock y before making any decisions.

We denote by $\boldsymbol{x} = (j, j^R, z, v, y, h, a_p, a_r, \psi_e)$ the agent's current state, where j is age, j^R – retirement age, z – educational level, h – human capital, v – fixed effect, y – idiosyncratic AR(1) productivity shock, a_p – retirement wealth, a_r – regular wealth, and ψ_e – the indicator function of whether the worker has access to an ESRP. Note that a_r, the beginning of the period value of the regular wealth, is composed of both the last period savings and of the bequests received at the end of the last period. The probability of receiving bequests is age-, time-, and type-dependent, while the amount of bequests is drawn from a distribution that is both type and time-dependent, as explained below.

Let $V_t(\boldsymbol{x})$ denote the agent's value function at time t and state $\boldsymbol{x}$. The dynamic programming problem of a worker reads

$$\begin{aligned} V_t(\boldsymbol{x}) \quad &= \quad \max_{c,l,a'_r,\kappa} \Bigg\{ u(c, c_h(a_r), 1-l) + \beta\psi_j^{z,v}\mathbb{E}_{y'|y}\Bigg(\mathbb{E}_{\psi'_e|\psi_e}\Bigg[\Gamma^{z,v}_{j+1,t+1}\int V_{t+1}(\boldsymbol{x}'_b)\Phi^{z,v}_{t+1}(b)db \\ &+ \quad (1-\Gamma^{z,v}_{j+1,t+1})V_{t+1}(\boldsymbol{x}')\Bigg]\Bigg) + (1-\psi_j^{z,v})q(\tilde{b}_{t+1}(a'_r, a'_p))\Bigg\}, \end{aligned} \tag{12}$$

subject to $l \in [0,1]$, $a'_r \geq 0$, $\kappa\tilde{w}l \in [0, \min(e, \chi_w)]$, to the law of motion of a_p in (7), to the function for $c_h(a_r)$ defined in (5) and to the budget constraint, which is given by:

$$a'_r + \kappa\tilde{w}l + (1+\tau_c)c + ra_m(a_r) = a_r + r(a_r - a_e(a_r)) + e - \tau_{SS,t}\min\{e, cap\} - \Psi_t(\iota; \boldsymbol{\lambda}_{I,t}, j^R), \tag{13}$$

where e are pre-tax earnings defined in (2), $\Psi_t(\cdot)$ is the income tax liability specified in (10), ι is taxable income defined in (11), $\kappa\tilde{w}l$ are the worker's contributions to the private retirement plan, and $a_e(a_r)$ and $a_m(a_r)$ are the housing equity and housing mortgage amounts defined in equation (6) respectively. As discussed earlier, only the non-housing part of regular wealth earns returns.

An agent of type (z, v) and age j dies with probability $1 - \psi_j^{z,v}$, in which case the agent derives utility from leaving a bequest to their "offspring", represented by the last term $q(\tilde{b}_{t+1}(a'_r, a'_p))$ in the problem above, where $\tilde{b}_{t+1}(a'_r, a'_p)$ denotes the after-tax bequest as a function of both a'_r and a'_p, which we define in Appendix A.1.[13] As in the data, we explicitly assume that both regular assets and the current after-tax balance of private retirement funds are bequeathed in the case of death. In addition, we assume that the deferred taxes on private retirement wealth are paid before transferring it as regular wealth to the offspring. This implies that, from the recipient's point of view, the composition of inherited wealth (regular assets vs. private pensions) is irrelevant.

If the agent survives to the next period, there is also a chance that she will receive a bequest next period. When modeling the distribution of bequests among surviving agents, we build upon Nishiyama and Smetters (2007), who assume that bequests are distributed randomly. Their approach accounts for the empirical fact that many households do not receive any bequests during their lifetime, while others receive multiple bequests. We capture this empirical regularity by assuming that, if the agent survives, which occurs with probability $\psi_j^{z,v}$, there is a probability $\Gamma(\cdot)$ that they will receive a bequest next period and a probability $1 - \Gamma(\cdot)$ that they will receive none. Given this, $V_{t+1}(\boldsymbol{x}')$ is the value function of the agent at time $t + 1$ if they do not receive any bequests, in which case she transits to the state $\boldsymbol{x}' = (j+1, j^{R'}, z, v, y', h', a'_p, a'_r, \psi'_e)$. Moreover, $V_{t+1}(\boldsymbol{x}'_b)$ is the value function of the agent at $t+1$ if they receive a bequest, in which case $\boldsymbol{x}'_b = (j+1, j^{R'}, z, v, y', h', a'_p, a'_r + b', \psi'_e)$, with b' being the bequest received as regular wealth.

We extend the approach of Nishiyama and Smetters (2007) in two ways to account for additional empirical facts. First, we assume type and age dependence in the probability of receiving bequests, i.e., $\Gamma_{j+1,t+1}^{z,v}$ varies with type (z, v) and j. This allows us to replicate the fact that higher-income households are more likely to receive bequests than lower-income households, and it ensures that the age profile of bequest receipts aligns with the data. Second, we account for the fact that income-richer households receive larger bequests, which is captured by the type-specific distribution of received bequests, $\Phi_{t+1}^{z,v}$. Of course, both $\Gamma_{j+1,t+1}^{z,v}$ and $\Phi_{t+1}^{z,v}$ are endogenous objects and, in equilibrium, they are determined by the life-cycle savings behavior of households who leave these bequests (see Appendix A.2 for more details).

Households have access to an ESRP if $\psi_e = 1$. With probability ν, they redraw the

[13] Note that bequests are left both accidentally (when households die earlier than expected) and intentionally due to this "warm glow" motive.

employer's copayment status ψ_e each period and, conditional on a redraw, households gain access to an ESRP with the type-dependent probability $\pi_p(z,v)$.[14] Given this, the transition probabilities of ψ_e are given by the following matrix:

$$\begin{bmatrix} 1-\nu\pi_p(z,v) & \nu\pi_p(z,v) \\ \nu\left(1-\pi_p(z,v)\right) & 1-\nu\left(1-\pi_p(z,v)\right) \end{bmatrix},$$

where the upper left element corresponds to $\psi_e = 0$ and $\psi_e' = 0$.

Since the agent remains in the labor force next period, her retirement status next period will remain unchanged: $j^{R'} = j^R = 0$. Given the optimal choice of hours worked l, the agent's next period stock of human capital h' will follow from the law of motions (3). Given the optimal choice of the proportion of earnings going to pension contributions κ, the agent's next period stock of retirement wealth a_p' follows from the law of motion (7). Given the optimal choice of hours, pension contributions, and regular wealth, current period consumption c follows from the budget constraint (13).

Problem of workers of age $J^E, ..., J^R - 1$

Once an agent reaches the age of J^E, she may choose to enter retirement, which is assumed to be an absorbing state. The retirement choice is given by

$$V_t(\cdot) \equiv \max\{V_t^W(\cdot), V_t^R(\cdot)\}. \tag{14}$$

Here, $V_t^W(\cdot)$ is the value of continuing to work, and it is defined as in equation (12), while the term $V_t^R(\cdot)$ is the value function of a retired agent defined below in equation (15). If $V_t^W(\boldsymbol{x}) < V_t^R(\boldsymbol{x})$ for a given state variable $\boldsymbol{x}$, then the worker retires and we denote this with $\mathcal{R}_t(\boldsymbol{x}) = 1$. This implies $j^{R'} = j$. To simplify notation, the retirement indicator always takes the value of one when the agent is in retirement, i.e. $\mathcal{R}_t(\boldsymbol{x}) = 1$ whenever $j^R \neq 0$ and $\mathcal{R}_t(\boldsymbol{x}) = 0$ whenever the agent is working.

Problem of retirees (age $J^E, ..., J$)

Retired agents devote their unitary time endowment to leisure and they decide how to allocate their regular wealth and how much to withdraw from their retirement account. Since the pension plan indicator ψ_e, the stock of human capital h and the productivity shock y do not affect the household's decisions and welfare during retirement, we redefine the

[14] This choice is motivated by our empirical evidence (Figure 3(c)), which shows that offer rates by type are quite flat over the life-cycle, but they vary strongly with income.

state vector as $\boldsymbol{x}^R = (j, j^R, z, v, a_p, a_r)$. The retirement age indicator remains unchanged for retirees, namely, $j^{R\prime} = j^R$. Hence, the agent transits from the current state $\boldsymbol{x}^R$ to the next period's state $\boldsymbol{x}^{R\prime} = (j+1, j^R, z, v, a_p', a_r')$.

The retired agent's maximization problem reads

$$\begin{aligned} V_t^R(\boldsymbol{x}^R) \;\; = \;\; \max_{c,a',\omega} \Bigg\{ & u(c, c_h(a_r), 1) + \beta\psi_j^{z,v} \Bigg[\Gamma_{j+1,t+1}^{z,v} \int V_{t+1}^R(\boldsymbol{x}_b^{R\prime}) \Phi_{t+1}^{z,v}(b) db \\ & + (1 - \Gamma_{j+1,t+1}^{z,v}) V_{t+1}^R(\boldsymbol{x}^{R\prime}) \Bigg] + (1 - \psi_j^{z,v}) q(\tilde{b}_{t+1}(a_r', a_p')) \Bigg\}, \end{aligned} \tag{15}$$

subject to the constraints $a_r' \geq 0$, $\omega \geq S_j(1+r)a_p$, to the law of motion of a_p in (8), to the function for $c_h(a_r)$ defined in (5), and to the budget constraint, which is given by:

$$a_r' + (1+\tau_c)c + ra_m(a_r) = a_r + r(a_r - a_e(a_r)) + \omega + p_g(\bar{p}_g(z,v), j^R) - \Psi_t(\iota; \boldsymbol{\lambda}_{I,t}, j^R), \tag{16}$$

where the agent's taxable income ι is defined in (11), the income tax schedule $\Psi_t(\cdot)$ is specified in (10), and $\boldsymbol{x}_b^{R\prime}$ is defined similarly to the workers' case.

If the retiree wants to liquidate some assets in order to supplement public pensions and increase consumption, there is a non-trivial trade-off between using regular assets or private pensions beyond the minimal requirement $S_j(1+r)a_p$. Deferred taxes on private retirement accounts need to be paid, either when withdrawals happen, or at death by the estate of the deceased.

3.6 Production technology

The economy is populated by a continuum of competitive firms that rent capital and labor from households. We assume that college graduate workers and non-college graduate workers are imperfect substitutes in the production function, but workers of the same education are perfect substitutes across different ages. Let $N_{z,t}$ denote the aggregate labor of type z at time t measured in efficiency units. Then, the total effective labor at time t is given by

$$N_t = \left(N_{L,t}^{\rho} + N_{H,t}^{\rho}\right)^{\frac{1}{\rho}}, \tag{17}$$

where $1/(1-\rho)$ is the elasticity of substitution between the two worker types.

The representative firm produces the final output good according to the production function

$$Y_t = ZK_t^{\varpi} N_t^{1-\varpi}, \tag{18}$$

where Z is the total factor productivity (TFP), K_t is the aggregate capital stock, and $\varpi \in (0, 1)$ measures the elasticity of output with respect to the input of capital services. Since we assume an open economy setting, the capital rental rate r will be determined exogenously and the capital to labor ratio K_t/N_t is determined by the following condition:

$$r = \varpi Z \left(K_t/N_t\right)^{\varpi - 1} - \delta. \tag{19}$$

Recall that workers with $\psi_e = 1$ are entitled to receive compensation packages that include matched contributions for their private retirement accounts, but we assume that firms cannot discriminate between workers with or without this entitlement in terms of hourly wages per efficiency unit within education levels. This implies that they have to break even (make zero profits) on average, taking into account the whole pool of workers of a given skill that will receive an ESRP. Given $l(\mathbf{x})$ and $\kappa(\mathbf{x})$, and given the optimal choice of contributions of workers with characteristics $\mathbf{x}$, the optimality condition of the firm determining the wage rates (skill prices) $w_{z,t}$ is:

$$w_{z,t}\left[1+\sum_j \int_{\boldsymbol{x}:z} \psi_e \frac{h_{j,z} v y_j l(\boldsymbol{x})}{N_{z,t}} \min(\kappa(\boldsymbol{x}), \chi_f) dF_{t,j}\right] = (1-\varpi) Z \left(\frac{K_t}{N_t}\right)^{\varpi} \left(\frac{N_t}{N_{z,t}}\right)^{1-\rho} \text{ for } z \in \{H, L\}, \tag{20}$$

where $F_{t,j}$ is the distribution of agents of age j over the state space in time t. As shown by the previous equation, since employers with $\psi_e = 1$ offer a one-to-one match of the per hour contribution of the worker $\kappa(\boldsymbol{x})$ up to the limit, the marginal cost of hiring an additional hour of labor in efficiency units is augmented by the expected (hourly) employee contributions to the retirement plans.

