# Increased Inequality in Financial Wealth for Retirees*

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**Abstract**

Inequality in financial wealth for retirees increased in the U.S. between 1989 and 2019. This paper analyzes how three channels contribute to the increase in inequality: First, defined contribution plans and individual retirement accounts were introduced into the economy. Second, inequality in wages increased. Third, life expectancy increased and heterogeneity in life expectancy increased. I calibrate a life cycle model with heterogeneous agents to match the U.S. economy. The retirement plans have different features and tax benefits and a worker's ability to take advantage of these features depend on their type of retirement plan. The distribution of retirement plans, the wage inequality, and the life expectancy changes exogenously over time in the baseline economy. To measure each channel's contribution to the increase in inequality, the channel is allowed to change over time or fixed at a constant level such that the model can measure the difference in inequality in financial wealth for retirees.

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# 1 Introduction

Inequality in financial wealth for retirees increased in the U.S. between 1989 and 2019. Financial wealth is measured as the sum of taxable assets, defined contribution and individual retirement account assets, and present value of expected Social Security and defined benefit payments before subtracting debt. The $P95/P5$ ratio, the 95th percentile divided by the 5th percentile, increased from xx to xx over the time period. This yields an increase of xx percentage points.

I use a life cycle model with heterogeneous agents in the analysis. In addition to age, individuals are heterogeneous in six states: education, idiosyncratic labor productivity, average life cycle earnings, type of retirement plan, retirement assets, and standard assets. *Ex ante*, individuals have either college or non-college education. An individual's survival probability depends on age, education and time. A worker's labor productivity depends on an idiosyncratic labor productivity shock in addition to his age and level of education. Social Security benefits depend on the individual's average life cycle earnings. An individual is either a defined benefit (DB), defined contribution (DC), or an individual retirement account (IRA) individual. An individual's possibility to take advantage of tax benefits when saving towards retirement depends on his type of retirement plan. All workers can save in a standard-non-contingent taxable asset. Defined contribution and IRA workers can save a limited amount in a retirement asset that provides tax benefits compared to the standard asset.

The workers' options to save towards retirement depend on their retirement plan. Defined benefit workers are subject to a mandatory retirement plan: A specified percent of their earnings are subtracted every period. In retirement they receive a predetermined benefit from the retirement plan every period they are alive. They cannot choose the amount saved in the retirement plan and they cannot save in the retirement asset. The defined contribution workers can save a limited amount in the retirement asset. The firm will match their saving proportionally. In retirement they choose how much to dissave from the retirement asset every period. An IRA worker is similar to a defined contribution worker. However, the firm does not match the retirement saving. There are tax benefits to all the retirement plans.

I calibrate the model to the U.S. economy and use it to study the increase in inequality over the time period. The change in inequality is incorporated by exogenously changing over time the parameters governing each channel: change in retirement plans, increased inequality in earnings, and increased life expectancy and increased heterogeneity in life expectancy. In particular, the change in retirement plans is accounted for by changing the share of workers with different types of retirement plans. Increase in inequality in earnings is modeled by increasing the share of workers with college education and increasing the variance of the idiosyncratic labor productivity shock. Increase in life expectancy and increase in heterogeneity in life expectancy is accounted for by changing the survival probability for college and non-college individuals. I measure the effect of each channel by measuring the change in inequality in financial wealth when either allowing the channel to vary over the time period as observed in the data or by keeping it at a constant level.

This paper yields three main findings. First, the increase in the share of defined contribution workers in the economy increases inequality in financial wealth for retirees by xx percent. The inequality increases because the optimal amount to save for retirement depends on the type of assets available to the worker. The discounted value of the expected utility of savings in the retirement asset is higher than the same amount saved in the standard asset because of the different tax treatments and because the matching contribution offered to the defined contribution worker. Due to this effect, workers with high income will save more if they can save in the retirement asset. A defined benefit worker cannot save in the retirement asset, while a defined contribution worker can save in this asset. Hence, the inequality in financial wealth is higher for the group of defined contribution workers than for the group of defined benefit workers. The overall inequality in financial wealth for retirees in the economy therefore increases when the share of defined contribution workers increases.

Second, increased inequality in earnings explains xx percent of the increase in financial wealth for retirees. Changes in earnings is incorporated into the model by increasing the share of college educated workers and increasing the variance of the idiosyncratic labor productivity shock. Inequality in financial wealth for retirees increases because inequality in defined benefit payments increases, inequality in total assets saved for retirement increases, and because inequality in Social Security benefits increases. Defined benefit payments depend on earnings at the end of the working life. When inequality in earnings increases the inequality in defined benefit payments also increases. All workers can save in at least one asset. Workers with high income save more than workers with low income. Hence, inequality in total assets saved for retirement increases when the inequality in earnings increases. Social Security benefits depend on average earnings over the life cycle. When inequality in earnings increases, inequality in Social Security benefit increases.

Third, the increase in life expectancy and the increase in heterogeneity in life expectancy explains xx percent of the increase in inequality in financial wealth for retirees. Both channels increase the inequality in financial wealth because of change in the optimal choice of saving for retirement and the discounting of defined benefit and Social Security payments. Individuals who expect to be retired for a long time will choose to save more for retirement than other individuals. Discounted values of payments from defined benefit retirement plans and Social Security will increase for individuals who expect to live many time periods. Due to these channels, increased life expectancy increases inequality in financial wealth across age groups. On the other hand, increased heterogeneity in life expectancy increases inequality in financial wealth within the same age group.

The paper is related to three strands of literatures. First, wealth in Social Security and defined benefit plans are measured following Mitchell, Olson, and Steinmeier (1996), Gustman, Mitchell, Samwick, and Steinmeier (1997), and Devlin-Foltz, Henriques, and Sabelhaus (2016). I focus on men who already have retired and I document that inequality in financial wealth in the U.S. increased from 1989 to 2016 for this group.

Second, the paper is related to the literature on saving for retirement: Scholz, Seshadri, and Khitatrakun (2006), Engen et al. (1999), Engen, Gale, and Uccello (2005), De Nardi and Yang (2014), and O'Dea (2018).

Third, I build on previous studies modeling tax free saving accounts: İmrohoroğlu, İmrohoroğlu, and Joines (1998), Kitao (2010), Ho (2017), Love (2007), and Nishiyama (2011). The literature review is incomplete.

The rest of the paper is organized as follows. Section 2 documents the evidence of increased inequality in financial assets for retirees. Section 3 presents the benchmark model used for the analysis. The calibration is described in section 4. Section 5 presents the results and section 6 concludes.

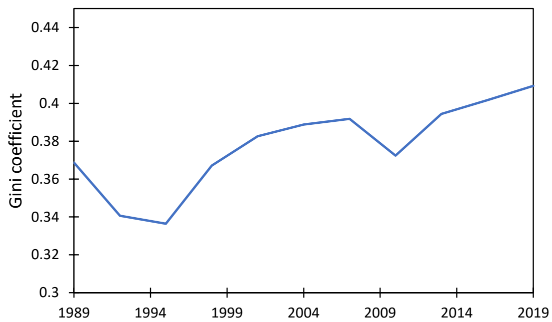
## 2 Data

I document the increase in financial wealth for retirees by analyzing data from the Survey of Consumer Finances over the time period 1989-2019. The sample used in the analysis is men, at least 66 years old, who are fully retired.

