Increased Inequality in Financial Wealth in Retirement*

Kaja Kierulf†

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Abstract

Inequality in financial wealth in retirement increased in the U.S. between 1989 and 2016. This paper analyzes three channels that contribute to the increase in inequality: First, the main type of retirement plans utilized in the economy has changed from defined benefit to defined contribution plans. Second, inequality in earnings has increased. Third, life expectancy has increased. A life cycle model with heterogeneous workers is calibrated to match the U.S. economy. Savings for retirement accumulate tax free. Depending on the type of retirement plan, some workers can choose how much to save for retirement while others cannot. The three channels are changed exogenously and the analysis focuses on the workers' optimal behavior given these changes. I find that the change in retirement plans explains 36 percent of the increased inequality. The increase in earnings inequality explains 5 percent and the increased life expectancy explains 19 percent of the increased inequality in financial wealth in retirement.

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†Department of Economics, University of Minnesota. E-mail: kieru001@umn.edu.

1 Introduction

Inequality in financial wealth in retirement increased in the U.S. between 1989 and 2016. In this paper financial wealth is measured as the sum of taxable assets, defined contribution and IRA assets, and present value of expected Social Security and defined benefit payments before subtracting debt. The 95/5 ratio, the 95th percentile divided by the 5th percentile, increased from 13.5 to 19.1 over the time period. This yields an increase of 41.5 percent.

Workers prepare for retirement by saving assets. This saving choice is studied in the literature on retirement saving. Scholz, Seshadri, and Khitatrakun (2006), for example, studies the adequacy of saving for retirement. To analyze inequality in financial wealth in retirement this paper extends Scholz, Seshadri, and Khitatrakun (2006) by introducing a retirement asset that accumulates tax free.

A life cycle model with heterogeneous workers is used for the analysis. In addition to age, workers are heterogeneous in five states: Workers are, *ex ante,* either college educated or non-college educated. A worker's labor productivity depends on his level of education and he faces an idiosyncratic labor productivity shock each period. *Ex ante*, a worker is either a defined benefit (DB), defined contribution (DC), or an individual retirement account (IRA) worker. 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 is similar to the standard asset, but accumulates tax free.

A worker's options to save for retirement depends on his retirement plan. A defined benefit worker cannot choose how much to save tax free for retirement himself: A certain percent of his earnings is saved every time period. In retirement he receives a predetermined income stream from the retirement plan. He cannot save in the retirement asset. A defined contribution worker can save a limited amount in the retirement asset. The firm will match his saving by a specified percentage. In retirement he chooses how much to withdraw 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 and his maximum allowed saving in the retirement asset is less.

Retirees receive Social Security benefits that are redistributive. The government finances its spending on consumption, interest payments on debt, and Social Security by levying consumption taxes, capital income taxes, and labor income taxes. The consumption and capital income tax rates are assumed to be fixed and the government balances its budget each period by adjusting the labor tax rate.

After calibrating the model to the U.S. economy it is used to study the increase in inequality between two balanced growth paths. The change in inequality is measured by exogenously changing the parameters governing each channel. In particular, the change in retirement plans is accounted for by changing the mass of workers with different types of retirement plans. Increase in inequality in earnings is modeled by increasing the mass of workers with college education, increasing the college premium, and increasing the variance of the idiosyncratic labor productivity shock. Increase in life expectancy is accounted for by increasing the survival probability.

This paper yields three main findings. First, the change in the type of retirement plans utilized in the economy increases the inequality in financial wealth in retirement by 36 percent. The inequality increases because the amount of assets a worker saves for retirement depends on his retirement plan. Social Security benefits are redistributive and a worker with low income will therefore not save a lot for retirement to obtain consumption smoothing. However, a worker with high income will save a substantial part of his earnings for retirement. 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. 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 defined contribution workers than for defined benefit workers. The overall inequality in financial wealth in retirement in the economy therefore increases when the share of defined contribution workers increases.

Second, increased inequality in earnings explains 5 percent of the increase in financial wealth in retirement. Changes in earnings is incorporated into the model by increasing the share of college educated workers, increasing the education premium and increasing the variance of the idiosyncratic labor productivity shock. Inequality in financial wealth in retirement increases because the inequality in defined benefit payments increases and because the inequality in assets saved for retirement increases. Defined benefit payments depend on earnings over 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.