As long as $\rho < 1$, both types of workers are imperfect substitutes and the first condition implies that relative skill prices in equilibrium co-move with the relative supply of the two types. Importantly, imperfect substitutability implies that whenever either type increases (decreases) its labor supply as a response to policy changes, it increases (decreases) the marginal productivity and hence wages of the other type.

3.7 Equilibrium

The equilibrium of this economy is defined in Appendix A.3. The equilibrium is consistent with the optimal decisions of households and firms, given equilibrium prices, bequests, and government policies. It also guarantees that, given prices and optimal decisions, markets clear and the distribution of bequests left is consistent with the distribution of bequests received. For these conditions, a key object is $F_{t,j}(\boldsymbol{x})$ defined as the distribution of households across the state $\boldsymbol{x}$ for a given age j at time t.

We impose budget clearing for the two government systems, modeling the social security budget independently of the federal budget, in line with U.S. legislation. We assume that the social security tax, $\tau_{SS,t}$, balances the social security budget every period. In addition, the government finances an exogenous stream of spending G_t (wasted in the context of our framework) with exogenous debt issuance $D_{t+1} > 0$ and other tax revenue, while the income tax level, $\bar{\lambda}_{I,t}$, balances the government budget every period.

4 Calibration

Overview. When calibrating the model parameters, we assume the economy is in a steady-state equilibrium, and we drop time subscripts throughout this section. The model period is one year, and the parameters are calibrated to 2010–2022. For the baseline model, we assume an open economy setting, which keeps the interest rate r fixed at 4%.

Many of the parameters are calibrated following the calibration strategy in Ábrahám et al. (2025) and using the Survey of Consumer Finances (SCF), which we have used as the basis for the empirical analysis in Section 2. As discussed earlier, the household is the unit of observation because asset accumulation and consumption are typically determined at the household rather than the individual level. Accordingly, all key variables are measured as household aggregates (or averages), whereas age and education refer to the household head.[15] Building on the sample selection criteria outlined in Section 2, we now apply a small set of additional restrictions that better align the data with the model environment, but do not generate noticeable differences regarding the empirical facts documented earlier. Specifically, we exclude households whose earnings fall within the top 1% of the earnings distribution or households whose total wealth is in the top 1% of the wealth distribution.[16]

Table 1 summarizes the parameters, distinguishing those set outside the model from those calibrated within the model, for which empirical targets appear in brackets. Below, we provide more details on the calibration strategy.

Demographics. Agents enter the model as workers at the real-life age of 25 ($j = 1$). The maximum possible age is $J = 76$ (real-life age of 100). The early-retirement age is

[15] We refer to household heads with a completed college degree or higher as *college graduates* and all remaining households are considered *high-school graduates*.

[16] Since the model does not allow for any borrowing (apart from collateralized mortgage borrowing), while private pension wealth cannot be negative by construction, we set pension wealth and regular wealth to zero if total wealth is non-positive. If regular wealth is negative despite positive net worth, it is also set to zero, and the full net worth is reassigned to private retirement wealth.

Table 1: Model parameters.

Parameter	Interpretation	Value
Parameters determined outside the model:		
Demographics and preferences		
(J, J^E, J^R)	Maximum age, early and normal retirement age	(76, 38, 42)
n	Population growth rate, %	0.0
P_H	Share of college graduates at birth	0.38
$\{\psi_j^{z,v}\}$	Type- and age-specific survival rates	Vectors
Portfolio composition		
$\xi_h(a_r)$	Share of housing in regular wealth for homeowners	See text
$\xi_e(a_r)$	Share of equity in housing for homeowners	See text
Labor productivity		
γ_h	Elasticity of human capital production	0.543
ρ_y	Persistence of AR(1) shock	0.98
Production		
(ϖ, δ)	Capital share and capital depreciation, %	(33.0, 8.0)
ρ	Elasticity of substitution is $1/(1-\rho)$	0.285
r	Return on saving	4%
Retirement plans		
S_j	Minimum withdrawal from the retirement account	Vector
ν	Probability of switching employers	0.25
χ_f	Limits on firm's contributions, %	4.5
Government policies		
τ_κ	Share of tax-deductible pension contributions	1.0
λ_I	Income tax progressivity	0.216
λ_{SS}	Pension system progressivity	1.42
τ_c	Consumption tax, %	4.1
(d_y, g_y)	Debt-to-GDP ratio and Wasted spending-to-GDP ratio, %	(100.0, 7.8)
Parameters calibrated inside the model (target in brackets):		
Demographics, preferences, and bequests		
β	Discount factor (total wealth-to-income = 5.7)	0.96
η	Curvature for utility from leisure (Frisch elasticity of labor supply = 0.5)	1.6
ς_l	Relative utility weight on leisure (average hours = 0.4)	0.83
ς_h	Relative utility weight on housing (total regular wealth-to-income = 4.4)	0.63
$\underline{c}_h$	Housing for renters (total regular wealth-to-income at age 25–40 = 1.8)	0.6
ϕ_1	Degree of altruism (total wealth-to-income at age 95–99 = 6.2)	10.0
ϕ_2	Degree of bequests as luxury good (share of deceased leaving zero bequests = 20%)	6.0
$\{\Gamma_j^{z,v}\}$	Type- and age-specific prob. to receive a bequest (prob. to receive bequest by age)	Vectors
$\{\Phi^{z,v}\}$	Type-specific distribution of received bequests (prob. to receive bequest by age)	Vectors
Labor productivity		
$(h_{1,H}, h_{1,L})$	Initial skill levels (age profile of earnings)	(1.4, 0.2)
(θ_H, θ_L)	Ability levels (age profile of earnings)	(0.21, 0.14)
δ_h	Skill depreciation, % (age profile of earnings)	8.0
σ_ϵ^2	Variance of AR(1) shock (curvature of residual earnings variance by age)	0.01
(v_H, v_L)	Fixed effect (Gini index for pre-government earnings = 0.40)	(1.29,0.78)
Production		
Z	TFP (average wage rate $w = 1.0$)	0.27
Housing		
$\hat{a}_r$	Regular wealth threshold for homeownership (7.7% of total regular wealth)	0.14
Retirement plans		
$\{\pi_p(z, v)\}$	Type-specific probability to be offered an employer-sponsored plan,% (Figure 3(c))	(30, 80, 80, 88)
χ_w	Cap on worker's contributions ($\chi_w/\mathcal{E}$ = 0.32)	0.12
Social Security		
$\{\overline{p}_g(z, v)\}$	Type-specific public pension benefit (replacement rate by average lifetime earnings)	(0.07, 0.10, 0.11, 0.14)
cap	Maximum taxable earnings ($cap/\mathcal{E}$ = 2.1)	0.7
δ_g	Penalty for early retirement (share of retired agents at age 62 = 26%)	0.2

$J^E = 38$ (real-life age of 62), while the mandatory retirement age, J^R, is equal to 42 (real-life age of 66). The share of college graduates at birth, P_H, is set to 38%, consistent with our SCF sample. We borrow the estimates for the age- and type-specific mortality rates, $1-\psi_j^{z,v}$, from our previous work, where we calibrated them to target the age profile of survival probability rates as well as the mortality rates by income at real-life age of 70. Appendix B.1 presents the fit for the survival probabilities at different ages. The population growth rate n is set to zero, which best matches the age profile of population weights in the SCF.

Preferences and bequest parameters. The agent's period utility function u is given by (1) and the parameter ς_l is set to match a 40.0% share of disposable time devoted to market work, and the power parameter on leisure, η, is used to pin down a Frisch elasticity of labor supply of 0.5. The utility from leaving bequests is specified as:

$$q(a_r' + a_p') = \phi_1 \log(\phi_2 + \tilde{b}_{t+1}(a_r', a_p')). \tag{21}$$

where ϕ_1 is the degree of altruism and ϕ_2 captures how much bequests are a luxury good. We use these two parameters to target the total wealth-to-income ratio at ages 95–100 and the share of deceased agents who leave no bequests, equal to 20%.

The remaining preference parameters are calibrated internally to match the aggregate age profiles of wealth in the SCF. The discount factor β targets the total wealth-to-income ratio of 5.7. Recall that entering homeownership requires regular wealth, so the utility weight on housing is a key determinant of the regular wealth stock. For this reason, the weight on housing services ς_h targets the total regular wealth-to-income ratio of 4.4. In addition, entering homeownership results in a "jump" in utility (compared to renting), hence, $\underline{c}_h$, is a key determinant of the demand for regular assets by young households (aged 25-40), and we use the ratio of regular wealth-to-income of these households, which is equal to 1.8, to calibrate this parameter. Note that matching the previous aggregate ratios implies, by construction, the aggregate split between pension and non-pension wealth. As an external check, we verify that the model reproduces the relative importance of these asset types across the income distribution.

Finally, we calibrate the age- and type-specific probabilities of receiving a positive bequest, $\Gamma_j^{z,v}$, and the type-specific distribution of received bequests, $\Phi^{z,v}$, inside the model to ensure that the resulting age profile of these probabilities, averaged across types, is consistent with the data.[17]

Private retirement plans. In the data, individual employee contributions cannot exceed an annual limit established by the Internal Revenue Service (IRS). In 2022, which is

[17] See Appendix B2 in Ábrahám et al. (2025) for details.

the final year in our data, the maximum retirement contribution allowed by the IRS was $\$20{,}500$. Following the adjustment method used in Brendler (2023), we scale this amount by a factor of 1.6 to account for household size (i.e., the number of earners), yielding an adjusted contribution cap of $\$32{,}800$. Given that the average taxable earnings in the 2022 SCF sample are $\$102{,}688$, the implied ratio of the maximum contribution to average earnings is 0.32. We determine χ_w in the model by multiplying this ratio with the average steady-state level household labor earnings.

In the data, the maximum value of matching employer contributions varies substantially from plan to plan.[18] For example, the maximum match varies between 3% and 7% of pay among plans with single- or multi-tier match formulas.[19] We set $\chi_f = 4.5\%$ so that the maximum employer-matching contribution is the average of these percentages. In other words, employer-matching contributions in the model are $1.00 per dollar up to a maximum of 4.5% of total earnings.

As for the minimum required withdrawals from the private retirement account, S_j, the IRS does not stipulate any requirements before the age of 73 (age of $j = 48$ in the model), so we set $S_j = 0$ for $J^E \leq j < 48$. From age 73 onward, the IRS requires individuals to withdraw a minimum amount that is determined by the expected remaining lifespan of the agent. To compute this factor in the model, we use the same formula as the IRS, but, for internal consistency, we compute the lifespan at different ages using our calibrated/estimated survival probabilities $\psi_j^{z,v}$. More details about their calibration are provided in Appendix B.2.