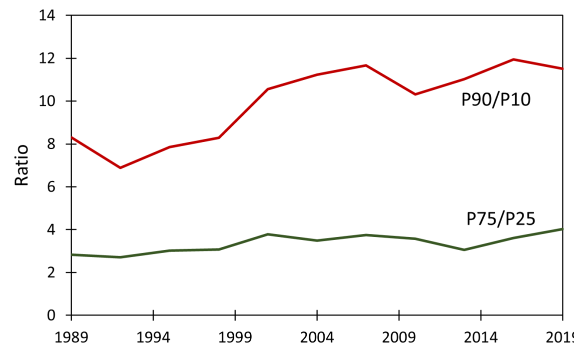
Financial wealth is measured as financial assets subtracting debt. Financial assets include taxable financial assets and retirement assets. Taxable assets include bank accounts, bonds, stock, mutual funds, etc. Retirement assets include assets in defined contribution plans and IRAs in addition to present value of expected Social Security and defined benefit payments. The measure of debt includes lines of credit, credit cards, installment loans etc. Debt include all measures of debt except debt related to real estate.

Figure 1 displays multiple measures of inequality. All measures indicate that inequality in financial wealth for retirees increases from 1989 to 2019. First, the Gini coefficient is shown in figure 1a. An advantage of the Gini coefficient is that the full sample is used in the measure. The coefficient increases over the time period which indicates an increase in inequality. Second, the $P95/5P$, $P90/P10$, and the $P75/P25$ ratios are shown in figure 1b. The $P95/P5$ ratio is calculated by dividing the $95th$ percentile of the distribution by the $5th$ percentile of the distribution. The $P90/P10$ and the $P75/P25$ ratios are constructed by the corresponding calculations. All the ratios increase over the time period which also indicates an increase in inequality.

Further, I decompose financial wealth into four parts: present value of expected Social Security benefit, present value of expected defined benefit payments, defined contribution and IRA assets, and taxable assets. Any debt is subtracted from the taxable assets in this calculation. The decomposition of the average financial wealth is displayed in figure 2a. The total value of average retirement wealth has increased over the time period. The graph shows that Social Security, defined benefit and taxable assets are important components of financial wealth throughout the whole time period. However, defined contribution and IRA assets were not an important component of financial wealth in 1989, but the value of these




(a) Gini coefficient




(b) Ratios of 95/5 and 90/10 percentiles.

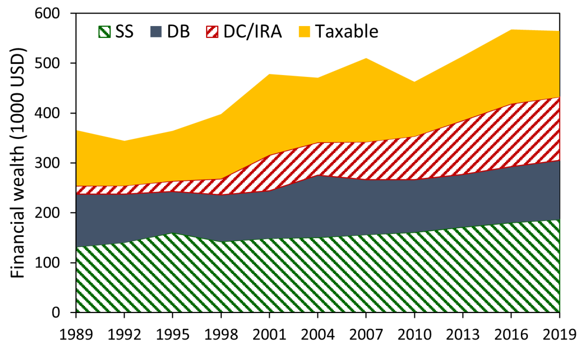
Figure 1: Measures of inequality of financial wealth for retirees over the time period 1989-2019. Wealth is measured in 2019 dollars.

assets increased substantially over the time period.

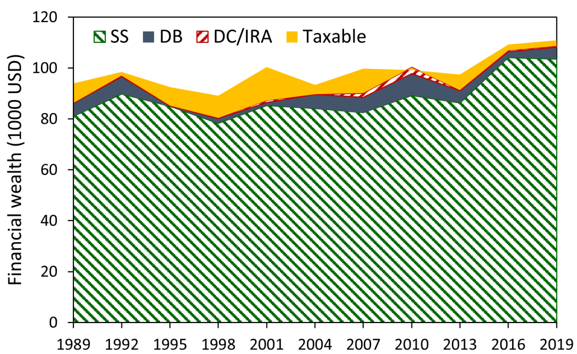
The decomposition of financial wealth is also computed for the top and bottom 10 percent of the distribution. The decomposition of the top 10 percent is displayed in figure 2b. Financial wealth increases for this sub-sample. The sources of wealth is more disperse for the top 10 percent of the distribution than for the bottom 10 percent of the distribution. Social Security assets increase slightly and are a small small share of financial wealth. The value of defined benefit assets are roughly constant over the time period while taxable assets have increased slightly over the time period. Defined contribution and IRA assets have increased substantially over the time period. The decomposition of the bottom 10 percent is displayed in figure 2c. Financial wealth increases slightly in the time period for this sub-sample. Almost all financial wealth comes from Social Security benefits.

This paper focuses on three factors that contribute to the increase in in equality in financial wealth for retirees: type of retirement plans, wage inequality, and survival probability. The rest of this section describes how these factors change over time.

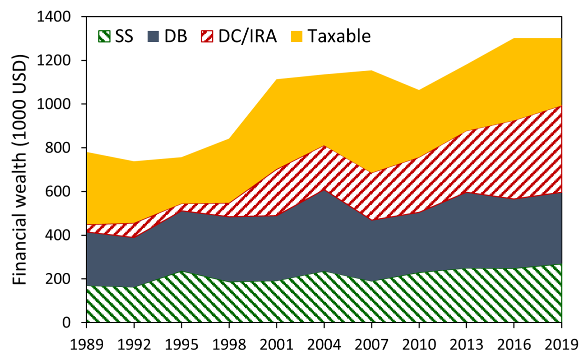
The type of retirement plans utilized in the economy changed over the time period 1983-2019, see figure 3. In 1983 defined benefit plans were the plan used by most workers in the economy while in 2019 this had changed to defined contribution plans. The data is from the Survey of Consumer Finances and the sample used is men aged 25-65 who are working.




(a) Average




(b) Percentile 5-15




(c) Percentile 85-95

Figure 2: Decomposition of financial wealth for retirees into Social Security (SS), defined benefit (DB), defined contribution and IRA (DC/IRA), and taxable (Taxable) assets. The graphs shows different parts of the wealth distribution. Wealth is measured in 2019 dollars.

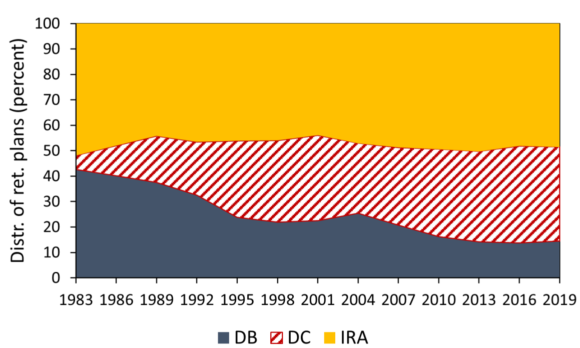



Figure 3: Type of retirement plans for workers.