Third, the increase in life expectancy explains 19 percent of the increase in inequality in financial wealth in retirement. This channel gives rise to increased inequality both within and between age cohorts. The inequality increases within an age cohort because workers save more for a prolonged retirement period. To be able to smooth consumption, workers with high income will increase their savings more than workers with low income. An increase in life expectancy therefore corresponds to an increase in inequality in financial wealth within each cohort. A worker's financial wealth at age 65, when he has just retired, is larger if his life expectancy increases. As the worker ages he will consume his wealth and when he is expected to live for only a few more time periods, he has consumed most of his wealth. Hence, the inequality in financial wealth fore retirees also increases between different age cohorts.

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 in retirement. 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.

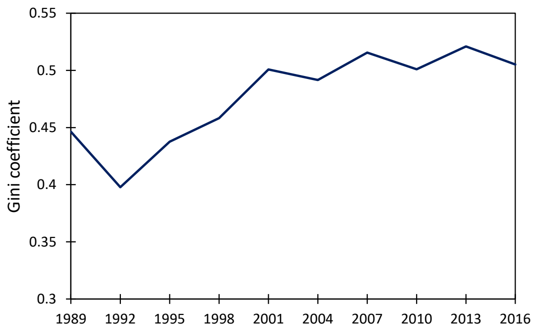
2 Data

I document the increase in financial wealth for retirees by analyzing data from the Survey of Consumer Finances over the time period 1989-2016. The sample used in the analysis is men, at least 66 years old, who are fully retired.

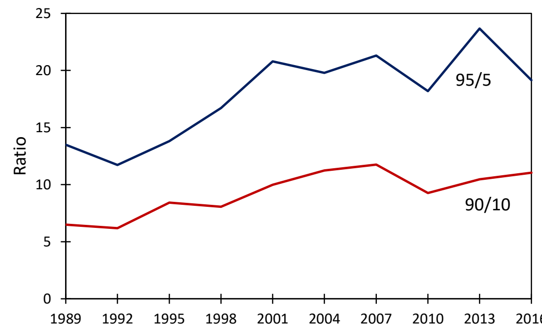
Financial wealth is measured as financial assets subtracting debt. Financial assets include taxable financial assets and retirement assets. Taxable assets include bank accounts, bonds, stock, mutual funds, etc. Retirement assets include present value of expected Social Security and defined benefit payments in addition to assets in defined contribution plans and IRAs. 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. Debt related to property is excluded because real estate is not included in the assets. See appendix A for details regarding the data analysis.

Figure 1 displays multiple measures of inequality. All measures indicate that inequality in financial wealth for retirees increases from 1989 to 2016. First, the Gini coefficient is shown in figure 1a. The whole population is included in the measure, which is an advantage of the Gini coefficient. The coefficient increases over the time period which indicates an increase in inequality. Second, the 95/5 and the 90/10 ratios are shown in figure 1b. The 95/5 ratio is calculated by dividing the $95th$ percentile of the distribution by the $5th$ percentile of the distribution. The 90/10 ratio is constructed by the corresponding calculations. Both the ratios increase over the time period which also indicates an increase in inequality.

Figure 2 shows the $90th$ percentile, median, and $10th$ percentile of the financial wealth distribution. The $90th$ percentile increases while the $10th$ percentile is constant throughout the time period. The increase in inequality over the time period is therefore due to the wealthiest part of the distribution becoming wealthier while the wealth of the poorest part of the distribution remains on a constant level.



(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 1989-2016. Wealth is measured in 2016 dollars.

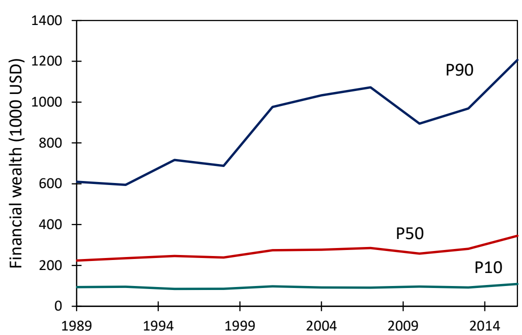


Figure 2: $90th$ percentile, median, and $10th$ percentile of the financial wealth distribution for retirees. Wealth is measured in 2016 dollars.