For the probability of "switching employers" ν, we use $\nu = 1/4 = 0.25$, assuming an average job tenure of 4 years.[20] Finally, the type-dependent probability of access to ESRPs $\pi_p(z, v)$ is calibrated inside the model to match the schedule of offer rates by income in the SCF data that we presented in the empirical section (Figure 3(c)).[21]

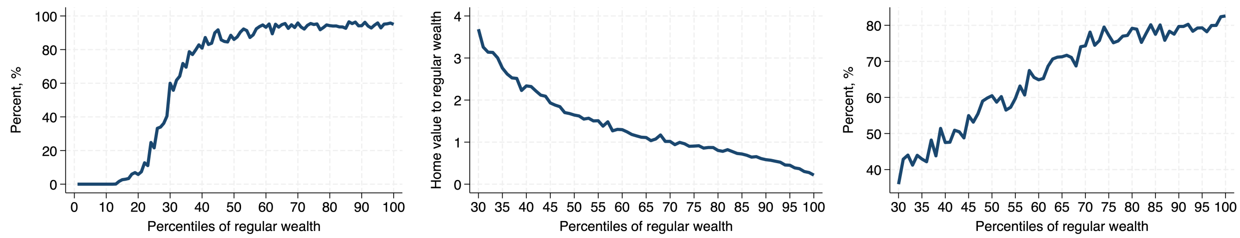
Housing. Figure 5(a) displays the homeownership rates by percentiles of the regular wealth distribution, based on our SCF dataset. The figure shows that homeownership is very limited among households in the bottom 25% of the regular wealth distribution, while ownership rates rise sharply, exceeding 80% above the 35th percentile. In our frame-

[18]See the 2024 Vanguard report "How America Saves" available at `https://corporate.vanguard.com/content/dam/corp/research/pdf/how_america_saves_report_2024.pdf`.

[19]An example of a common single-tier match formula is a matching contribution of $0.50 per dollar on the first 6% of pay. Less common are the multi-tier match formulas, such as $1.00 per dollar on the first 3% of pay and $0.50 per dollar on the next 2% of pay.

[20]According to the U.S. Bureau of Labor Statistics, the median job tenure was 3.9 years in January 2024.

[21]The offer rate in the SCF data is a *stock* of households having received an offer rather than the share of households receiving an offer per period of time (*flow* rate). Hence, we calibrate the flow rates inside the model, matching the stock rates by type in the SCF data, given ν.



(a) Homeownership. (b) Housing in regular wealth. (c) Home equity in housing.

Figure 5: Calibration of the housing parameters.

Notes: Panel (a) plots homeownership rates by percentiles of the regular wealth distribution. Panels (b) and (c) report, respectively, the schedule of housing in regular wealth, $\xi_h(\cdot)$, and the share of home equity in housing, $\xi_e(\cdot)$, restricting the sample to households above the 30th percentile of the regular wealth distribution. All panels are constructed using the SCF sample.

work, homeownership is modeled as a binary function of regular wealth, and we set the ownership threshold $\hat{a}_r$ at 7.7% of total regular wealth in the steady state. Note that this corresponds to the 30th percentile of the regular wealth distribution, where the homeownership rate is approximately 50%. Panel (b) of Figure 5 shows the schedule of housing relative to regular wealth, which is represented by $\xi_h(\cdot)$ in the model, by percentiles of regular wealth distribution. In addition, Panel (c) displays the share of home equity in total housing, represented by $\xi_e(\cdot)$ in the model. In both panels, we restrict the sample to wealth levels above the ownership threshold $\hat{a}_r$. To construct the schedules of $\xi_h(\cdot)$ and $\xi_e(\cdot)$ in the model, we first express the percentiles as multiples of aggregate regular wealth and then fit smooth, strictly monotonic functional forms for each schedule.[22]

Human capital accumulation, productivity shock and fixed effect. We calibrate the parameters of the law of motion for skills in (3) to match the profiles of pre-government earnings by age and education in the SCF. Moreover, the parameters ρ and σ_ϵ^2 of the idiosyncratic productivity shock y_j, which follows an AR(1) process given by (4), are calibrated inside the model to match the slope of the empirical age profile of residual earnings dispersion, and the fixed effect v, which can take two values (v_L, v_H), is calibrated inside the model to match the Gini index for pre-tax earnings inequality equal to 0.40.

Production. The capital share ϖ and the depreciation rate δ are set outside the model to match the average ratio of capital income to GDP, equal to 33%, and the average ratio of investment to GDP, equal to 8%, respectively. In line with Katz and Murphy (1992), ρ in (17) is set to 0.285, which implies that the elasticity of substitution between college and high-school graduate workers is equal to 1.4. The TFP factor Z is normalized such that the

[22]In particular, we fit $\ln(y) = b_0 + b_1 \ln(x)$ to the home value schedule in Figure 5(b) and $\ln(y) = c_0 + c_1/x$ to the home equity share schedule in Figure 5(c), where x denotes the multiple of total regular wealth for each percentile. The estimated coefficients are: $b_0 = -0.1258$, $b_1 = -0.5395$, $c_0 = -0.2097$, and $c_1 = -0.0848$.

weighted average of w_H and w_L is 1.0.

Income tax-transfer program. We set the income tax progressivity λ_I to 0.216, the government spending G, such that the share of government spending-to-GDP in the steady state, G/Y, is equal to 7.8%, the share of federal government debt to GDP, D/Y in the steady state is set to 100%, and the consumption tax, τ_c to 4.1%. The resulting equilibrium level of the income tax rate $\bar{\lambda}_I$ is 12.4%, corresponding to the average income tax rate of an agent with economy-wide average taxable income.

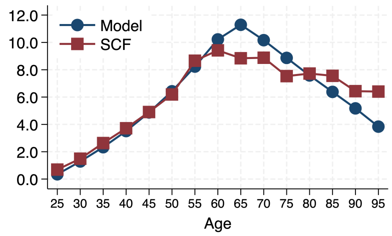
Social Security. To set the four levels of public pensions $\bar{p}_g(z,v)$ for each type, we proceed as follows. Brendler (2023) demonstrates that for the vast majority of retirees retiring at the normal retirement age, the statutory replacement rate can be approximated very well by a flexible functional form:

$$R(\bar{e}/\mathcal{E}) = \bar{\lambda}_{SS} \times (\bar{e}/\mathcal{E})^{1-\lambda_{SS}}\,, \tag{22}$$

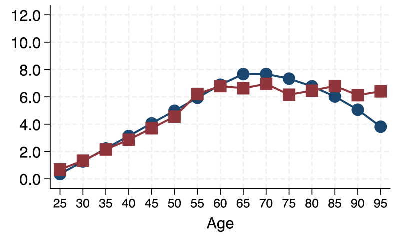
where $\bar{e}$ are the worker's average capped lifetime earnings at the time of retirement, $\mathcal{E}$ are the economy-wide average lifetime earnings among all retired agents, $\bar{\lambda}_{SS}$ controls pension generosity, and λ_{SS} governs pension system progressivity. In the current paper, since we have introduced an additional continuous state variable a_p, tracking lifetime earnings for each agent is computationally not feasible. Hence, we compute the average normalized lifetime earnings by type, $\bar{e}(z,v)/\mathcal{E}$, among those agents who enter retirement. We then use the approximated schedule above to compute the associated replacement rate for each type, $R(\bar{e}(z,v)/\mathcal{E})$. To do so, we borrow the progressivity estimate $\lambda_{SS} = 1.42$ and adjust inside the model pension generosity $\bar{\lambda}_{SS}$ to match the Social Security rate of 10.6%. The resulting replacement rates for Type 1 to Type 4 agents are 37.8%, 30.8%, 28.3%, and 24.4%, respectively. The pension levels are then determined as $\bar{p}_g(z,v) = R(\bar{e}(z,v)/\mathcal{E}) \times \bar{e}(z,v)$.

The parameter cap is set to 2.1 times the average taxable earnings $\mathcal{E}$. We obtain this value from the data by computing the ratio between the statutory maximum taxable earnings threshold, adjusted for the household size, as we did for the private retirement contribution limits earlier, and the economy-wide average taxable earnings.[23] The penalty factor for early retirement δ_g in (9) is estimated inside the model by targeting the share of households at age 62 in the SCF who report receiving pension benefits (26%).

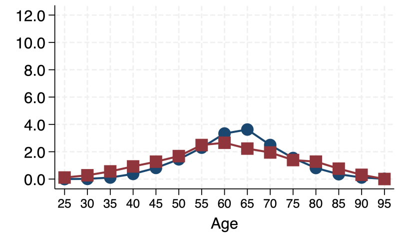
[23]The statutory value of the cap is \$132,900 in 2022, and we multiply it by 1.6 to obtain \$212,640. The average taxable earnings among working-age population (25–65) in the SCF are \$102,688 in 2022 U.S. dollars. Hence, cap is calibrated to target the ratio of \$212,640/\$102,688 equal to 2.1.



(a) Total wealth.



(b) Regular wealth.



(c) Retirement wealth.

Figure 6: Normalized regular and retirement wealth by age.

Notes: Wealth in the model and data is normalized by the economy-wide average income. The empirical profiles in both panels are constructed using SCF 2010–2022. The values on the horizontal axis represent the midpoint of 5-year age groups.

5 Findings

In this section, we explore some of the quantitative implications of our model in several dimensions. In the first section (Section 5.1), we investigate whether our model is capable of matching some of the key untargeted moments regarding private retirement accounts. In the second section (Section 5.2), we show the role of housing in generating these facts. Through a set of counterfactual exercises, a third section (Section 5.3) isolates the effects of the different tax advantages of private retirement accounts in terms of the short- and long-term impact on both the main macroeconomic aggregates and the amount of redistribution. Finally, Section 5.4 studies whether eliminating these tax advantages can help to address fiscal shortfalls.

5.1 Private pension wealth and private pension contributions

This subsection explores the extent to which our quantitative model, featuring a detailed empirically motivated modeling of private retirement accounts with rational forward-looking agents that have access to these as well as regular savings, is able to account for some of the key empirical patterns discussed in Section 2.

Figure 6 displays the model fit of the age profiles of total wealth (Panel a), broken down into regular wealth (Panel b) and retirement wealth (Panel c). Both in the data and the model, the variables are normalized by the economy-wide average income. It is important to point out that our calibration only targeted the (normalized) level of total and regular wealth, as well as the relative regular wealth of young households (25-40 years old). Hence, to a large extent, these life-cycle profiles were not targeted.

Overall, the figures reflect that the model does a remarkable job in matching the age

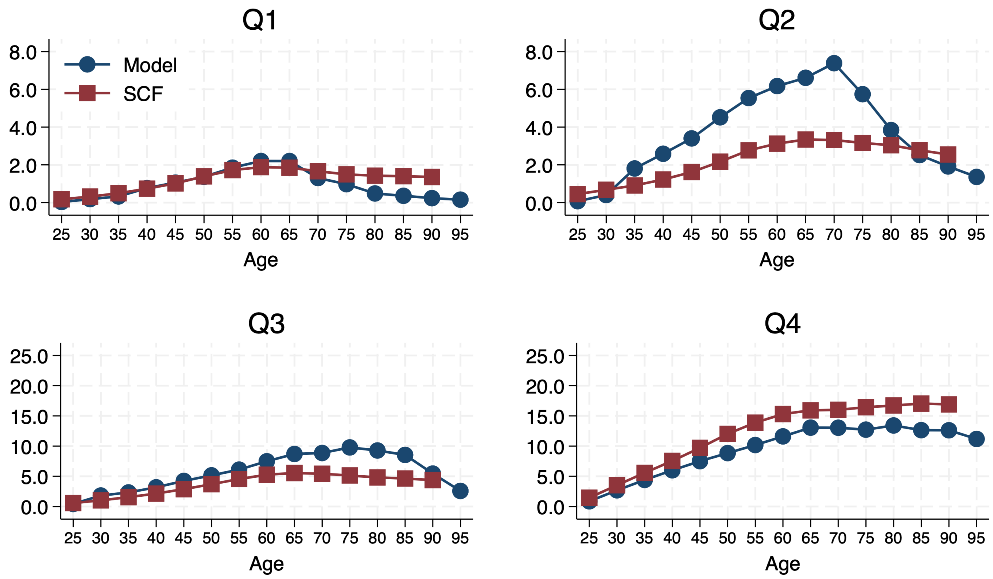


Figure 7: Normalized regular wealth by age and income quartiles.