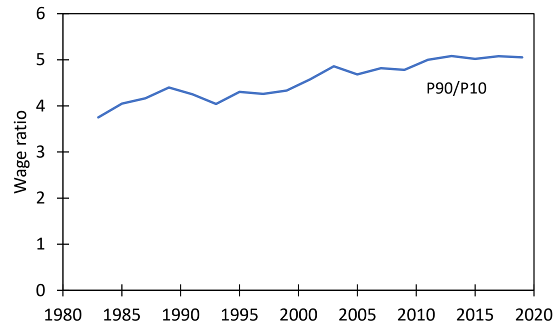



Figure 4: The $P90/P10$ wage ratio.

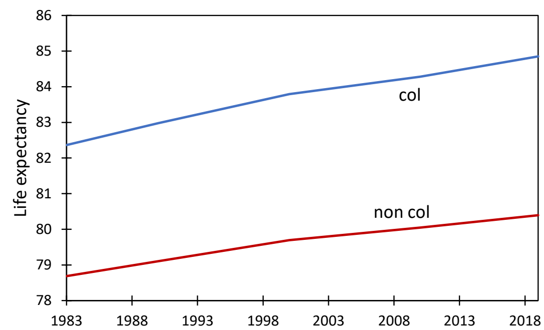



Figure 5: Life expectancy for college and non-college respondents at age 65.

The increase in wage inequality over the time period is documented in figure 4. The figure shows the $P90/P10$ for men who are working. The data is from the PSID and the sample is men age 25-65.

Life expectancy has increased for both college and non-college groups over the time period. The college population was expected to live longer than the non-college population at the beginning of the time period. Over the time period the college population increased the life expectancy more than the non-college population, e.g. the heterogeneity in life expectancy increased over the time period.

# 3 Model

The model used for the analysis is a discrete time, partial equilibrium, overlapping generations model with heterogeneous agents.

## 3.1 Preliminaries

The economy is populated by a continuum of individuals. Each time period $t$ a new cohort is born. The cohort size increases proportionally by $g^n$ each period.

Individuals are indexed by type $s = \{j, e, \eta_t, \zeta_t, \nu_t, a_t^\mu, a_t\}$, where $j$ is age, $e$ is education level, $\eta_t$ is the stochastic component of labor productivity, $\zeta_t$ is average annual earnings, $\nu_t$ is type of retirement plan, $a_t^\mu$ is retirement assets, and $a_t$ is standard assets. Individuals of age $j^R$ or higher are called retirees and individuals younger than $j^R$ are called workers. The maximum lifespan of an individual is $J$. The probability of survival until next period $\psi_{jet}$ depends on age, education, and the cohort the individual was born into. $\Phi_t(s)$ denotes the measure of individuals of type $s$ at time $t$.

The individuals' education level is either college or non-college. It is set exogenously and it is constant throughout their life. The share of college and non-college individuals born each period varies with time. There are three types of individuals in the economy: defined benefit (DB), defined contribution (DC), and individual retirement account (IRA) individuals. The share of each type of individual depends on age, education, and time.

The worker's labor earnings depend on the labor supply $l_t$, the stochastic labor productivity $\eta_t$, and the deterministic life cycle labor productivity $w_{je}$. The deterministic life cycle component depends on age and education. The stochastic component of labor productivity is given by an autoregressive shock

$$\eta_t = \rho\eta_{t-1} + \epsilon_t.$$

$\epsilon_t$ is drawn from a distribution with mean zero and variance $\sigma_{\epsilon t}^2$ which varies with time. Starting at age $j^R$ all individuals receive Social Security benefits $SS_\zeta$, which depend on average life cycle earnings. Depending on the type of individual, a retiree might also receive payments from the retirement plan.

Individuals are endowed with one unit of time in every period. Workers can allocate the time between work and leisure. Retirees cannot work and use all their time for leisure. The period-by-period utility from consumption and labor is given by

$$U(c_t, l_t) = \frac{1}{1-\sigma}(c_t^{\gamma}(1-l_t)^{1-\gamma})^{1-\sigma}.$$

Following De Nardi (2004), individuals derive utility from leaving bequests $(a^{\mu}_{t+1} + a_{t+1})$

$$\varphi(a^{\mu}_{t+1} + a_{t+1}) = \varphi_1 \left(1 + \frac{a^{\mu}_{t+1} + a_{t+1}}{\varphi_2}\right)^{1-\sigma}.$$

$\varphi_1$ governs the strength of the bequest motive and $\varphi_2$ governs the extent to which bequests are a luxury good.

## 3.2 Retirement plans

An individual is either a defined benefit, a defined contribution or an IRA individual. An individual's type is set exogenously. Defined benefit and IRA workers face a probability of becoming a defined contribution worker next period. There are tax benefits for saving in the retirement plans.[1] Contributions to the retirement plan is compulsory for defined benefit workers. Contributions to the retirement plan is equal to saving in the retirement asset and it is optional for defined contribution and IRA workers.

A defined contribution worker chooses how much to save in the retirement asset $x^{\mu}_t$, each time period. The amount he chooses to save in the retirement asset is matched proportionally by $\kappa^{DC}$ and added to the retirement asset. The defined contribution worker pays a lump sum fee $\xi_{st}$, every time period

$$\xi_{st} = \kappa^{DC} x^{\mu}_t \qquad \text{if } \nu = DC.$$

The fee is equal to the matching contribution such that the pre tax value of the retirement plan each time period is 0. However, allowing for a proportional matching contribution and lump sum fee changes the incentives for saving in the retirement asset compared to not

1. This IRS website is informing how taxes on retirement plans are modelled https://www.irs.gov/retirement-plans/retirement-plan-faqs-regarding-contributions-are-retirement-plan-contributions-subject-to-withholding-for-fica-medicare-or-federal-income-tax.

allowing for these features. A worker can save, but not dissave from the retirement asset. A retiree cannot save, but can dissave from the retirement asset. There are limits to how much the worker is allowed to save in the retirement asset. These limits are not equal to the corresponding limits for an IRA worker. The retirement assets accumulate tax free. The workers do not pay income tax, but they do pay FICA tax on the amount $x_t^\mu$, they save in the retirement asset. The workers pay neither income tax nor FICA tax on the matching contribution, which is equal to the fee $\xi_{st}$. Retirees pay income tax, but not FICA tax, when they dissave in retirement. A defined contribution individual will remain a defined contribution individual for the rest of their life.

IRA workers choose how much to save in the retirement asset $x_t^\mu$, each time period. They do not receive a matching contribution on their investment and they do not pay any fees

$$\xi_{st} = 0 \qquad \text{if } \nu = IRA.$$

An IRA worker can save, but not dissave from the retirement asset. A retiree cannot save, but can dissave from the retirement asset. There are limits to how much the worker is allowed to save in the retirement asset. These limits are quantitatively not equal to the corresponding limits for a defined contribution worker. The incentives to save in the retirement asset compared to the standard asset are due to different tax treatment only. The retirement assets accumulate tax free. The IRA workers do not pay income tax, but they do pay FICA tax on the amount $x_t^\mu$, they save in the retirement asset. Retirees pay income tax, but not FICA tax, when they dissave in retirement.