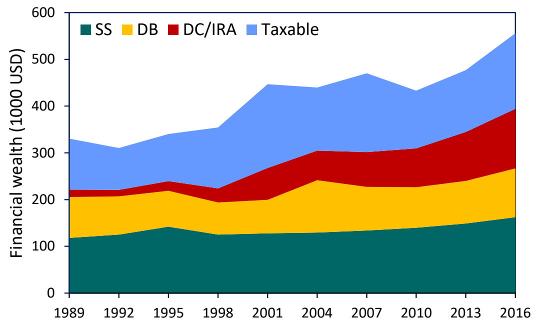
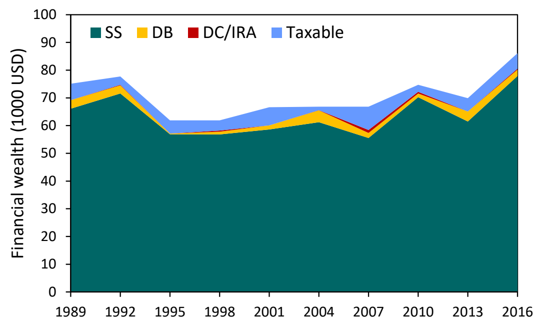


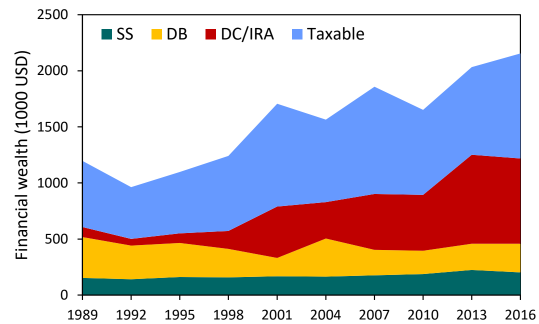
Figure 3: Decomposition of financial wealth for retirees into Social Security (SS), defined benefit (DB), defined contribution and IRA (DC/IRA), and taxable (Taxable) assets. The graphs shows the average of the decomposition. Wealth is measured in 2016 dollars.

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 average of the decomposition of the distribution is displayed in figure 3. 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. None the less, the value of these assets increased substantially over the time period. By 2016 defined contribution and IRA assets make up 30 percent of the average financial wealth for retirees.

The decomposition of financial wealth is also computed separately for the bottom and top 10 percent of the distribution. The decomposition of the bottom 10 percent is displayed in figure 4a. Financial wealth is constant throughout the time period for this subgroup of the population. Almost all financial wealth comes from Social Security benefits and it is constant throughout the time period. The decomposition of the top 10 percent is displayed in figure 4b. Financial wealth increases for this subgroup of the population. The sources of wealth is more disperse for the top 10 percent of the distribution. Social Security assets are a constant, but small share of financial wealth. The value of defined benefit assets have decreased slightly over the time period while taxable assets have increased slightly over the



(a) Bottom 10 percent of the distribution.



(b) Top 10 percent of the distribution.

Figure 4: 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. The magnitudes on the y-axis is different for the two graphs. Wealth is measured in 2016 dollars.

time period. However, defined contribution and IRA assets have increased substantially over the time period. By 2016 the value of this type of assets make up 35 percent of financial wealth for the top 10 percent wealthiest.

3 Model

The model is a discrete time, general equilibrium, overlapping generations model with heterogeneous workers.

3.1 Firms

Firms use a constant returns to scale Cobb-Douglas production function to produce goods

$$\hat{Y}_t = \theta \hat{K}_T^{\alpha}(Z_t \hat{N}_t)^{(1-\alpha)}.$$

$\hat{K}_t$ is the aggregate capital stock in the economy. $\hat{N}_t$ is the labor input measured in efficiency units. α is capital's share of income. θ is the total factor productivity. Z_t is the labor-augmenting technological progress given by $Z_t = (1+g_z)^t$. g_z is the growth rate of technology.

Workers enter the economy at age 25 and the growth rate of workers entering the model is g_n. Firms hire labor at wage w_t and rent capital at rate r_t.

Aggregate output is used for total private consumption, $\hat{C}_t$, government consumption, $\hat{G}_t$ and investment, $\hat{K}_{t+1} - (1-\delta)\hat{K}_t$. δ is the rate of capital depreciation. Let $v_t \equiv \frac{\hat{v}_t}{(1+g_z)^t(1+g_n)^t}$ denote detrended variables. However, labor units, $\hat{N}_t$, are detrended by growth in population only. The detrended resource constraint is

$$C_t + G_t + (1+g_z)(1+g_n)K_{t+1} = \theta K_t^{\alpha} N_t^{1-\alpha} + (1-\delta)K_t.$$

Time subscripts are dropped for the remainder of the paper and $'$ is used to denote next-period variables.

3.2 Workers

Workers are indexed by type $s = \{j, e, \eta, \nu, a_\mu, a\}$, where j is age, e is educational level, η is the stochastic component of labor productivity, ν is type of retirement plan, a_μ is retirement assets, and a is standard assets. Workers of age j_r or higher are retirees and workers younger than j_r are active workers. $\Phi(s)$ denotes the measure of workers of type s.