Notes: Wealth in the model and data is normalized by the economy-wide average income. Income quartiles are defined within each 5-year age group. The empirical profiles in both panels are constructed using SCF 2010–2022. The values on the horizontal axis represent the midpoint of 5-year age groups.

profile of both total wealth accumulation and its components. The model performs particularly well at replicating the gradient of regular wealth accumulation during the working life, with a slightly lower asset accumulation in private pension wealth compared to the data, especially for younger households. After retirement, the model also performs quite well. Regarding private pensions, the statutory required minimum distributions for private retirement accounts (S_j) are designed such that private retirement wealth is decumulated gradually, and having introduced this feature in the model allows us to match the pattern for this type of wealth very closely. As for regular wealth, the model somewhat overstates asset decumulation after the working life, but this is not so surprising, since we have abstracted from health shocks, the indivisibility of housing, and long-term medical expenses.

Figures 7 and 8 show the model fit of regular wealth and retirement wealth by age and income quartiles. For regular wealth, the fit is quite good except for the second income quartile, with a faster wealth accumulation in the model for the middle-income types and a slightly slower decumulation for the richest income group. Looking at the second figure, it is clear that the model can replicate the life-cycle pattern of private retirement wealth remarkably well, except for a somewhat slower accumulation for younger households,

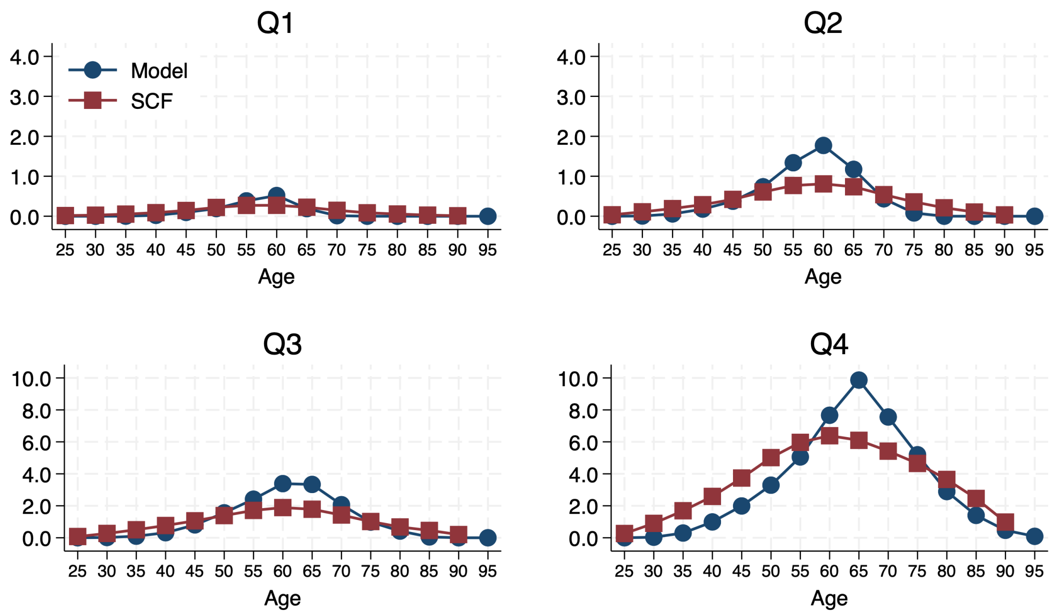


Figure 8: Normalized pension wealth by age and income quartiles.

Notes: Wealth in the model and data is normalized by the economy-wide average income. Income quartiles are defined within each 5-year age group. The empirical profiles in both panels are constructed using SCF 2010–2022. The values on the horizontal axis represent the midpoint of 5-year age groups.

especially in the highest quartile, and smoother profiles around the peak in the data.[24]

Two additional dimensions in which the model performs qualitatively well are the average pickup and contribution rates to ESRPs. Figure 9 displays the pickup rates generated by the model, together with their counterparts in the data. As already shown in the empirical section, the pickup rates in the data increase both with age and income, and the model is able to generate this life-cycle and income-dependent path. While the model matches well the strong income dependence, the age slope is higher than in the data because the model enrollment in ESRPs among young households is too low. This is consistent with the observation that the model matches quite well the income dependence of private retirement wealth accumulation, but we have somewhat lower accumulation during early ages for most quartiles (Figure 8). Finally, Figure 10 displays the model fit of contribution rates to ESRPs by age and income conditional on participation, showing a really good fit in terms of both life-cycle and income profiles.

We conclude that the model seems to be capable of capturing many of the key regularities of both regular and private retirement wealth accumulation.

[24]One reason for the peak in the model is the fact that we do not model family structure, and hence spouses are forced to retire together.

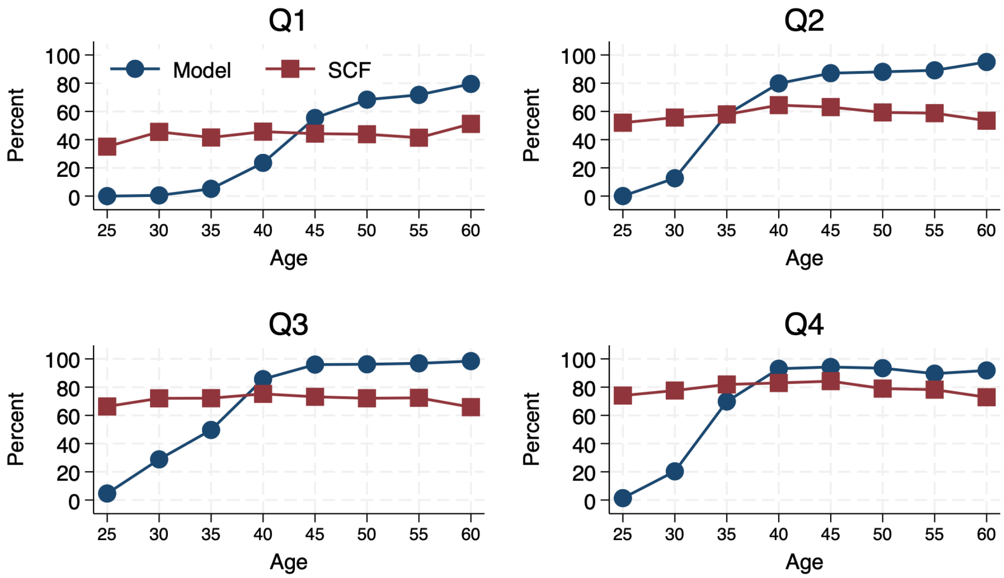


Figure 9: Pickup rates for retirement plans by age and income in the model and data.

Notes: The pickup rate, both in the model and the data, is defined as the fraction of workers who enroll in a private retirement plan out of all workers whose employers offer such a plan ("stock" variable). Income quartiles are defined within each 5-year age group.

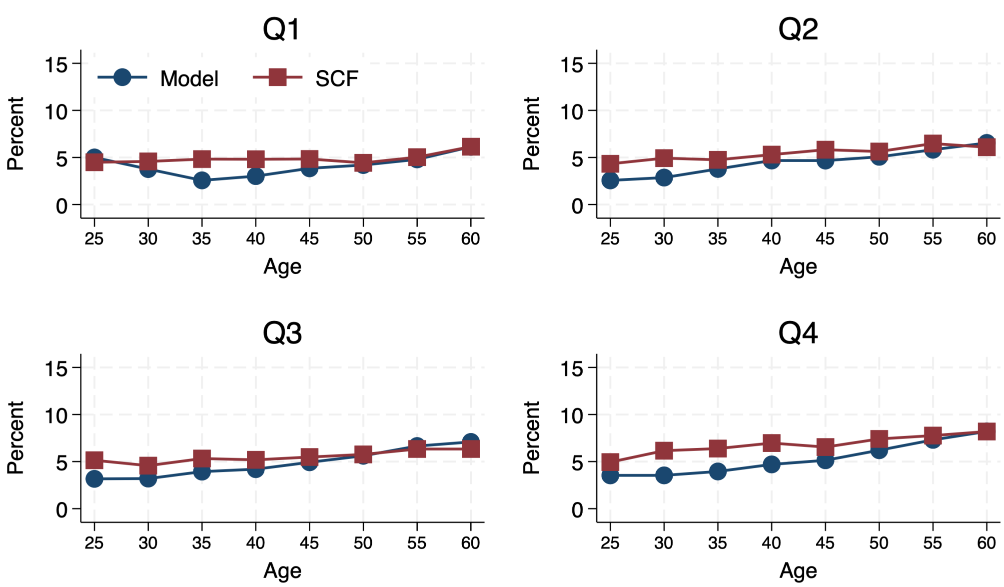
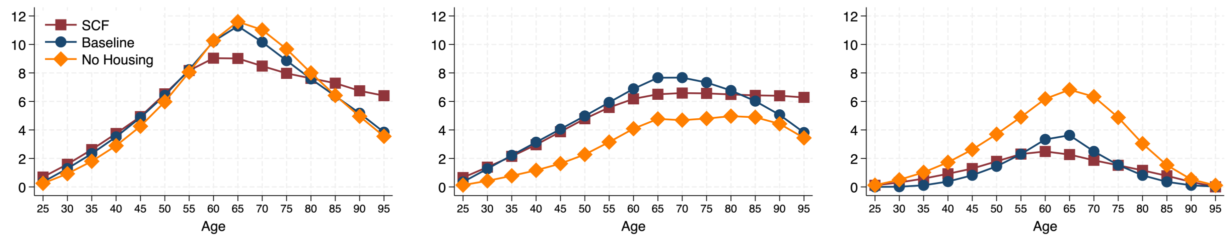


Figure 10: Model fit of average contribution rates to ESRPs by age and type.

Notes: The figure shows contribution rates conditional on participation in the plan. Income quartiles are defined within each 5-year age group.



(a) Total wealth. (b) Regular wealth. (c) Retirement wealth.

Figure 11: Wealth accumulation in the data, baseline model, and counterfactual model without housing.

5.2 The role of housing for wealth accumulation

In this subsection, we show that the presence of housing, even if modeled in a somewhat reduced form, is crucial for the model to match the profiles of private retirement wealth. We do this by a conducting counterfactual experiment in which we have recomputed the model by setting the relative weight for housing ς_h to zero in the utility function (1) and by setting the share of housing in regular wealth $\xi_h(a_r)$ to zero as well. This implies that households neither receive any utility from housing services nor invest any regular wealth in housing. In order to make the two model versions comparable, we have recalibrated β so that the total wealth-to-income ratios are the same in the two economies.

Figure 11 compares the life-cycle profiles of total wealth (Panel a), regular wealth (Panel b), and retirement wealth (Panel c) in the data, the baseline model, and the model with no housing. As the figure reflects, removing housing preserves the aggregate life-cycle pattern of total wealth, but it fails to match the joint life-cycle profiles of its two components–retirement and regular wealth. In fact, a very interesting observation is that both the baseline model and the model without housing do very similarly regarding aggregate wealth, not only in terms of total wealth levels, but also in terms of total wealth accumulation over the life-cycle. However, the differences in the composition of total wealth are striking. As Panels (b) and (c) reflect, in the model without housing, households across all age groups have consistently lower regular wealth and higher pension wealth. Note that, in the benchmark model, the demand for homeownership increases the desirability of regular wealth for young households disproportionately, as this type of wealth is required (as collateral) for buying a house, and this investment will carry over to older ages. At the same time, at later ages, the marginal utility from housing is diminishing, and the higher after-tax return on private retirement wealth dominates. At that point, households start investing more in private retirement wealth, which grows rapidly after the age of 40 until retirement.

5.3 The role of tax advantages

In this subsection, we assess the positive and normative effects of the preferential tax treatment of private retirement wealth. In the model, investment in private retirement wealth allows households to defer taxation until retirement age through three channels. First, there is a positive fraction of contributions to the private retirement plan, τ_κ, that are deducted from the worker's taxable income, thereby reducing the worker's current tax liability. Second, for workers who have access to an ESRP, individual contributions to the retirement accounts are matched by the employer up to a proportion χ_f of earnings, and these are also tax-exempt at the time of contributions. Third, the return on accumulated private retirement wealth during the working stage is not taxed either.