An IRA worker faces a probability $\pi_{jet}^{IRA}$, of becoming a defined contribution worker next period. The probability depends on age, education, and time. If the worker transitions to a defined contribution worker, the value of his retirement asset $a_t^\mu$, does not change. The individual will remain a defined contribution individual for the rest of his life.

A defined benefit retiree receives a constant payment $DB_{e\eta}$, every time period. The payment depends on earnings in the last period of work assuming the individual worked 0.33 time units in that time period, e.g. the payment depends on education and the labor productivity shock in the last period of work. While working, a fee is subtracted as a lump sum from the worker's earnings every period. The fee $\xi_{st}$, is a constant share of earnings

$$\xi_{st} = \kappa^{DB}_{jet} \eta w_{je} l_t \qquad \text{if } \nu = DB.$$

The retirement plan is actuarially fair for each education and cohort group. This determines the share of earnings $\kappa^{DB}_{jet}$ workers contribute to the retirement plan each period. For the cohort born at time $\underline{t}$, the share of earnings $\kappa^{DB}_{jet}$ is

$$\kappa^{DB}_{jet} = \frac{\sum_{\tilde{j}=j^R}^{J} \sum_{\eta} \frac{\prod_{\hat{j}=j^R-1}^{\tilde{j}} \psi_{\hat{j}e\hat{t}}}{(1+r)^{\tilde{j}-(j^R-1)}} DB_{e\eta}}{\sum_{\tilde{j}=1}^{j^R-1} \sum_{\eta} \frac{(1+r)^{(j^R-1)-\tilde{j}}}{\prod_{\hat{j}=\tilde{j}}^{j^R-2} \psi_{\hat{j}e\hat{t}}} \eta w_{\tilde{j}e} l_{\tilde{t}}}$$
$$\text{s.t.} \quad t = \underline{t} + j - 1, \quad \tilde{t} = \underline{t} + \tilde{j} - 1, \quad \hat{t} = \underline{t} + \hat{j} - 1.$$

The share of earnings $\kappa^{DB}_{jet}$ depends on education and cohort only and is therefore constant throughout the workers life. The fee ensures that the ex ante expected discounted value of the retirement plan pre tax is equal to 0. The assets in the retirement plan accumulate tax free. The defined benefit workers do not pay income tax or FICA tax on the fee used to fund the retirement plan. In retirement they pay income tax on the payment they receive from the retirement plan, but they do not pay FICA tax. A defined benefit worker cannot save in the retirement asset $a^{\mu}_t$.

A defined benefit worker faces a probability $\pi^{DB}_{jet}$ of becoming a defined contribution worker next period. The probability depends on age, education, and time. If the worker transitions to a defined contribution worker, the value of his retirement asset $a^{\mu}_t$, next period will be equal to the present value of expected benefits in retirement. He will be a defined contribution individual for the rest of his life and he will therefore not receive any defined benefit payments in retirement.

## 3.3 Worker and retiree's problems

Recall that individuals are indexed by type $s = \{j, e, \eta_t, \zeta_t, \nu_t, a^{\mu}_t, a_t\}$, where $j$ is age, $e$ is education level, $\eta_t$ is the stochastic component of labor productivity, $\zeta_t$ is average annual earnings, $\nu_t$ is type of retirement plan, $a^{\mu}_t$ is retirement assets, and $a_t$ is standard assets. A worker solves the following problem

$$
\begin{aligned}
V_t(j, e, \eta_t, \zeta_t, \nu_t, a^\mu_t, a_t) = & \max_{c_t, l_t, x^\mu_t, a_{t+1}} U(c_t, l_t) \\
& + \beta\psi_{jet} E_{\eta_{t+1}|\eta_t} E_{\nu_{t+1}|j\nu_t t} V_{t+1}(j+1, e, \eta_{t+1}, \zeta_{t+1}, \nu_{t+1}, a^\mu_{t+1}, a_{t+1}) \\
& + (1-\psi_{jet})\varphi(a^\mu_{t+1} + a_{t+1}) \\
\text{s.t.} \qquad c_t = & (1-\tau^W_0)\left(\eta_t w_{je} l_t - \xi_{st} - x^\mu_t + r a_t\right)^{1-\tau^W_1} \\
& - \tau^{FICA}(\eta_t w_{je} l_t - \xi_{st}) + a_t - a_{t+1} \\
a^\mu_{t+1} = & x^\mu_t (1 + \mathbb{1}_{\nu_t = DC}\kappa^{DC}) + (1+r)a^\mu_t \\
\zeta_{t+1} = & ((j-1)\zeta_t + \eta_t w_{je} l_t - \xi_{st})/j \\
x^\mu_t \in [0, \bar{x}^\mu_t], \quad \bar{x}^\mu_t = & \begin{cases} 0 & \text{for } \nu_t = DB \\ min\{\theta^{DC}\eta_t w_{je} l_t, \hat{x}^{\mu DC}\} & \text{for } \nu_t = DC \\ min\{\theta^{IRA}\eta_t w_{je} l_t, \hat{x}^{\mu IRA}\} & \text{for } \nu_t = IRA \end{cases} \\
a_{t+1} \geq 0, \quad & c_t \geq 0, \quad 0 \leq l_t \leq 1.
\end{aligned}
$$

Each period the worker chooses how much to consume $c_t$, work $l_t$, save in retirement assets $x^\mu_t$, and the level of standard assets next period $a_{t+1}$, such that the utility $V_t$, is maximized. Workers discount next period's utility by $\beta$. The probability of surviving until next period $\psi_{jet}$ depends on age, education, and time. If the worker dies, he receives utility from bequeathing his assets. Workers receive wage $\eta_t w_{je}$ for each time unit they work. Income tax is progressive and governed by the parameters $\tau^W_0$ and $\tau^W_1$. Federal Insurance Contribution Act (FICA) tax $\tau^{FICA}$, is flat and applies to earnings after the fee of the retirement plan is subtracted. The average annual earnings $\zeta_t$, is based on earnings after the fee of retirement plan is subtracted. Interest rate for both the retirement and standard assets is $r$. The indicator function $\mathbb{1}_{\nu=DC}$ equals one for defined contribution workers. $\kappa^{DC}$ is the matching contribution for the defined contribution worker. Workers cannot dissave from the retirement assets and there is a maximum limit on how much they can save. $\theta^{DC}$ and $\theta^{IRA}$ are the maximum shares of earnings workers are allowed to save in the retirement asset for defined contribution and IRA workers respectively. $\hat{x}^{\mu DC}$ and $\hat{x}^{\mu IRA}$ are the absolute maximum limits workers are allowed to save in the retirement asset for defined contribution and IRA workers respectively. Taking into account both limits, $\bar{x}^{\mu}_t$ is the maximum limit the worker is allowed to save in retirement assets. Defined benefit workers are not allowed to save in the retirement asset. Individuals cannot borrow in either the retirement or standard asset.

The fee of the retirement plan is deducted from the worker's income as a lump sum. Saving in retirement assets is deducted from income before tax while saving in standard assets is deducted after tax. When saving in the retirement asset, defined contribution workers receives a matching contribution on their savings. Retirement assets accumulate tax free. The worker pays tax on returns on standard assets each period.