The worker's educational level is either college or non-college. It is set exogenous and is constant throughout his life. The stochastic component of labor productivity is given by a stationary finite-state Markov process:

$$Q(\eta, H) = Prob(\eta' \in H : \eta).$$

$Q(\eta, H)$ denotes the probability of next period's stochastic labor productivity conditional on current stochastic labor productivity. There are three types of workers in the economy: defined benefit (DB), defined contribution (DC), and individual retirement account (IRA) workers.

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

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

The active worker's labor earnings depend on the labor supply, l, stochastic labor productivity, η, and deterministic life cycle labor productivity ζ_{je}. The deterministic life cycle component depends on age and education. Starting at age j_r all workers receive Social Security benefits, SS_{je}, that depend on age and education. Depending on the type of worker, a retiree might also have income from his retirement plan. The probability of survival until next period, ψ_{je}, depends on age and education. The maximum lifespan of a worker is J. In the event of death, the worker's assets are uniformly distributed across the population by means of lump-sum transfers, B.

3.3 Retirement plans

A worker is either a defined benefit, a defined contribution or an IRA worker. A worker's type does not change throughout his life. The shares of the different types of workers is set exogeneously.

An active defined benefit worker pays a fixed share of his labor earnings as a cost for the retirement plan. In retirement he receives a predetermined payment from the plan every period. The worker cannot save in retirement assets. The retirement cost for an active defined contribution worker varies throughout the working life. The worker can save in retirement assets and the firm contributes to the savings. Capital accumulates tax free in the retirement asset. A retiree can withdraw savings from the retirement assets, but an active worker can not do so. In retirement he can withdraw savings from the retirement assets. An IRA worker has similar options to a defined contribution worker. However, he does not pay any costs for the retirement plan and the firm does not contribute to the retirement savings.

The cost of the retirement plan for an active workers is

$$\xi_s = \begin{cases} \varphi_{DB}\zeta_{je}\eta w l(s), & \text{if } \nu = DB \\ \varphi_{DC} x_\mu(s), & \text{if } \nu = DC \\ 0, & \text{if } \nu = IRA. \end{cases}$$

φ_{DB} is the share of the earnings a defined benefit worker pays in cost of the retirement plan. φ_{DC} is the matching contribution for an active defined contribution worker. Given the worker's savings in the retirement asset, x_μ, the firm contributes a share φ_{DC} of the workers retirement saving. A firm does not contribute to an IRA worker's retirement plan, hence there is no cost for the retirement plan.

A defined benefit worker receives a predetermined income stream in retirement. For simplicity, the benefit payments received depend on age and education only. The benefits are a share of the average earnings over the working life of defined benefit workers in the same age and education group. At age $j_r - 1$ the value of the benefit for a period is

$$DB_{(jr-1)e} = b_{DB,e} \sum_{j=1}^{jr-1} \frac{1}{(1+g_z)^{(jr-1)-j}} \frac{(1+g_n)^j \int \zeta_{j,e} \eta w l(s) \Phi_t(\{j\},\{e\},d\eta,\{DB\},da_\mu,da)}{\sum_{k=1}^{jr-1}(1+g_n)^k \int \Phi_t(\{k\},\{e\},d\eta,\{DB\},da_\mu,da)}.$$

$b_{DB,e}$ is the share of the average earnings the defined benefit workers receive in retirement. The share depends on education. Younger retirees receive more in benefits than older retirees because of technological progress. The relationship between the benefit for workers of different ages is

$$DB_{(j+i)e} = \frac{1}{(1+g_z)^i} DB_{je}.$$

At the end of the last period before retirement the present value of total fees paid by defined benefit workers in the same age and education group is equal to the present value of total expected benefit payments for the same group:

$$\begin{aligned}\sum_{j=1}^{jr-1} \left[\prod_{k=j}^{jr-2} \frac{1}{\psi_{ke}}\right] \left[\frac{1+r}{1+g_\theta}\right]^{(jr-1)-j} & \phi_{DB,e} \frac{\int \zeta_{je} \eta w l(s) \Phi_t(\{j\},\{e\},d\eta,\{DB\},da_\mu,da)}{\int \Phi_t(\{j\},\{e\},d\eta,\{DB\},da_\mu,da)} \\ &= \sum_{j=jr}^{jn-1} \left[\prod_{k=jr-1}^{j-1} \psi_{ke}\right] \frac{1}{(1+r)^{j-(jr-1)}} DB_{(jr-1)e}.\end{aligned}$$