Eliminating the tax advantages of private retirement contributions and their returns during working life can potentially have important effects on efficiency and inequality. First, the tax benefits are more accessible to middle- and high-income households, thereby mitigating the progressivity of the tax and public pension systems. In other words, eliminating those benefits would make the system more progressive. In fact, since the exemptions redistribute from lower-income to higher-income workers, eliminating them may reduce inequality. Second, the exemptions provide labor supply and saving incentives for high-income households, potentially reducing the aggregate distortions of the tax and public pension systems, an effect that would favor maintaining the tax advantages. At the same time, eliminating them can potentially increase the tax base and therefore allow for a reduction in income taxation for all agents. Given all this, the overall effect of eliminating the tax advantages above on inequality, labor supply, and savings distortions is a quantitative question.

In our main experiment (*full reform*), we eliminate the possibility of saving in private retirement accounts entirely by setting $\kappa = 0$ for all households starting when the reform is implemented. At the same time, we assume that all past investments in private retirement funds can be kept tax-free until withdrawal, with returns also being untaxed. Moreover, after the funds are withdrawn, they have the same tax treatment and minimum distribution rules as in the benchmark model. To understand the impact of each of the tax advantages separately, we also conduct experiments in which we eliminate each of the tax advantages in isolation. In particular, the first experiment eliminates only the tax exemption on household contributions by setting $\tau_\kappa = 0$. In the second experiment, we shut down employer-sponsored tax-free contributions by setting $\chi_f = 0$, while keeping $\tau_\kappa = 1$. Finally, the third experiment combines the previous two by setting both $\tau_\kappa = 0$ and $\chi_f = 0$, while still allowing returns on private retirement wealth to accrue tax-free until withdrawal. Comparing the outcome of this third experiment with the full reform, which removes all tax advantages, including the tax-free returns, identifies the marginal effect of taxing returns on private retirement wealth.[25]

Table 2: Long-run impact of fiscal reforms on macroeconomic aggregates, %.

	τ_κ	χ_f	$\tau_\kappa + \chi_f$	Full
Retirement Wealth A_p	-46.4	-53.2	-93.5	-100
Regular Wealth A_r	-0.9	-1.2	0.7	0.6
Total Wealth $A = A_p + A_r$	-11.1	-12.8	-20.5	-22.03
Total Hours	0.01	0.29	0.37	0.45
Total Output	0.48	0.84	0.97	0.81
Total Consumption	-2.56	-2.63	-5.20	-5.78

Notes: Percentage changes in the long-run steady state under an open economy with fixed interest rate r. Column τ_κ removes the tax exemption for individual contributions; column χ_f removes employer tax-free matches; column $\tau_\kappa + \chi_f$ removes the tax exemption for individual contributions and the employer tax-free matches, while returns remain untaxed until withdrawal; "Full" eliminates all the previous advantages, including taxing returns on private retirement wealth. The difference between $\tau_\kappa + \chi_f$ and "Full" isolates the marginal effect of taxing returns on retirement wealth.

Table 2 displays the percentage change for some of the model aggregates in the long-run steady state. The table reveals several important facts regarding the long-term effects of the reforms. Consider first retirement wealth. Of course, when all tax advantages are eliminated in the full reform, retirement wealth decreases by 100%. Moreover, the first two columns also reveal that both the employer and the employee tax-free contributions are very important for retirement savings: removing employer tax-free contributions reduces retirement wealth by 53.2%, compared with 46.4% when eliminating the employee exemption. In fact, retirement wealth decreases by 93.5% when the tax-free contributions from both individuals and employers are eliminated, which in turn implies that the importance of tax-deferring returns on accumulated private pension wealth is very small.

The table also shows that regular and retirement wealth are not substitutable in the long run. In fact, there are only negligible long-run changes in regular wealth after any of the reforms, which lead to a large drop in total wealth accumulation in the long run. This implies that (at least in the long run) the preferential treatment of private retirement savings does not crowd out regular savings but instead brings in additional resources for future consumption. As for the other aggregates, all the reforms lead to a decrease in long-

[25] Measuring directly the tax deferral of interest income on private pension accounts is tricky, as we would need to distinguish "old" and "new" pension wealth (requiring the introduction of a new continuous state variable).

Table 3: Change in wealth shares by wealth percentiles.

	Percentiles of wealth distribution					
	0–20	20–40	40–60	60–80	80–100	Top 10
$\tau_\kappa = 0$	0.00	0.01	2.93	-2.65	-0.29	-0.41
$\chi_f = 0$	0.00	-0.05	4.29	-3.41	-0.84	-0.48
$\tau_\kappa = \chi_f = 0$	0.00	0.08	9.98	-8.06	-2.01	-6.09
All	0.00	0.12	12.54	-4.94	-7.71	-10.06

Notes: The table shows the percentage point changes in shares of wealth held by different percentiles of the wealth distribution in the final steady state relative to the baseline.

run aggregate consumption following the decline in total wealth, with a long-run increase in both hours and output. Recall that we have a small open economy where "domestic" wealth accumulation is decoupled from the capital stock used in the production function. As a result, we can have lower total wealth and at the same time higher productive capital. In our model, the lower wealth accumulation and consumption lead to an increase in labor supply through wealth effects, and that leads in turn to an increasing demand for capital by competitive firms (increasing one-to-one with effective labor), which in turn raises output.

Note that the preferential tax treatment of private retirement accounts creates higher after-tax return on savings for all households who have some accumulation in these accounts. Because of tax progressivity and unequal access to employer copayment (Figure 3), this return differential is also increasing in income. At the same time, it is well-known that return heterogeneity contributes significantly to wealth concentration (see, for example, Hubmer et al., 2021; Fagereng et al., 2020; Bach et al., 2020; Benhabib et al., 2019). In Table 3, we quantify how the tax benefits on PRAs affect different quintiles of the wealth distribution by comparing the share of wealth held in the status quo and the new steady state for the different counterfactual reforms that we have studied above.

As opposed to most of the papers above, which focus on the very top of the wealth distribution (top 1% or 0.1%), the wealth channel through PRAs benefits a much larger share of households located in the top half of the distribution. In fact, for the first two counterfactual reforms, the most noticeable change is the significant reshuffling of wealth between the third and fourth quintiles. For example, when we eliminate the option of employer copayments ($\chi_f = 0$), we see that the wealth share of the third quintile increases by 4.29 percentage points, while the wealth share of 4th quintile drops by 3.41 percentage points, and there is only a small drop in the share of the top 20% (or top 10%) of the wealth distribution. These channels amplify each other due to the fact that the return differential is effectively much higher when both employer and employee contributions are possible while being subject to deferred taxation. In fact, when they are eliminated together, the aggregate effect is significantly larger on the third and fourth quintiles, and there is a significant drop in the share of the top 10% (6.09 percentage points).

When we consider the effects of all these policies together, the change of wealth distribution shifts considerably from the top to the middle. In particular, the share of the top 10 decile drops by more than 10 percentage points, while the middle quintile's share increases by 12.5 percentage points. These results highlight that the tax advantages associated with PRAs have long-run effects, not only on the level of wealth (more than 20%), but also on the concentration/distribution of wealth, as they benefit significantly more the relatively rich households.

To understand the short-run effects of the reforms, we have also computed the transitional dynamics. Clearly, a change in the policy parameters will trigger transitional paths for all the aggregates, prices (except for the interest rate), and taxes from the pre-reform to the final steady state associated with the new policy. As usual, taking this transition into account will be very important when determining their welfare effects. Regarding taxes, we assume that the social security tax rate $\tau_{SS,t}$ adjusts to balance the social security government budget in (36), and the average income tax level $\bar{\lambda}_{I,t}$ balances the government budget in (37).

The aggregate transitional dynamics are depicted in Figure 12. The figure displays the paths for total wealth, regular and retirement wealth, as well as output, effective labor, and consumption. The dotted line depicts the results for the full reform, while the solid and dashed lines depict the results for the cases in which only the tax exemption of individual contributions is eliminated or both the individual tax exemption and the availability of employer contributions are eliminated, respectively. The qualitative paths are very similar across all the reforms. When the different tax advantages of private retirement accounts are eliminated, both pension wealth and total wealth gradually decrease to a lower steady-state value. While regular wealth increases in the short run to compensate for the drop in retirement savings, it eventually also goes down, returning to roughly the same level as in the initial steady state. This implies that, in the short run, there is some substitutability between the two wealth accounts. We will document below that this is mostly due to the path of taxes during the transition. Following the increase in regular wealth in the short run, we also see an increase in consumption at first, which eventually decreases towards its lower long-run steady-state value.

Looking at the decomposition, the results are similar across all reforms. Both the elimination of tax advantages on private contributions and the elimination of employer-sponsored copays contribute similarly to the decrease in pension and total wealth, as well

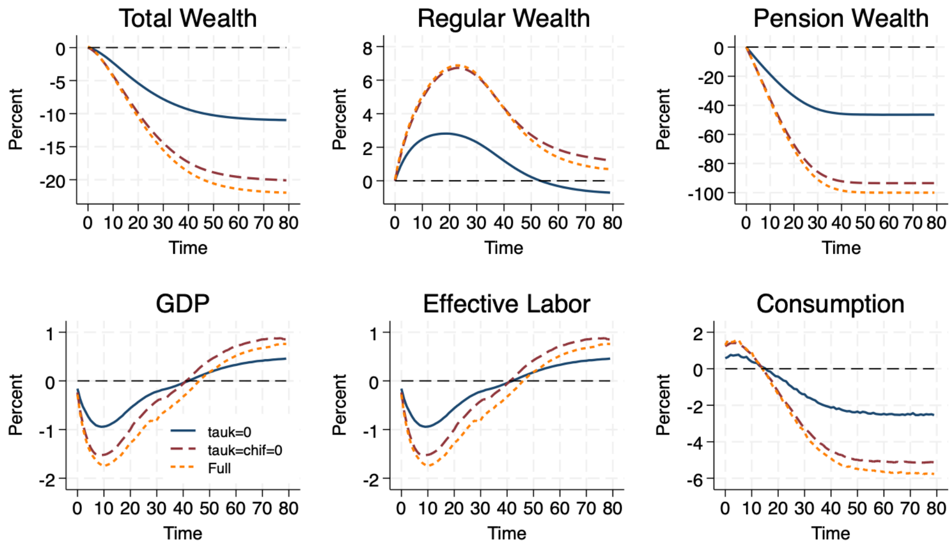


Figure 12: Transitional dynamics of aggregate variables in the counterfactual experiments.
Notes: The full reform eliminates all three advantages, including taxing returns on private retirement wealth.

as to the path of all other aggregates. In contrast, the effect of the deductibility of returns is very small, consistent with the results in Table 2.

As discussed earlier, all the reforms we consider make the income tax-transfer system more progressive, since the tax benefits linked to private retirement accounts are more accessible for middle- and high-income households. In other words, the exemptions provide labor supply and saving incentives, reducing the aggregate distortions of the tax and public pension systems. This implies that, when the tax advantages are eliminated, both savings (total wealth) and labor supply incentives decline. This is reflected in the considerable decrease in effective labor that we observe in the short run. In the long run, however, this trend is reversed due to wealth effects, as discussed earlier.

To better understand the underlying reasons behind the short-run dynamics, Figure 13 depicts the transitional dynamics for taxes and prices after the full reform. In particular, the figure displays the paths for wages $w_{z,t}$ by educational level $z \in \{L, H\}$, total compensation by educational level, defined as the marginal product of labor from eq. (20), as well as social security taxes $\tau_{SS,t}$ and the average income tax level $\bar{\lambda}_{I,t}$.