A retiree solves the following problem

$$\begin{aligned}
V_t(j, e, \eta, \zeta, \nu, a^{\mu}_t, a_t) = & \max_{c_t, x^{\mu}_t, a_{t+1}} U(c_t, l_t) + \beta \psi_{jet} V_t(j+1, e, \eta, \zeta, \nu, a^{\mu}_{t+1}, a_{t+1}) \\
& + (1 - \psi_{jet}) \varphi(a^{\mu}_{t+1} + a_{t+1}) \\
\text{s.t.} \qquad c_t = & (1 - \tau^R_0) \left( SS_{\zeta} + \mathbb{1}_{\nu=DB} DB_{e\eta} - x^{\mu}_t + r a_t \right)^{1-\tau^R_1} + a_t - a_{t+1} \\
a^{\mu}_{t+1} = & x^{\mu}_t + (1+r) a^{\mu}_t \\
x^{\mu}_t \in & [-(1+r) a^{\mu}_t, 0], \quad a_{t+1} \geq 0, \quad c_t \geq 0.
\end{aligned}$$

Each time period the retiree chooses how much to consume $c_t$, dissave from the retirement assets $-x^{\mu}_t$, and the level of standard assets next period $a_{t+1}$ to maximize utility $V_t$. A retiree cannot work and therefore $l_t = 0$ for all time periods. Labor productivity $\eta$, average annual earnings $\zeta$, and type of retirement plan $\nu$ do not change after retirement. Their value equals the value in the last period of work. Retirees discount next period's utility by $\beta$. The probability of surviving until next period $\psi_{jet}$ depends on age, education, and time. If the retiree dies, he receives utility from bequeathing his assets. All retirees receive Social Security benefits $SS_{\zeta}$. The indicator function $\mathbb{1}_{\nu=DB}$ equals one for defined benefit retirees. These retirees receive payments $DB_{e\eta}$, which depend on education and labor productivity. Defined contribution and IRA retirees cannot save, but can dissave from the retirement asset. Individuals cannot borrow in either the retirement or standard asset. Retirees pay tax on Social Security benefits, defined benefits payments, dissaving of retirement assets, and return on standard assets. The tax is progressive and governed by $\tau^R_0$ and $\tau^R_1$. Interest rate for both the retirement and standard assets is $r$.

Social Security benefits depend on the average annual earnings

$$SS_\zeta = \frac{\zeta^{\omega_1}}{\omega_2}. \tag{1}$$

$\omega_1$ governs how the marginal rate of Social Security benefits depend on the average annual earnings and $\omega_2$ is a scaling parameter. The average lifetime earning does not change after retirement and the Social Security benefits remain constant across time.

# 4 Calibration

The model is matched to the data by determining some parameters outside the model equilibrium while others are calibrated to match moments in the U.S. economy. Estimates are based on men. The model period is 2 years. Parameters reported here are annualized, with a few clear exceptions. 1 unit in the model is 50 000 USD in 2019.

## 4.1 Parameters determined outside the model equilibrium

Table 1 reports parameters set outside the model equilibrium.

**Demography, preferences and interest rate**

Individuals enter the economy at age 25, retire at age 65 and can maximum live until age 100. Given a model period of 2 years, this implies the retirement age in the model $j^R$ to be 21 and maximum lifespan $J$ to be 38. The population growth $g^n$ is 1.5 percent annually. Interest rate $r$ is 4 percent annually. The coefficient of relative risk aversion is $\sigma$ is 2.

**Retirement plans**

The matching contribution from firms for defined contribution workers $\phi_{DC}$ is set to 0.76. Maximum allowed absolute saving in the retirement asset for a defined contribution worker $\hat{x}_{\mu DC}$ and an IRA worker $\hat{x}_{\mu IRA}$ is set to 0.343. and 0.091 respectively. Maximum saving in the retirement asset relative to earnings for a defined contribution worker $\theta_{DC}$ and an IRA worker $\theta_{IRA}$ is set to 0.06 and 1.0 respectively.

Table 1: Parameters determined outside the model equilibrium

| Parameter | Description | Value |
|---|---|---|
| $j^R$ | Retirement age (65 years) | 21 |
| $J$ | Maximum life span (100 years) | 38 |
| $g^n$ | Population growth rate | 0.015 |
| $r$ | Interest rate | 0.040 |
| $\sigma$ | Risk aversion parameter | 2.000 |
| $\kappa^{DC}$ | Matching rate from firms | 0.760 |
| $\hat{x}^{\mu DC}$ | Max absolute saving ret. asset DC | 0.343 |
| $\hat{x}^{\mu IRA}$ | Max absolute saving ret. asset IRA | 0.091 |
| $\theta^{DC}$ | Max relative saving ret. asset DC | 0.060 |
| $\theta^{IRA}$ | Max relative saving ret. asset IRA | 1.000 |
| $\omega_1$ | Curvature parameter SS benefits | 0.500 |
| $\omega_2$ | Scaling parameter SS benefits | 2.236 |
| $\rho$ | Autocorrelation coefficient | 0.969 |
| $\sigma_\eta^2$ | Variance of initial persistent shock | 0.151 |
| $\tau_0^W$ | Level tax parameter worker | 0.066 |
| $\tau_1^W$ | Progressive tax parameter worker | 0.106 |
| $\tau_0^R$ | Level tax parameter retiree | 0.058 |
| $\tau_1^R$ | Progressive tax parameter retiree | 0.073 |
| $\tau^{FICA}$ | FICA tax rate | 0.153 |

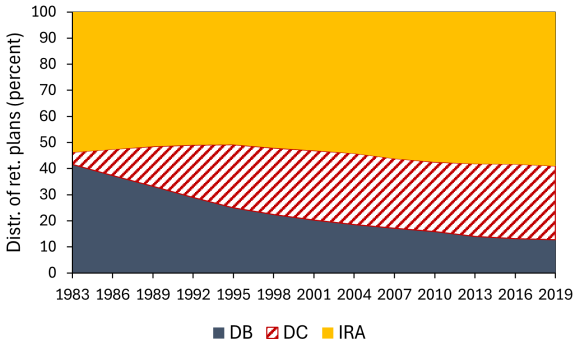
The payments received by defined benefit retirees are based on the defined benefit function in Scholz, Seshadri, and Khitatrakun (2006). Their regression depends on union status, years of service in the pension-covered job, and expectations about earnings in the last year of work.

SCF data for years 1983 and 1989-2019 determines the distribution of the different types of retirement plans. The distribution depends on education and changes over time, see Figure 6. A respondent in the survey is deemed a defined benefit worker if he has at least one defined benefit retirement plan. The distribution in year 1986 is assumed to be an average of years 1983 and 1989. A rolling average using three years is applied to smooth the data.