Both active defined benefit workers and defined benefit retirees have claims to assets in the defined benefit plan. Summing up these claims give the total value of assets in the defined benefit plan:

$$\begin{aligned}A_{DB} = & \sum_{i=1}^{jr-1} \int \sum_{j=1}^{i} \left[\prod_{k=j}^{i-1} \frac{1}{\psi_{ke}}\right] \left[\frac{1+r}{1+g_\theta}\right]^{i-j} \\ & \times \phi_{DB,e} \frac{\int \zeta_{je} \eta w l(l) \Phi_t(\{j\},\{e\},d\eta,\{DB\},da_\mu,da)}{\int \Phi_t(\{j\},\{e\},d\eta,\{DB\},da_\mu,da)} \Phi_t(\{i\},de,d\eta,\{DB\},da_\mu,da) \\ & + \sum_{i=jr}^{jn-1} \int \sum_{j=i+1}^{jn} \left[\prod_{k=i}^{j-1} \psi_{ke}\right] \frac{1}{(1+r)^{j-i}} DB_{je} \Phi_t(\{i\},de,d\eta,\{DB\},da_\mu,da).\end{aligned}$$

The first term of the equation is the claim from active defined benefit workers. The second term is the claim from defined benefit retirees.

3.4 Government

The government engages in three activities: First, it provides Social Security benefits to retirees. Second, it consumes good. The government consumption per capita g grows at the rate of technological progress. Total government consumption is therefore given by $G = g \int \Phi(ds)$. Government consumption is included in the model to equalize the size of the government sector in the the model to the data. This will ensure that the tax burden in the model is consistent with the data. Third, it supplies one-period risk-free debt, D. The return of government debt is the same as the return on physical capital by no arbitrage. Government debt grows at the rate of technological progress and population.

For simplicity, the Social Security benefits depend on age and education. It is given as a share of the average earnings across the working life for an age and education group. At age $j_r - 1$ it has the value

$$SS_{(jr-1)e} = b_{SS,e} \sum_{j=1}^{jr-1} \frac{1}{(1+g_z)^{(jr-1)-j}} \frac{(1+g_n)^j \int \zeta_{je} \eta w l(s) \Phi_t(\{j\},\{e\},d\eta,d\nu,da_\mu,da)}{\sum_{k=1}^{jr-1}(1+g_n)^k \int \Phi_t(\{k\},\{e\},d\eta,d\nu,da_\mu,da)}.$$

$b_{SS,e}$ is the share of the average earnings the retirees receive as benefits. The share depends on education. Because of growth in technology, younger retirees receive more in benefits than older retirees. The relationship between benefits for workers of different ages is

$$SS_{(j+i)e} = \frac{1}{(1+g_z)^i} SS_{je}.$$

The government finances the expenditures by means of three taxes: consumption tax, τ_c, capital income tax τ_κ, and labor tax τ_l. The government balances the budget every period by adjusting the labor tax while consumption and capital taxes stay fixed. The labor tax satisfies

$$\begin{aligned} g_c \int \Omega(ds) + (1+r)D + \int \mathbb{1}_{j \geq j_r} SS_{je} \Omega(ds) = \\ \tau_l \int \mathbb{1}_{j<j_r}(\zeta_{je}\eta w l(s) - \xi_s - x_\mu(s)) + \mathbb{1}_{j \geq j_r}(\mathbb{1}_{\nu=DB} DB_{je} - x_\mu(s))\Omega(ds) \\ + \tau_\kappa r \int (a(s) + Tr)\Omega(ds) + (1+g_z)(1+g_n)D'. \end{aligned}$$

The indicator function $\mathbb{1}_{j\geq j_r}$ equals one for all retirees. Similarly, the indicator function $\mathbb{1}_{j<j_r}$ equals one for all active workers. At last, the indicator function $\mathbb{1}_{\nu=DB}$ equals one for all defined benefit workers.

3.5 Worker's problem

Recall that workers are indexed by type $s = \{j, e, \eta, \nu, a_\mu, a\}$, where j is age, e is educational level, η is the stochastic component of labor productivity, ν is type of retirement plan, a_μ is retirement assets, and a is standard assets. An active worker solves the following problem

$$
\begin{aligned}
V_j(e,\eta,\nu,a_\mu,a) &= \max_{c,l,x_\mu,x} U(c,l) + \beta\psi_{je}E_{\eta'|\eta}V_{j+1}(e,\eta',\nu,a'_\mu,a') \\
\text{s.t.} \qquad (1+\tau_c)c + x &= (1-\tau_l)(\zeta_{je}\eta wl - \xi_s - x_\mu) \\
a' &= (1+(1-\tau_\kappa)r)(a+B) + x \\
a'_\mu &= (1+r)a_\mu + (1+\mathbb{1}_{\nu=DC}\varphi_{DC})x_\mu \\
& x_\mu \in [0,\bar{x}_\mu], \qquad \bar{x}_\mu = min(\zeta_{je}\eta wl, \hat{x}_\mu), \qquad \hat{x}_\mu \in \{\hat{x}_{\mu DB}, \hat{x}_{\mu DC}, \hat{x}_{\mu IRA}\} \\
& x \geq -(1+(1-\tau_\kappa)r)(a+B) \\
& c \geq 0 \\
& 0 \leq l \leq 1
\end{aligned}
$$