First, the elimination of the tax advantages of private retirement accounts considerably widens the tax base in the short run, even with lower labor earnings, since the reforms prevent households from shielding any labor income from taxation. As a result, the government is able to reduce both social security and average income taxes in the short run, contributing to the initial rise in both consumption and regular wealth (which is also sub-

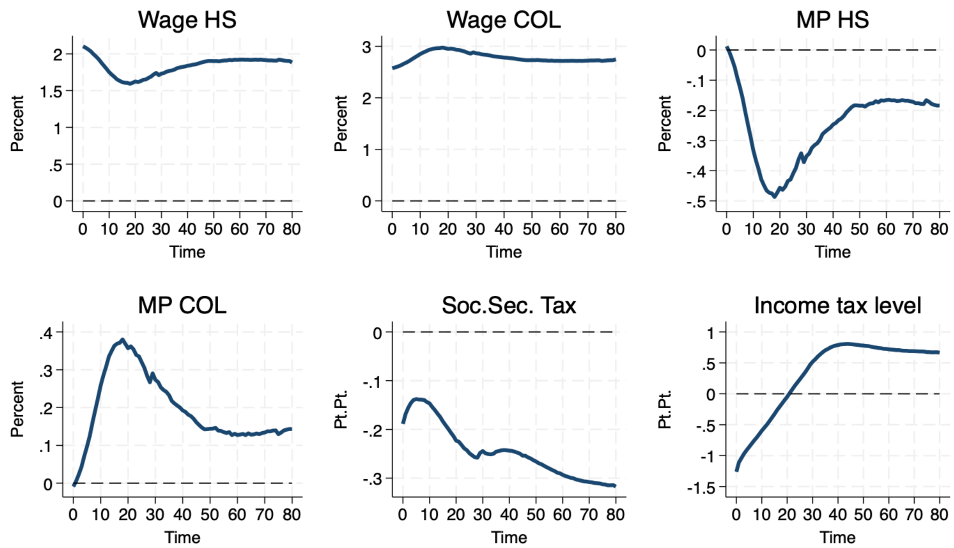


Figure 13: Transitional dynamics of prices and taxes in the counterfactual experiments.
Notes: The full reform eliminates all three advantages, including taxing returns on private retirement wealth.

ject to lower taxation after the reform). In the long run, the decline in total wealth erodes the tax base, and the government cannot afford to have lower average income taxes. In fact, these increase to approximately zero with the first reform and above zero when the second reform is also implemented, with little to no effects from the last reform.

Second, when looking at wages per efficiency units, we observe a significant increase (2% and close to 3%) for both education groups in the full reform. A big part of these changes are due to the employer contributions to private retirement plans being eliminated. As firms are competitive, when these contributions are eliminated, wages need to go up. Because of the income dependence of ESRPs, college graduate households use more of them, hence the reform implies larger wage increases to the more educated. Note also that these increases do not need to translate into an increase in total compensation (which includes the firm contributions in the benchmark model). Looking at the full reform, the figure shows that college graduates enjoy a small short-run increase in total compensation (around 0.4%), while high school graduates suffer a short-term loss of a similar magnitude. In the long run, these compensation changes are of an even smaller magnitude. This differential response is coming from the changes in labor composition. As college graduates reduce their labor supply more than high school graduates, they become scarcer, and their relative wage increases since the two groups are not perfect substitutes.

To assess the welfare effects of the full reform, we compute the associated welfare

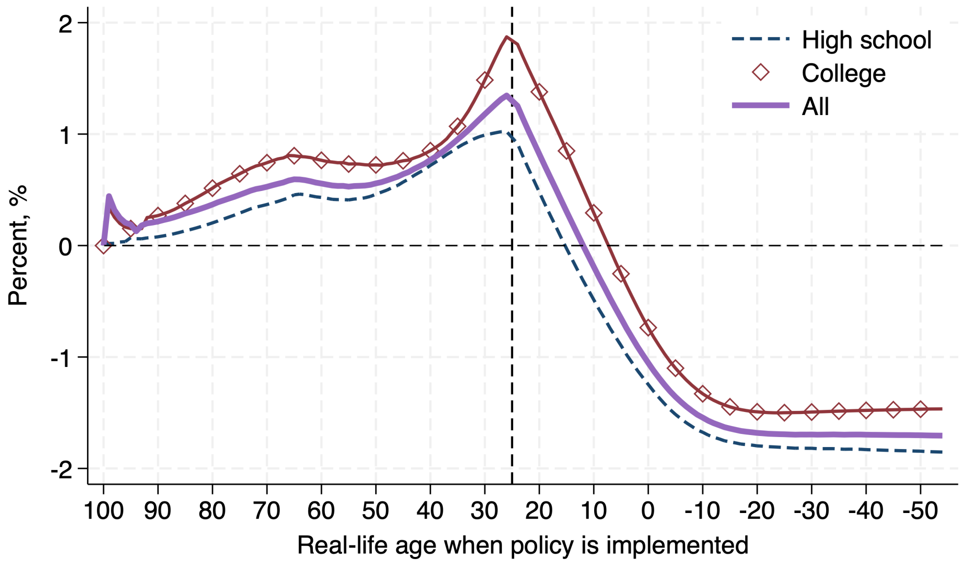


Figure 14: Welfare effects of the full reform by education (CEV, %).

Notes: The full reform eliminates all three advantages, including taxing returns on private retirement wealth. The vertical dashed line denotes labor-market entrants at the time of reform implementation (real-life age 25).

changes for the currently alive and transitional cohorts, explicitly accounting for transition dynamics. These are depicted in Figure 14. For each cohort, we report the average welfare effect and the breakdown by education (high school vs. college). In the figure, cohorts to the left of the entry age (real-life age 25)—which marks labor-market entrants at the time of reform—represent generations already alive when the reform is enacted, while cohorts to the right of age 25 correspond to children and unborn generations.

The figure reflects that eliminating all the tax advantages of private retirement accounts leads to sizable welfare gains for the currently alive, including the retirees, with big losses incurred by future generations. This is not surprising, as it clearly reflects the paths of consumption and leisure (hours) discussed above. In other words, the reform generates substantial inter-generational redistribution towards current generations. In contrast, there is a relatively small redistribution across different education levels, with slightly higher gains for college graduates. As we have discussed before, the higher gains (lower loss in the long run) for college graduates are coming through a general equilibrium effect on their relative wages.

In sum, eliminating the fiscal advantages of private retirement accounts has a sizable negative effect on aggregate savings, indicating that both types of savings are not substitutable. Moreover, the policy has large inter-generational redistribution towards current generations, while there is only limited redistribution within generations. At the same

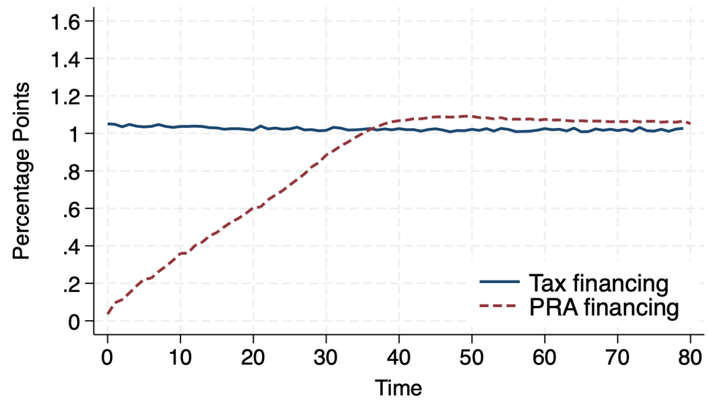


Figure 15: Transition of income tax level under fiscal consolidation.

time, eliminating the tax advantages can expand significantly the tax base in the short run. Motivated by this, we use our framework to study a fiscal consolidation application in which the government can finance a permanent increase in spending, either with average income taxes only or by eliminating the tax advantages on private retirement contributions.

5.4 A fiscal consolidation application

So far, we have shown that eliminating the tax advantages associated with private pensions is increasing (temporarily) the tax base, which allows the government to lower taxes, at least in the short run. This implies that the elimination of these tax advantages can be, in principle, used to fill budget gaps. Below, we are going to use our model to compare the efficiency and redistributive implications of fiscal consolidations that either increase average taxes or (mostly) rely on eliminating some of the tax advantages of private retirement accounts.

In what follows, we study a fiscal reform in which the government decides to increase its government expenditures G by 5% permanently from the current period onward. Moreover, we assume that the higher level of expenditures can be financed in two different ways, with the common element that the government budget constraint (37) must be satisfied every period for $t \geq 0$. The first way to finance the additional expenditures is through increased income taxation: the income tax level $\bar{\lambda}_{I,t}$ increases to satisfy the budget constraint of the government every period. The second way to finance the increased expenditures consists of eliminating one of the tax advantages of private contributions by letting $\tau_\kappa = 0$ for all agents for $t \geq 0$, while $\bar{\lambda}_{I,t}$ also adjusts (as needed) to satisfy the budget constraint of the government every period.

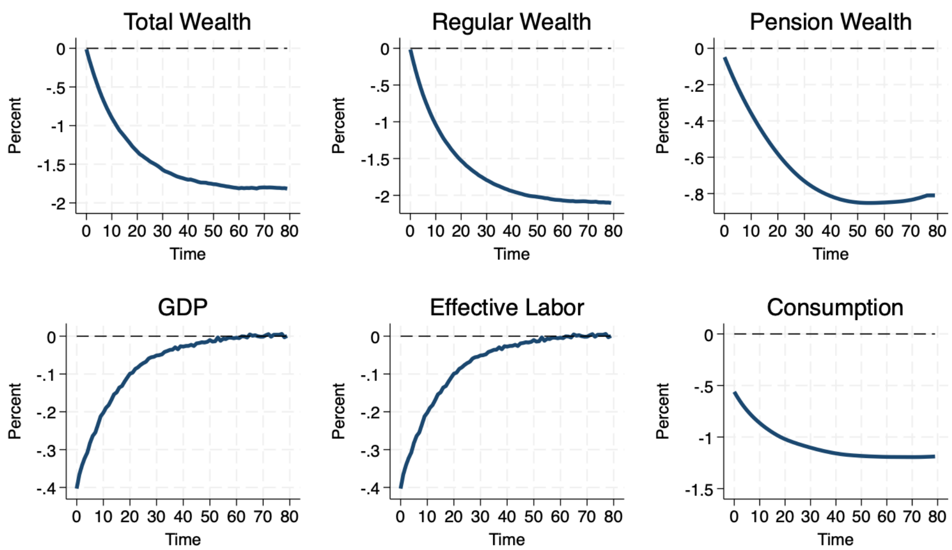
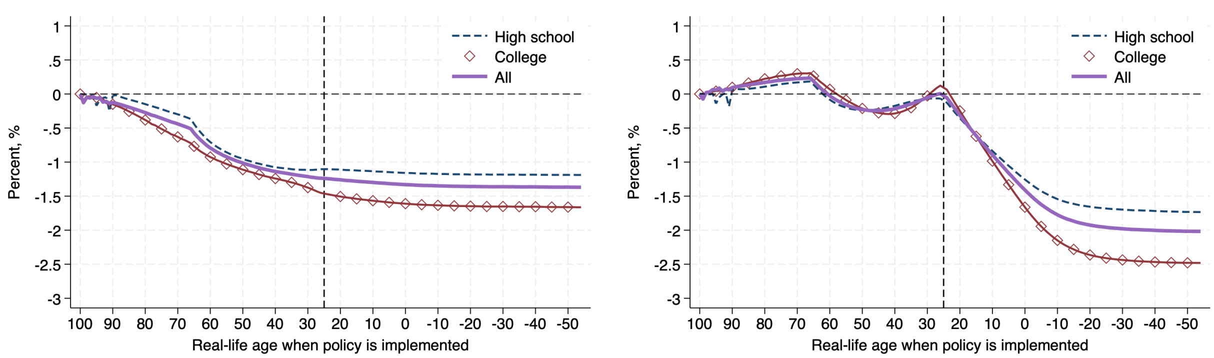


Figure 16: Transitional dynamics of aggregate variables under fiscal consolidation with tax financing.



(a) Tax financing.

(b) PRA financing.

Figure 17: Welfare effects under fiscal consolidation.

Figure 15 displays the transitional dynamics for the average income tax level $\bar{\lambda}_{I,t}$ for both experiments. For the first experiment, the average tax level rises immediately and permanently as a response to the increase in government spending. Figure 16 shows that this reform has moderate effects on wealth accumulation and labor supply. However, as expected, increased G crowds out private consumption by more than 1%.