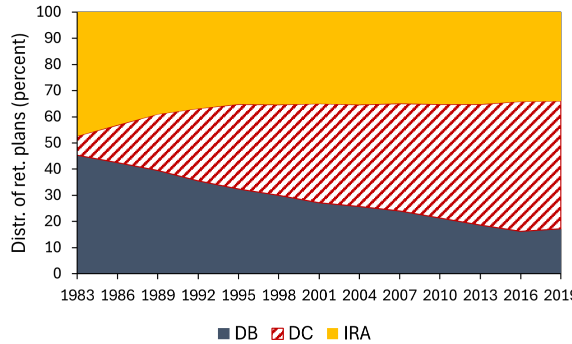
There was a policy change for retirement plans in 1982 when defined contribution retirement plans were introduced into the economy. I assume the distribution of retirement plans for all cohorts entering the model prior to the policy change are equal to one another. Similarly, I assume the distribution of retirement plans for all cohorts entering the model after the policy change are equal to one another. The earliest survey data containing information on the distribution of retirement plans is 1983. It seems likely that the distribution of retirement plans did not changed a lot from 1982 to 1983. Therefore, I assume the distribution of retirement plans for all cohorts entering the model in 1983 or earlier is equal to the distribution in 1983. By 2019 almost all cohorts entering the economy before the policy change has exited the labor market. I therefore assume the distribution observed in the data in 2019 is equal to the distribution of retirement plans for cohorts entering the economy after the policy change. The distribution for cohorts entering the model after 1983 is therefore assumed approximately equal to the distribution for year 2019. Table 2 reports the shares of each type of retirement plan when the cohorts enter the model.[2]

Cohorts entering the model in 1983 or earlier are subject to a retirement plan shock. Defined benefit and IRA workers in these cohorts face a probability of becoming a defined contribution worker next period. Only workers younger than 55 years face the shock. The probabilities depend on the type of retirement plan and the time period. The probability distribution of the shock is uniform. The size of the shock is determined such that the

2. Female labor supply changed a lot in the 20th century. Assuming the distribution of retirement plans for women who work all years prior to 1983 was equal to the distribution in 1983 does not seem realistic. This is an important reason for not including women in the analysis.




(a) Non-college workers




(b) College workers

Figure 6: Distribution of types of retirement plans for workers.

Table 2: Distribution of retirement plans when cohorts enter the model.

| | 1983 or earlier | | 1985 or later | |
|---|---|---|---|---|
| Retirement plan | College | Non-College | College | Non-College |
| Defined benefit | 45.3 | 41.5 | 16 | 13 |
| Defined contribution | 7.3 | 4.7 | 50 | 28 |
| IRA | 47.4 | 53.7 | 34 | 59 |

Table 3: Probability for defined benefit and IRA workers to become a defined contribution worker next period.

| | College | | Non-College | |
|---|---|---|---|---|
| | DB | IRA | DB | IRA |
| 1981 and earlier | 0.00 | 0.00 | 0.00 | 0.00 |
| 1983 | 0.02 | 0.07 | 0.05 | 0.00 |
| 1985 | 0.02 | 0.07 | 0.05 | 0.00 |
| 1987 | 0.03 | 0.07 | 0.05 | 0.00 |
| 1989 | 0.03 | 0.07 | 0.08 | 0.00 |
| 1991 | 0.03 | 0.00 | 0.08 | 0.00 |
| 1993 | 0.03 | 0.00 | 0.08 | 0.00 |
| 1995 | 0.03 | 0.00 | 0.08 | 0.00 |
| 1997 | 0.03 | 0.00 | 0.08 | 0.00 |
| 1999 | 0.00 | 0.00 | 0.08 | 0.00 |
| 2001 and later | 0.00 | 0.00 | 0.00 | 0.00 |

probability distributions of retirement plans matches the distribution shown in Figure 6. The probability of changing plans is 0 for 1981 or earlier and for 2001 or later. The shocks are presented in Table 3.

### Social Security benefits

The Social Security benefits $SS_\zeta$ are estimated by approximating the modelling in Huggett and Ventura (2000). Making their old-age component of Social Security benefits consistent with my model gives

$$\begin{aligned} SS_\zeta = {} & 0.9 \min(\zeta, 0.222) + 0.32 \max\left(0, \min(\zeta, 1.340) - 0.222\right) \\ & + 0.15 \max\left(0, \min(\zeta, 2.658) - 1.340\right). \end{aligned} \tag{2}$$

The benefit formula in equation (2) is approximated by the Social Security benefit formula in equation (1): $SS_\zeta = \frac{\zeta^{\omega_1}}{\omega_2}$. $\omega_1$ is set to 0.5 and $\omega_2$ is set to $\sqrt{5} = 2.236$. See Figure 7 for comparison between the accurate and approximate benefit formulae.

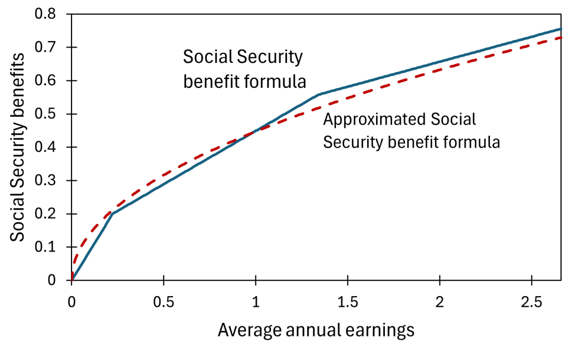



Figure 7: Accurate and approximated Social Security benefit formulae.

### Labor productivity

The deterministic life cycle component and the stochastic component of labor productivity is estimated following Heathcote, Storesletten, and Violante (2010) closely.

The deterministic life cycle component $w_{je}$ is based on the following ordinary least-square regression: The logarithm of hourly wage is regressed on a time dummy, a time dummy interacted with an education dummy, a cubic polynomial in age, and a cubic polynomial in age interacted with an education dummy

$$\ln v_{ijt} = \alpha_{0t} + \alpha_{1t}e_i + \alpha_2 j_{ijt} + \alpha_3 j_{ijt}^2 + \alpha_4 j_{ijt}^3 + \alpha_5 e_i j_{ijt} + \alpha_6 e_i j_{ijt}^2 + \alpha_7 e_i j_{ijt}^3 + u_{ijt}.$$

$v_{ijt}$ is the wage of individual $i$ of age $j$ at time $t$, $e_i$ is the education dummy, and $j_{ijt}$ is the age. $\alpha$ are the regression coefficients. The residuals $u_{ijt}$ are estimates of the stochastic labor productivity component. It is estimated as the sum of two orthogonal components: a persistent autoregressive shock $\eta_{ijt}$ and a transitory shock $\tilde{\varepsilon}_{ijt}$

$$u_{ijt} = \eta_{ijt} + \tilde{\varepsilon}_{ijt}$$

$$\eta_{ijt} = \rho\eta_{i(j-1)(t-1)} + \varepsilon_{ijt}.$$

$\rho$ is the autocorrelation coefficient. $\tilde{\varepsilon}_{ijt}$ and $\varepsilon_{ijt}$ are drawn from distributions with mean zero and variances $\sigma^2_{\tilde{\varepsilon}t}$ and $\sigma^2_{\varepsilon t}$ respectively. I assume $\eta_{ijt}$, $\tilde{\varepsilon}_{ijt}$, and $\varepsilon_{ijt}$ are orthogonal to each other and i.i.d. across individuals in the population. The initial value of the persistent shock is drawn from a time-invariant distribution with mean zero and variance $\sigma^2_{\eta}$.