Each period the worker chooses how much to consume, c, work l, save in retirement assets x_μ, and save in standard assets x. Workers discount next period's utility by β. The probability of surviving until next period is ψ_{je} and depends on age and education. The indicator function $\mathbb{1}_{\nu=DC}$ equals one for all defined contribution workers. φ_{DC} is the matching contribution from the firm for the defined contribution worker. $\hat{x}_{\mu DB}, \hat{x}_{\mu DC}$, and $\hat{x}_{\mu IRA}$ are the potential maximum limits to save in the retirement assets for a defined benefit, defined contribution, or IRA worker respectively. $\bar{x}_\mu$ is the maximum limit the worker is allowed to save in retirement assets.

The cost of the retirement plan is deducted from the active worker's labor earnings as a lump sum. Saving in retirement assets is deducted before labor tax while saving in standard assets is deducted after labor tax. Retirement assets accumulate tax free. When saving in retirement assets, the firm matches an active defined contribution worker's saving by the matching contribution. The worker pays capital tax on returns on standard assets and bequest.

An active worker cannot withdraw savings from the retirement assets and there is a maximum limit on how much they can save: A defined benefit worker cannot save in the retirement asset at all. Hence, the potential maximum limit for an active defined benefit worker is $\hat{x}_{\mu DB} = 0$. A defined contribution worker can save more in the retirement asset than an IRA worker and therefore $\hat{x}_{\mu DC} > \hat{x}_{\mu IRA}$. In addition, no worker can save more than their earnings. Ensuring these constraints, the maximum allowed saving in retirement assets for a worker is $\bar{x}_{\mu}$.

A retiree cannot work and therefore $l = 0$. A retiree solves the following problem

$$
\begin{aligned}
V_j(e, \eta, \nu, a_\mu, a) &= \max_{c, x_\mu, x} U(c, l) + \beta \psi_{je} E_{\eta'|\eta} V_{j+1}(e, \eta', \nu, a'_\mu, a') \\
\text{s.t.} \qquad (1 + \tau_c)c + x &= SS_{je} + (1 - \tau_l)(\mathbb{1}_{\nu = DB} DB_{je} - x_\mu) \\
a' &= (1 + (1 - \tau_\kappa)r)(a + B) + x \\
a'_\mu &= (1 + r)a_\mu + x_\mu \\
x_\mu &\in [-(1 + r)a_\mu, 0] \\
x &\geq -(1 + (1 - \tau_\kappa)r)(a + B) \\
c &\geq 0
\end{aligned}
$$

Retirees pay labor tax on payments from the defined benefit plan and withdrawals from the retirement assets. Retirees cannot save in the retirement asset, but can withdraw all retirement assets they have accumulated.

3.6 Definition of equilibrium

Given a consumption tax rate, τ_c, capital income tax, τ_κ, government consumption, G, government debt, D, initial condition for capital, K_0, and the measure of types, Φ_1, an equilibrium in the model is a sequence of model variables such that

1. Given prices, cost of and benefits from the retirement plan, government policies, and accidental bequest, workers maximize utility subject to their constraints.

2. Factor prices satisfy marginal product pricing conditions

$$r = \theta\alpha \left(\frac{N}{K}\right)^{1-\alpha} - \delta$$
$$w = \theta(1-\alpha) \left(\frac{K}{N}\right)^{\alpha}.$$

3. Goods, capital, and labor market clears

$$C + G + (1+g_z)(1+g_n)K' = \theta K^{\alpha} N^{1-\alpha} + (1-\delta)K$$
$$K' + D' = \frac{\int a'(s) + a'_{\mu}(s)\Phi(ds)}{(1+g_n)} + \frac{A_{DB}}{(1+g_z)(1+g_n)}$$
$$N = \int \zeta_{je}\eta l(s)\Phi(ds).$$

4. Accidental bequest is given by

$$B' = \frac{\int (1-\psi_{je})(a'(s) + a'_{\mu}(s))\Phi(ds)}{(1+g_n)\int \Phi(ds)}.$$

5. Government policies satisfy the government budget constraint.

6. The aggregate law of motion for Φ is induced by the policy functions and the exogenous stochastic process for idiosyncratic risk.