Finally, Figure 17(a) displays the welfare effects of this reform by age and education type for this first experiment. Since the increased G has resource costs but no utility or production benefits, it should not be surprising that the reform implies welfare losses for all generations. The welfare losses follow closely consumption (and leisure) and are relatively constant (between 1% and 1.5% in terms of consumption equivalent measure) for current working and future generations.

For the second reform, which eliminates the tax advantages associated with individual private pension contributions, Figure 15 shows a very different pattern for income taxes. While there is still an increase in the average level of income taxes in the long run, the short-run increase is very gradual, and it only reaches its higher long-run level after around 40 periods. As a result, current generations are largely shielded against the income tax increase. Similarly to the counterfactual exercises of the previous section, the elimination of tax advantages expands the tax base so that, in the short run, there is no need to raise income taxes significantly. However, as it is clear from Figure 15, over time, the tax base erodes and taxes need to rise even somewhat more than in the previous reform. As a result, the consumption drop is lower in the short run with the second reform, while the combination of higher taxes and reduced saving incentives (and hence wealth) imply a significantly lower consumption in the long run under the second reform, as reflected in Figure 18.

Figure 17(b) shows that, while future generations experience significantly larger welfare losses and are in fact worse off in the long run compared to the previous policy experiment, current generations are better off with the alternative financing choice. In sum, a fiscal consolidation that relies on the elimination of tax advantages on private retirement contributions to PRA creates considerable inter-generational redistribution towards current generations. If governments need political support to implement the reforms (or to get re-elected), they may find this type of solution more viable or attractive, even though it has severe consequences for future generations.

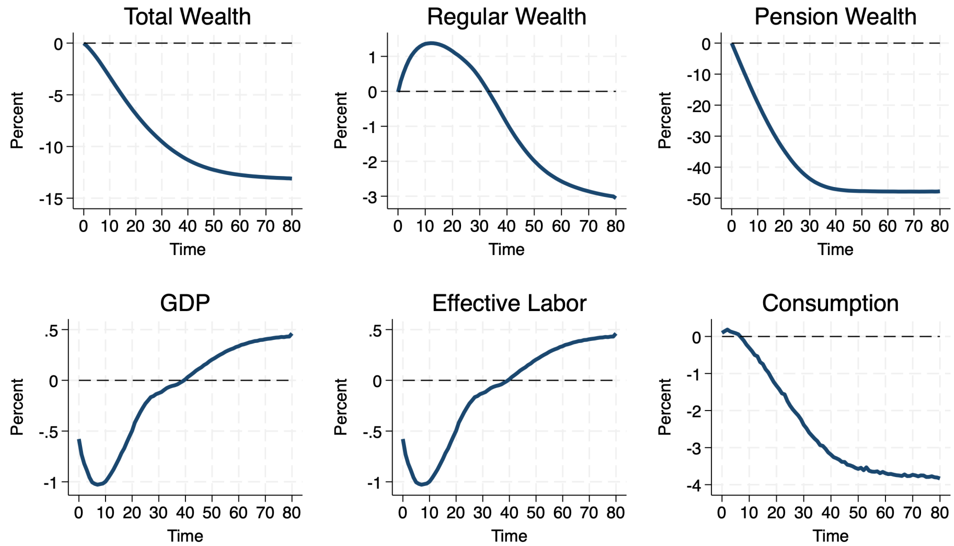


Figure 18: Transitional dynamics of aggregate variables under fiscal consolidation with PRA financing.

6 Conclusions

This paper uses a quantitative state-of-the-art OLG model with rational forward-looking agents to study the impact of eliminating the tax advantages of private retirement accounts. Apart from studying the impact of policy changes to the income tax-transfer system in relation to the private retirement accounts, an important contribution of the paper is to show that the model, including the main institutional aspects of these accounts as well as the main characteristics of homeownership over the life-cycle, can account for the accumulation of private retirement wealth. Using such a setting, we show that the tax benefits of private retirement wealth can partially crowd out regular wealth accumulation in the short run, but lead to significantly higher wealth accumulation in the long run. Moreover, eliminating them expands the tax base and generates substantial welfare gains for the current generations, at the expense of future generations, with a relatively minor effect on within-cohort inequality. When we use our framework to study a fiscal consolidation exercise in which the government has to finance a permanent increase in government spending, we show that eliminating some of the fiscal advantages of PRAs is superior to just increasing income taxes for the welfare of current generations.

More broadly, these results point to the fact that when income or public pension tax reforms are considered, it may be essential to model the distinct incentives and regulations around private pension plans that are deeply embedded in the tax and transfer system in order to get a reliable assessment of savings and labor supply responses. As we have seen in our counterfactual exercises and in the fiscal consolidation application, this channel can lead to unintended and not desirable redistribution across generations.

For future research, the framework introduced in this paper can be used to study more concrete policy proposals regarding private pension plans. For example, the Spanish government recently introduced shifts that reduced the tax advantages of individual contributions and, at the same time, they are encouraging the wider availability of employment (or occupation) based plans to reduce the regressivity built in the system and to foster wider access. Our framework has all the elements for studying the redistributive and long-term effects of such reforms. At the same time, for the 2026 budget, the U.K. Treasury has considered significant reductions of the tax advantages of private retirement contributions to expand the tax base, although only part of these proposals were implemented up to this point. Our results (based upon the U.S. institutional environment and calibration) would suggest that such policies may have short-term (political) benefits but may have long-term negative consequences. Of course, a more detailed analysis is required to study whether these results would hold for the institutional details of the UK environment as well.

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Supplemental online appendix

A Model

A.1 Bequests

As discussed in the main text, households in our model leave bequests to their "offspring" both because they gain utility from it ("warm-glow" motive), and because they die earlier than expected ("accidental bequests"). In this last case, we assume that the offspring inherits both the retirement wealth a'_p and the regular wealth a'_r.

Regarding the inherited pension wealth a'_p, the bequeathed amount after the deferred taxes are paid is equal to:

$$a'_p - \Psi_t(a'_p; \boldsymbol{\lambda}_I, j^R > 0),$$

where we apply the same general income tax formula that we use for withdrawals ω, since private pensions are subject to deferred taxes before they are inherited. In addition, in order to simplify the state space of the recipients, we assume that these taxes are paid in isolation from any other income of the recipient. Note also that the return on the after-tax amount is accounted for at the level of the recipient in her dynamic programming problems (12) and (15), and the return on the tax is accounted for at the government level in its budget constraint (37).

As for the inherited regular wealth a'_r, only the non-housing part $a'_r - a_e(a'_r)$ pays interest. This implies that, at the beginning of the period, the bequeathed regular wealth, together with the interest payment, is given by $a'_r + r(a'_r - a_e(a'_r))$. To avoid an additional state variable that keeps track of the sources of bequeathed wealth, we set, without loss of generality, the inherited regular wealth to $a'_r - \frac{r a_e(a'_r)}{1+r}$, which makes sure that the recipient inherits the right amount $a'_r + r(a'_r - a_e(a'_r))$.

After taking all these considerations into account, regular assets and after-tax private pension wealth become equivalent from the recipient's point of view, and bequests as a function of regular and pension wealth are denoted by

$$\tilde{b}_{t+1}(a'_r, a'_p) = a'_r - \frac{r a_e(a'_r)}{1+r} + a'_p - \Psi_{t+1}(a'_p; \boldsymbol{\lambda}_I, j^R > 0). \quad (23)$$

A.2 Bequest distribution

This section discusses how the probability of receiving bequests and the bequest distribution ($\Gamma^{z,v}_{j+1,t+1}$ and $\Phi^{z,v}_{t+1}$) are determined in equilibrium. When we model bequests, we do not model families explicitly but instead introduce a dynamic link between generations in a stylized way through the transition matrix $\pi(z^c, v^c \mid z^p, v^p)$, where (z^p, v^p) and (z^c, v^c) refer to the parents' and children's productivity type, respectively.[26] In particular, when a household of type (z^p, v^p) passes away with positive wealth, $\pi(z^c, v^c \mid z^p, v^p)$ is the probability that their bequest is received by a type (z^c, v^c) household.

In the data, if a household has not received a bequest, we cannot distinguish whether this is because no one has died who could leave a bequest for that household or because the parents have passed away but have left zero bequests. Given this, we only keep track of bequests that are strictly positive. First, we show how $\Phi_t^{r,s}$, the distribution of bequests received by type (z_r^c, v_s^c), is determined in equilibrium. If an offspring of type (z_r^c, v_s^c) receives a bequest, the distribution $\Phi^{r,s}$ from which the bequest is drawn is given by

$$\Phi_t^{r,s} = \sum_{m,n} \pi(z_r^c, v_s^c \mid z_n^p, v_m^p)\phi_t^{n,m}, \tag{24}$$

where $\phi_t^{n,m}$ is the probability (density) distribution of positive bequests left at time t by households of type (z_n, v_m). For any level of bequests $b > 0$, this density is given by

$$\phi_t^{n,m}(b) = \frac{\sum_j \int I_{\boldsymbol{x}:\{\tilde{b}(a'_{r,t-1}(\boldsymbol{x}),a'_{p,t-1}(\boldsymbol{x}))=b\}}(1-\psi_j^{z_n,v_m})dF_{t-1,j}(\boldsymbol{x}: z = z_n, v = v_m)}{\sum_j \int (1-\psi_j^{z_n,v_m})dF_{t-1,j}(\boldsymbol{x}: z = z_n, v = v_m)}, \tag{25}$$

where the denominator is the total measure of type (z_n, v_m) households deceased at time t and the numerator is the total number of type (z_n, v_m) households deceased at time t leaving a bequest of b.

We denote by $\chi_t = \sum_j \int I_{\boldsymbol{x}:\{\tilde{b}(a'_{r,t-1}(\boldsymbol{x}),a'_{p,t-1}(\boldsymbol{x}))>0\}}(1-\psi_j^{z_n,v_m})dF_{t-1,j}$ the proportion of agents passing away between period $t-1$ and t and leaving positive bequests among the total population in period $t-1$. The stationarity of our model implies that this is a constant in the steady state and that the overall probability of receiving bequests needs to be equal to χ_t. Also, denote the proportion of agents of type (z_n, v_m) among the deceased who have left positive bequests by $\mu^{n,m}$. This corresponds to the proportion of agents of type (z_n, v_m) leaving positive bequests, which is given by

$$\mu_t^{n,m} = \frac{\sum_j \int I_{\boldsymbol{x}:\{\tilde{b}(a'_{r,t-1}(\boldsymbol{x}),a'_{p,t-1}(\boldsymbol{x}))>0\}}(1-\psi_j^{z_n,v_m})dF_{t-1,j}(\boldsymbol{x}: z = z_n, v = v_m)}{\chi_t}. \tag{26}$$

Moreover, denote the proportion of children of type (z_r^c, v_s^c) receiving bequests by $\mu_{c,t}^{r,s}$. This

[26] De Nardi (2004), De Nardi and Yang (2016), Fuster et al. (2007), Fuster et al. (2008), among others, explicitly model the inter-generational links.

is given by

$$\mu_{c,t}^{r,s} = \sum_{n,m} \mu_t^{n,m} \pi(z_r^c, v_s^c \mid z_n^p, v_m^p). \tag{27}$$

By construction, the measure of total households leaving bequests and the measure of those receiving bequests have to be equal.

We are now ready to show how $\Gamma_{j,t}^{r,s}$, the probability of receiving bequests at age j, conditional on being type of (z_r, v_s), is determined in equilibrium. Denote the age distribution of bequest recipients among type (z_r^c, v_s^c) by $P_j^{r,s}$. Then, it follows that

$$\Gamma_{j,t}^{r,s} = \frac{P_j^{r,s} \mu_{c,t}^{r,s} \chi_t}{1+n}. \tag{28}$$

Note that χ_t is the proportion of households leaving bequests in period t within the population in period $t-1$. However, if there is population growth, the proportion of households receiving bequests in period t (among the population in period t) is given by $\chi_t/(1+n)$. $P_j^{r,s}$ comes directly from the data.