The parameters are estimated by minimizing the distance between the empirical and theoretical covariance moments of the stochastic labor productivity component. Individuals

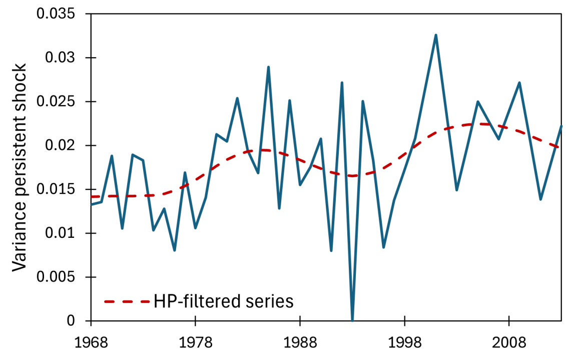



Figure 8: Estimates of the variance of the persistent labor productivity shock.

in the sample are grouped into 10 year adjacent age cells and the empirical moments are constructed using these cells. The identity matrix is used as the weighting matrix.

PSID data is used for the estimation. Data is available annually from 1967 to 1996 and biennially until 2018. For years prior to the first year the persistent shock is assumed to be equal to the value in the first year. For years with biennial missing data the persistent shock is assumed to be an average of the estimates in the year before and after. I estimate parameters up until 2012. Data for 2014, 2016, and 2018 are used to improve the estimates of parameters in earlier years only. For years with missing data, the autocorrelation coefficient and the variance of the initial persistent shock are assumed equal to their respective time-invariant values.

The autocorrelation coefficient is estimated to be 0.969. The variance of the initial persistent shock is estimated to be 0.151. Estimates of the persistent shock increases from a about 0.014 to 0.020 over the time period. A Hodrick-Prescott filter with smoothing parameter 100 is applied to the time series before the estimates are used in the model, see Figure 8. In the model, parameters in periods prior to the first and after the last period of estimates are assumed equal to the parameters in the first and last period respectively. The transitory shock is assumed to be fully insurable in the model.

**Taxes**

The main reference for the estimation of the tax functions is Heathcote, Storesletten, and Violante (2017). Let $T(y)$ be the tax at income level $y$. The tax function is given by

$$T(y) = y - (1 - \tau_0)y^{1-\tau_1}.$$

Let $\tilde{y}$ be the income after tax, e.g. $\tilde{y} = y - T(y)$. The relationship between income before and after tax is

$$\tilde{y} = (1 - \tau_0)y^{1-\tau_1}, \tag{3}$$

which is used to estimate the tax parameters. The tax functions for workers and retirees are estimated separately as there are differences in how these groups are taxed.[3] One important difference is Social Security benefits: While Social Security benefits are included in a retiree's income before tax $y$, the share of the payments that is taxable by law depends on the total income of the retiree.[4]

SCF data from 1988 to 2018 is used to estimate the tax functions. The survey includes financial information on the respondents' retirement plans. NBER's TAXSIM program is used to estimate the tax paid by each record in the dataset, see Feenberg and Coutts (1993). Moore's code is used to prepare the data for TAXSIM.[5]

Income before tax includes earnings, Social Security benefits, defined benefit payments, withdrawals from retirement accounts, business income, interest, dividend, capital gains, rent, royalties, child support and alimony, and other income. The taxable deductions mortgage interests and charitable contributions[6] are subtracted from the income measure. At last, employer's share of FICA tax is added to arrive at the final measure of income before tax.

3. For more information on taxation of seniors and retirees, see IRS website https://www.irs.gov/individuals/seniors-retirees.

4. See information on tax treatment of Social Security payments on Social Security Administration website https://www-origin.ssa.gov/benefits/retirement/planner/taxes.html.

5. I thank Kevin Moore for making available the SAS code on NBER website https://taxsim.nber.org/to-taxsim/scf27-32/. This section covers the main strategy on how the data is prepared for TAXSIM. Please see the code for more details.

6. The SCF only records charitable contributions of at least 500 USD.

Two remarks are in order to give further insight into how Moore prepares the data for TAXSIM. First, the tax rate of capital gains depends on how long an asset is held, but this information is not recorded in the SCF. Capital gains are therefore split into short-term and long-term portions. IRS Statistics of income Individual report (table 1.4) gives information on the share of capital gains that are short-term and long-term on the aggregate level. The shares are given for intervals of adjusted gross income (AGI): less than 50,000 USD, between 50,000 and 100,000 USD, and more than 100,000 USD. The amount of short-term and long-term capital gains for a record in the SCF survey is estimated based on the AGI for that record.

Second, some couples file taxes separately, and their income is split by the following strategy: earnings, Social Security benefits, defined benefit payments, withdrawal from retirement accounts, and business income is given at an individual level and split accordingly. Interest, dividend, capital gains, and other income is given at the household[7] level and is therefore split in two. Mop up variables of Social Security and pension income and business income is also given at the household level, but is split based on the shares of the corresponding individual income measures. Child support and alimony is split based on information regarding former marriages.

After tax income equals income before tax minus federal taxes as estimated by TAXSIM. Tax incentives for saving for retirement is a main consideration of this paper and transfers are therefore not included in the tax functions: In the model, workers who save a large share of their income in the retirement asset might have a small taxable income. Nevertheless, they should not receive transfers just because their taxable income is small.

Only men are included in the analysis in this paper and therefore some adjustments are necessary for taxpayers who file jointly with a partner. Let $y_{HH}$ and $T(y_{HH})$ be the household's income and taxes respectively. Similarly, let $y_M$ and $T(y_M)$ be the man's income and taxes. $T(y_M)$ is estimated such that the following ratios are equal

$$\frac{T(y_{HH})}{y_{HH}} = \frac{T(y_M)}{y_M}. \tag{4}$$

The households income is a record in the SCF dataset and the household's taxes are estimated

7. The term household in this paper refers to the term primary economic unit in the SCF.

by TAXSIM. The man's income is estimated from the SCF dataset similarly to how couples filing separately is estimated to split their income. Equation (4) then gives the man's taxes which is used in the estimation of the tax functions. The final dataset used to estimate the tax functions includes both men filing jointly and men filing separately or individually.

The tax parameters are estimated by ordinary least squares regressions using the logarithmic form of equation (3). The parameters for workers and retirees are estimated by separate regressions on groups of workers and retirees. Respondents at least 65 years old and receiving Social Security benefits are deemed retirees while other respondents are deemed workers. The tax parameters for workers $\tau_0^W$ and $\tau_1^W$ are estimated to be 0.066 and 0.106 respectively. Similarly, the tax parameters for retirees $\tau_0^R$ and $\tau_1^R$ are estimated to be 0.058 and 0.073. The FICA tax rate is set to 15.3 percent.