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 assuming balanced growth in 2016. Some of the parameters change between the two equilibria to take exogeneous changes in retirement plans, earnings, and survival probability into account. The model period is 2 years.

4.1 Parameters determined outside the model equilibrium

Table 1 reports the parameters that are set outside the model equilibrium. Table 2 reports the parameters that change between the two equilibria.

4.1.1 Components of labor productivity

The deterministic life cycle component and the idiosyncratic shock of labor productivity is estimated using data from the PSID. Data for every other year between 1968 and 2017 is used in the estimation.

Let male hourly wages be defined as $M_{it} = \ln W_{it} - \ln H_{it}$ where W_{it} is total earnings and H_{it} is total hours for worker i in year t. The deterministic life cycle component is found by the following fixed effect regression of male hourly wages:

$$M_{it} = f_i + \Pi_{a_1}\text{age}_{it} + \Pi_{a_2}\text{age}_{it}^2 + \Pi_{a_3}\text{age}_{it}^3 + \Pi_{a_4}\text{age}_{it}^4 + \sum_{f=1}^{F}\Pi_f\text{famsize}_{it} + \sum_{t=1}^{T}\Pi_t d_t + u_{it}.$$

f_i is the individual specific effect, age_{it} is the age, famsize_{it} is the family size, d_t is the time dummy, and u_{it} is the stochastic component of labor productivity. Π_{a_1}, Π_{a_2}, Π_{a_3}, Π_{a_4}, $\{\Pi_f\}_{f=1}^{F}$, and Π_t are the estimated parameters. I use a full set of dummy variables for family size and time periods. The deterministic component is computed by setting family size equal to 3, mean individual-specific effect for individuals of age 25-65, and the time dummy for the years 1989 or 2017. The component is estimated separately for college and non-college educated workers.

The stochastic component of labor productivity u_{it} is modeled as the sum of two orthogonal components: a persistent autoregressive shock and a transitory shock. Let ϵ_{it} denote the persistent shock and ν_{it} denote the transitory shock. The stochastic component is given by

$$u_{it} = \epsilon_{it} + \nu_{it}$$
$$\epsilon_{it} = \rho\epsilon_{i(t-1)} + \vartheta_{it}.$$

ν_{it} and ϑ_{it} are drawn from distributions with mean zero and variances $\sigma^2_{\nu,t}$ and $\sigma^2_{\vartheta,t}$. These parameters are currently from Heathcote, Storesletten, and Violante (2010): ρ is set to 0.973 and $\sigma^2_{\vartheta,t}$ is set to 0.01 in the first balanced growth path and 0.02 in the second balanced growth path.

4.1.2 Workers

The workers enter the economy at age 25 and retire at age 65. This implies that j_r is set to 20. A worker can maximum live until age 99, which implies that J is set to 37. The coefficient of relative risk aversion, σ, is set to 2.

The replacement rate for defined benefit payments, $b_{DB,e}$, is set to 0.3 for both college and non-college workers. The matching contribution from firms for defined contribution workers, ϕ_{DC}, is set to 0.5. Maximum allowed saving in the retirement asset for a defined contribution worker, $\hat{x}_{\mu DC}$, is set to 30 percent of GDP per capita. The maximum value an active IRA worker can save in the retirement, $\hat{x}_{\mu IRA}$, is set to 10 percent of GDP per capita.

The distribution of workers with different types of retirement plans in the economy changes between the two equilibria. In 1989 the 45 percent of the workers had a defined benefit plan, but this decreased to 10 percent of the workers by 2016. 15 percent of the workers had a defined contribution plan in 1989, but this increased to 30 percent in 2016. 40 percent of the workers had an IRA plan in 1989, which increased to 60 percent in 2016.

The distribution of workers with a college education also changed between the two equilibria. In 1989 20 percent of the workers had a college degree. This increased to 35 percent of the workers in 2016.

Survival probability depends, in the current calibration, on age only. Survival probability from the Social Security Administration's Life tables is used for the calibration. The tables are available for 2016, but not for 1989. Linear interpolation between life tables for 1980 and 1990 is used for the calibration for the equilibrium in 1989.

4.1.3 Technology and government

Capital's share of output is set to 0.360. Depreciation rate, δ, is set to an annual rate of 0.059. Labor-augmenting technological progress, g_z, is set to annual rate of 2 percent. Growth rate in population, g_n, is set to 1.5 percent.