A.3 Definition of Equilibrium

Given the initial capital stock K_0, an initial measure of households $\{F_{0,j}\}_{j=1}^J$, initial regular wealth $A_{r,0}$, initial pension wealth $A_{p,0}$, constant debt and government spending $\{D_t, G_t\}_{t=0}^\infty$, with $D_t = \bar{D}$ and $G_t = \bar{G}$, and interest rate r, a competitive equilibrium is a sequence of value and policy functions, $\{V_t, V_t^R, V_t^W, c_t, a'_{r,t}, a'_{p,t}, l_t, \kappa_t, \mathcal{R}_t\}_{t=0}^\infty$, production plans for firms $\{K_{t+1}, N_t, N_{z,t}, Y_t\}_{t=0}^\infty$, wages $\{w_{z,t}\}_{t=0}^\infty$, Social Security taxes $\{\tau_{SS,t}\}_{t=0}^\infty$, income tax variables $\{\bar{\lambda}_{I,t}, \mathcal{I}_t\}_{t=0}^\infty$, population measures $\{F_{t,j}\}_{t=1}^\infty$, aggregate consumption, aggregate accumulation of regular, housing and pension wealth, as well as aggregate accumulation of home equity and mortgages, $\{C_t, A_{r,t+1}, A_{h,t+1}, A_{p,t+1}, A_{e,t+1}, A_{m,t+1}\}_{t=0}^\infty$, such that the following statements hold for all $t \geq 0$:

1. The value functions $\{V_t, V_t^W, V_t^R\}$ solve the agent's optimization problem and the associated policy functions are $\{c_t, a'_{r,t}, a'_{p,t}, l_t, \kappa_t, \mathcal{R}_t\}$.

2. The aggregate effective labor supply $\{N_t\}$ is determined by (17) and aggregate output is determined by (18).

3. Given r the capital to labor ratio is determined by equation (19).

4. Wages $\{w_{z,t}\}$ are determined competitively from (20).

5. The average taxable income $\{\mathcal{I}_t\}$, total accumulated regular wealth $\{A_{r,t+1}\}$, total accumulated private pension wealth $\{A_{p,t+1}\}$, total accumulated housing stock $\{A_{h,t+1}\}$, home equity $\{A_{e,t+1}\}$ and mortgages $\{A_{m,t+1}\}$, and total consumption $\{C_t\}$ follow from the following conditions

$$\mathcal{I}_t \equiv \sum_j \int \iota_t(\boldsymbol{x}) dF_{t,j}, \tag{29}$$

$$A_{r,t+1} \equiv \sum_j \int a'_{r,t}(\boldsymbol{x}) dF_{t,j}, \tag{30}$$

$$A_{p,t+1} \equiv \sum_j \int a'_{p,t}(\boldsymbol{x}) dF_{t,j}, \tag{31}$$

$$A_{h,t+1} \equiv \sum_j \int a_h(a'_{r,t}(\boldsymbol{x})) dF_{t,j}, \tag{32}$$

$$A_{e,t+1} \equiv \sum_j \int a_e(a'_{r,t}(\boldsymbol{x})) dF_{t,j}, \tag{33}$$

$$A_{m,t+1} \equiv \sum_j \int a_m(a'_{r,t}(\boldsymbol{x})) dF_{t,j}, \tag{34}$$

$$C_t \equiv \sum_j \int c_t(\boldsymbol{x}) dF_{t,j}. \tag{35}$$

6. The Social Security tax $\{\tau_{SS,t}\}$ balances the Social Security budget:

$$\tau_{SS,t} \sum_j \int_{\mathcal{R}_t(\boldsymbol{x})=0} \min(cap, e) dF_{t,j} = \sum_j \int_{\mathcal{R}_t(\boldsymbol{x})=1} p_g(\bar{p}_g(z,v), j^R) dF_{t,j}. \tag{36}$$

7. The income tax level $\{\bar{\lambda}_{I,t}\}$ balances the consolidated government budget:

$$\begin{aligned} G_t + (1+r)D_t &= \sum_j \int \Psi_t(\iota; \boldsymbol{\lambda}_{I,t}, j^R) dF_{t,j} + \tau_c C_t + (1+n)D_{t+1} \\ &+ \sum_j \int (1-\psi_j^{z,v})(1+r)\max\{0, \Psi_t(a'_{p,t-1}(\boldsymbol{x}); \boldsymbol{\lambda}_{I,t}, j^R)\} \frac{dF_{t-1,j}}{1+n}. \end{aligned} \tag{37}$$

8. The distribution of positive bequests is determined by (24) and (25) and the probability of receiving bequests is determined by equations (26)-(28).

9. Given the agent's policy functions, the next period's distribution of agents is given by $F_{t+1,j+1} = \mathcal{F}_{t,j}(F_{t,j})$, where $\mathcal{F}_{t,j}$ is the law of motion induced by the Markov pro-

cess for labor productivity, the law of motion for skill acquisition, the law of motion for the average lifetime earnings, the endogenous accumulation of regular assets and private pensions, early retirement decisions, the bequest distribution rule across generations and population growth.

10. Labor markets clear for both types of labor:

$$N_{u,t} = \sum_j \int_{\boldsymbol{x}:\{j^R=0 \text{ and } z=u\}} yvhl_t(\boldsymbol{x})dF_{t,j} \text{ for } u \in \{H, L\}. \tag{38}$$

B Calibration

B.1 Type-specific survival probability rates

The conditional mortality rates in the model, $1-\psi_j^{z,v}$, depend on the agent's age j, education level $z \in \{z_L, z_H\}$ and productivity fixed effect $v \in \{v_L, v_H\}$. Following Ábrahám et al. (2025), we assume that they follow a Gompertz force of mortality (i.e., mortality hazard) function and take the estimated parameters from that paper. Figure 19 (last panel) shows the fit of mortality rates by income quintiles at age 70, which were targeted during the estimation. The remaining panels show how the model fits the mortality rates by income at other ages. These data moments were not targeted.

B.2 Minimum required distributions

This appendix explains how we set the age-profile of minimum required withdrawals from the private retirement account, S_j. We assume that the agent must withdraw at least the annual proportion of the current balance in the retirement account $(1+r)a_p$ such that the account is exhausted by the time of expected death. Note that, for an agent of age j, the probability of surviving up to age $k > j$, given that the agent is alive at age j, is given by $\Pi_{l=j}^{k-1}\bar{\psi}_l$, where $\bar{\psi}_l$ is the conditional probability (averaged across types) of an agent of age l. Moreover, the probability of death at age $k > j$, given that the agent is alive at age j, is given by $(\Pi_{l=j}^{k-1}\bar{\psi}_l) \cdot (1-\bar{\psi}_k)$. Hence, the probability that an agent of age j lives exactly $0 < k-j \leq J-j$ more years is given by $(\Pi_{l=j}^{k-1}\bar{\psi}_l) \cdot (1-\bar{\psi}_k) \cdot (k-j)$ and the expected life-span of an agent at $j < J$ is:

$$s_j = \sum_{k=j+1}^{J} (\Pi_{l=j}^{k-1}\bar{\psi}_l) \cdot (1-\bar{\psi}_k) \cdot (k-j).$$

Figure 19: Conditional mortality rates by age in the model and data.

Notes: The empirical rates (dashed line) were constructed based on the data by Chetty et al. (2016) for male individuals. The profile at age 70 was targeted during the calibration. In the model, income is given by the sum of capital income and earnings, $r * (a_r - a_e(a_r)) + e$, for workers and the sum of capital income, withdrawal from a private pension plan, and public pension benefit, $r * (a_r - a_e(a_r)) + \omega + p_g$, for retirees.

Of course, $s_J = 0$ as agents die at age J with certainty. Note that the household needs to consume the current period and for s_j subsequent periods. Hence, the minimum withdrawal at age $j \leq J$ can be defined as:

$$S_j = \frac{1}{1 + s_j}.$$

The values for the minimum withdrawal shares S_j are plotted in Figure 20.

B.3 Earnings and income inequality

This section examines how the benchmark model performs by analyzing various moments that were not targeted during calibration.

Figure 21 shows that the model accurately fits the inequality in pre-government earnings and incomes as measured by the Lorenz curves. The empirical curves were constructed using the SCF sample. The model counterparts are constructed using the model-generated cross-sectional distributions of earnings and income in the initial steady state.

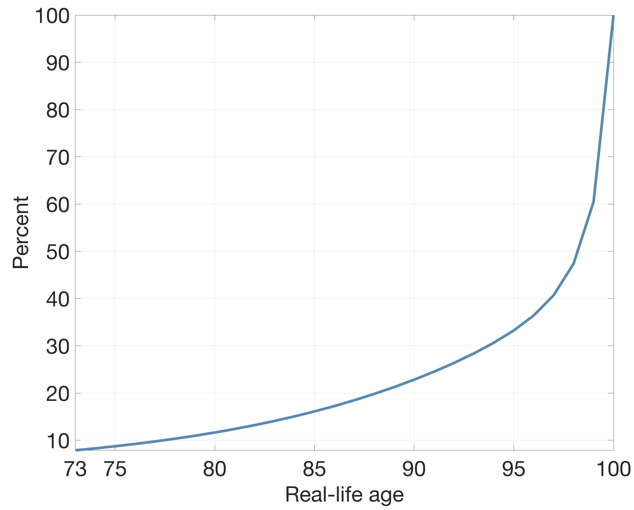

Figure 20: Minimum withdrawal share S_j by age.

Notes: We set S_j as the model-implied minimum withdrawal share at age j, based on expected remaining lifetime conditional on survival to j. Expected longevity is computed from age-specific survival probabilities $\{\psi_j^{z,v}\}$, averaged over types (z, v) at each age. We impose $S_j = 0$ for real-life ages below 73.

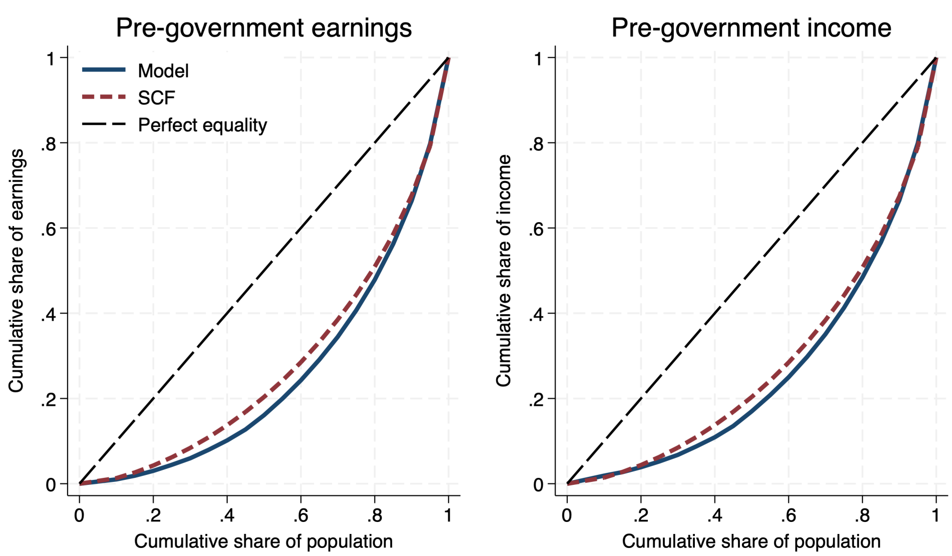

Figure 21: Earnings and income inequality in the model and data.

Notes: The figure shows how the model fits the Lorenz curves for earnings (left panel) and income (right panel). In the model, the Lorenz curves are constructed using the cross-sectional distribution of earnings and incomes in the initial steady state. In the model, earnings are given by e; income is given by the sum of capital income and earnings, $r*(a_r - a_e(a_r)) + e$, for workers and the sum of capital income, withdrawal from a private pension plan, and public pension benefit, $r*(a_r - a_e(a_r)) + \omega + p_g$, for retirees. The empirical curves are computed using the SCF sample; see Section 4 for sample selection criteria. Earnings are measured before taxes. Income is defined as the sum of pre-tax earnings, capital interest income, and income from public and private pension plans.