**Survival probability**

Survival probability in the model depends on age, education, and the date the individual is born. I follow Attanasio, Kitao, and Violante (2010) and Falcettoni and Nygaard (2023) and assume the college premium in survival probability $\Delta\Psi_j$ depends on age, but is constant across time. The college premium is the difference between survival probability for college and non-college individuals

$$\Delta\Psi_j = \mathbb{1}_{e=c}\psi_{jet} - \mathbb{1}_{e=nc}\psi_{jet} \qquad \forall t. \tag{5}$$

$\psi_{jet}$ is the survival probability at age $j$, education level $e$, and time $t$. The indicator functions $\mathbb{1}_{e=c}$ and $\mathbb{1}_{e=nc}$ equals one for college and non-college individuals respectively. The combined survival probability $\Psi_{jt}$ for a given age at a given time is the weighted average of the survival probability for a given age, education, and time group

$$\Psi_{jt} = (1 - \Lambda_{jt}^c)\mathbb{1}_{e=nc}\psi_{jet} + \Lambda_{jt}^c\mathbb{1}_{e=c}\psi_{jet}. \tag{6}$$

$\Lambda_{jt}^c$ is the share of college educated individuals of age $j$ at time $t$. Combining equation 5 and 6 gives survival probability $\psi_{jet}$ as an expression of the combined survival probability, education premium, and share of college educated individuals. The latter three can be obtained in the literature or estimated using data and then used to obtain an estimate of the survival probability depending on age, education, and time.

Bell and Miller (2005) publishes estimates of survival probability given age and cohort, e.g. the combined survival probability $\Psi_{jt}$. The estimates used in this analysis are the cohort life tables and the first cohort in the study is born in 1900. Survival probability for cohorts born prior to 1900 are assumed to be equal to the 1900 cohort.

The education premium in survival probability is estimated using data from the National Vital Statistics System (NVSS) and CPS. NVSS records all deaths in the U.S. and CPS gives an estimate of the number of individuals alive. The education premium is estimated by calculating the survival probability for college and non-college individuals for all ages before taking the difference between the two education groups. Assuming a log-linear relationship I run an ordinary least-squares regression of the education premium on age. The results yields an estimate of the education premium.

The share of college educated individuals is estimated using CPS data. The relationship between the share of college educated individuals and age is assumed to be linear. The ordinary least-square regression of the share of college educated individuals on age for each cohort gives the estimate. The share of college educated individuals increases from 4.1 percent for cohorts entering the model in 1925 or earlier to 22.6 percent for cohorts entering the model in 1989.

## 4.2 Parameters determined jointly in equilibrium

Table 4 reports the parameters determined jointly in equilibrium. The consumption share in the utility function $\gamma$ is calibrated to 0.355 such that average hours worked per employee is equal to full-time, 0.33. The bequest parameters $\varphi_1$ and $\varphi_2$ are set to $-0.300$ and 0.500 respectively.

The discount factor $\beta$ is calibrated to 0.955 such that the taxable wealth to taxable income ratio is 1.018. Taxable wealth and taxable income is estimated using data from the SCF for years 1988-2018. Taxable income includes earnings and return on taxable assets. Taxable assets are recoded for the household as a whole. Assuming the ratio is equal for men and women, both wealth and income measures are estimated for the household as a whole.

Table 4: Parameters determined jointly in equilibrium

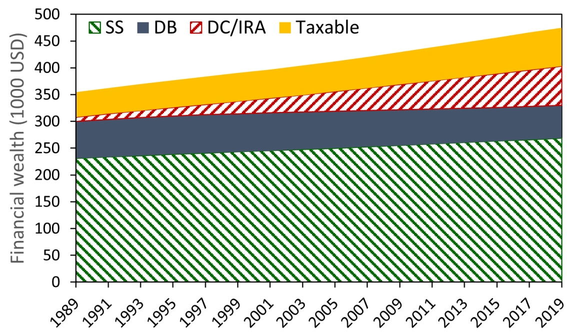
| Parameter | Description | Target | Value |
|---|---|---|---|
| $\beta$ | Discount factor | Taxable wealth to taxable income = 1.018 | 0.955 |
| $\gamma$ | Con share in utility | Avg. hours worked = 0.33 | 0.355 |
| $\varphi_1$ | Bequest parameter | - | -0.300 |
| $\varphi_2$ | Bequest parameter | - | 0.500 |

# 5 Results

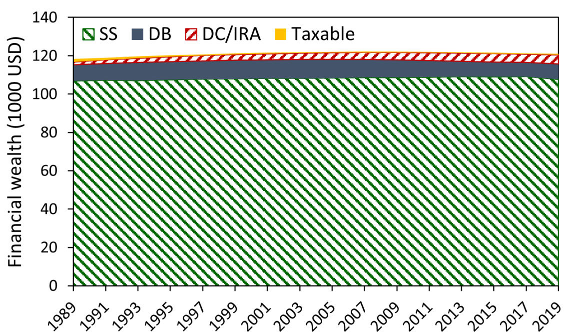
The results in this section are reported based on a preliminary calibration and will be updated. In particular, the bequest parameters will be calibrated and retirees will not be able to receive more than a maximum amount of Social Security benefits.

Figure 9 shows the results of the decomposition of financial wealth for retirees from 1989 to 2019. These results are the model version of the data shown in Figure 2. The average of the distribution shows that DC/IRA assets is the main reason of the increase in wealth over the time period. There is barely any increase in financial wealth for the 5-15 percentiles of the retirees. The financial wealth of the 85-95 percentiles has increased mainly because of DC/IRA assets and taxable assets.

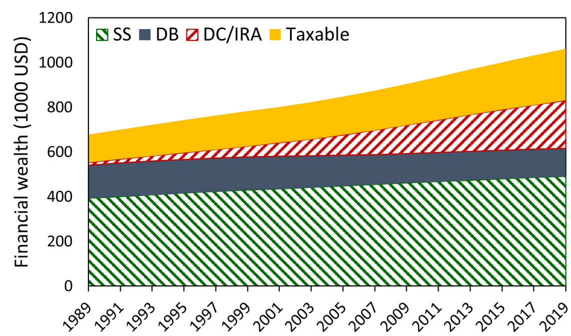
Over the time period 1989 - 2019 inequality in financial wealth increased in the data. Three channels contribute to the increase in inequality: change in retirement plans, increased inequality in earnings, and increased life expectancy and increased heterogeneity in life expectancy. The analysis will focus on how the three channels contribute to increase in inequality in financial wealth by allowing the channels to change with time as we see in the data or by fixing them at a constant level.




(a) Average




(b) 5-15 percentiles




(c) 85-95 percentiles

Figure 9: Decomposition of financial wealth into Social Security (SS), defined benefit (DB), defined contribution and IRA (DC/IRA), and taxable (Taxable) assets. The graphs shows different parts of the wealth distribution. Wealth is measured in 2019 dollars.

# 6 Conclusion

This paper documents the increase in inequality in financial wealth for retirees in the U.S. between 1989 and 2019. The paper builds an overlapping generations partial equilibrium model to analyze the change in inequality through three channels: First, a change in the type of retirement plans utilized in the economy from defined benefit to defined contribution plans explain xx percent of the increase in inequality. Second, increase in inequality in earnings explain xx percent of increase in inequality. Third, xx percent of the increase in inequality can be explained by increase in life expectancy and increase in heterogeneity in life expectancy.

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