Government consumption, G, is set to 0.156. It is calculated as government consumption per capita to output per capita. Consumption tax rate is set to 4.7 percent and capital income tax rate 32.1 percent. Labor taxes are used to balance the government budget and

Table 1: Parameters determined outside the model equilibrium

Parameter	Description	Value
j_r	Retirement age (65 years)	20
J	Maximum life span (99 years)	37
σ	Risk aversion parameter	2
b_{DB}	Replacement rate DB	0.3
φ_{DC}	Matching rate from firms	0.5
$\bar{x}_{\mu,DC}$	Max saving ret asset DC	0.3
$\bar{x}_{\mu,IRA}$	Max saving ret asset IRA	0.1
α	Capital income share	0.360
δ	Capital depreciation rate (annual rate = 0.059)	0.115
g_z	Productivity growth rate (annual rate = 0.020)	0.040
g_n	Population growth rate	0.015
g_c	Government consumption per capita	0.156
τ_c	Consumption tax rate	0.047
τ_κ	Capital income tax rate	0.321

will therefore adjust accordingly.

The parameters governing technology and government are from Conesa, Kehoe, Nygaard, and Raveendranathan (2020).

4.2 Parameters determined jointly in equilibrium

Table 3 reports the parameters that are determined jointly in equilibrium. I assume the economy is in balanced growth in 2016 and calibrate the parameters to match moments this year.

Total factor productivity, θ, is normalized such that GDP per capita is equal to 1. The discount factor, β, is set to match annual capital-to-output ratio of 3. The consumption share in the utility function, γ, is calibrated such that average hours worked per employee is equal to full-time, 0.333. Social security replacement rates, $b_{ss,e}$, are calibrated to match average

Table 2: Parameters changed between 1989 and 2016

Parameter	Description	Value 1989	Value 2016
$\sigma^2_{\vartheta,t}$	Variance of wage process	0.01	0.02
	Percent of workers with college educ	20	35
	Percent of workers with DB	45	10
	Percent of workers with DC	15	30
	Percent of workers with IRA	40	60

Table 3: Parameters determined jointly in equilibrium

Parameter	Description	Target (year=2016)	Value
θ	Choice of units output	GDP pc = 1	1.297
β	Discount factor	Capital to annual output = 3	0.897
γ	Con share in utility	Avg hour worked = 0.333	0.351
b_{SSc}	Rep rate SS col	Avg SS to GDP pc col = 0.293	0.473
b_{SSnc}	Rep rate SS non-col	Avg SS to GDP pc non-col = 0.244	0.594
D	Gov debt	Gov debt to annual output = 0.545	0.269

Social Security benefits across individuals with and without a college degree. Government debt, D, is set to match government debt to output.

NB: The data moments matched in the paper are from Conesa, Kehoe, Nygaard, and Raveendranathan (2020).

5 Results

The results in this section are reported based on a preliminary calibration and will be updated in the near future.

The model is validated by comparing measures of inequality in financial wealth for retirees in 1989 and 2016 to the data. The measures used for this analysis are the following ratios of percentiles: 95/5 and 90/10. The 95/5 ratio is the $95th$ percentile divided by the $5th$ percentile. The other ratio is computed similarly using the specified percentiles.

Table 4: Level of ratios for data and model

Ratio	Data (2016)	Model (2016)	Data (1989)	Model (1989)
95/5	19.1	35.7	13.5	28.1
90/10	11.1	15.5	6.5	11.8

Table 5: Change of ratios for data and model. The change is measured as ratio(2016)/ratio(1989).

Ratio	Data	Model
95/5	1.42	1.27
90/10	1.70	1.32

Table 4 reports the level of inequality for both the data and the model for the years 1989 and 2016. The level of inequality is higher in the model than in the data. Table 5 reports the change in inequality between the two periods. It is calculated as the ratio of inequality in 2016 divided by the ratio in inequality in 1989 for both the data and the model. The inequality changes less in the model than in the data.

The change in inequality is decomposed into the three channels: change of type of retirement plans, increased inequality in earnings and increased life expectancy. The effect of a channel is measured by exogenously changing the parameters that govern the channel and measure the effect on financial wealth in retirement. The 95/5 ratio is used for this analysis.

Starting with all parameters at the 2016 values, the values are changed to 1989 values in the following order: First, the change in retirement plans are set to the 1989 values. This explains 36 percent of the increase in inequality. Next, the earnings are changed from the 2016 to the 1989 level. This change explains 5 percent of the increase in inequality. Last, the change in parameters governing life expectancy explains 19 percent of the increase in inequality. In total the model explains 64 percent of the change in inequality. The change in percentage points can be found in table 6.

Table 6: Decomposition of inequality into the three channels. Inequality is measured by the 95/5 ratio.

Channel	Percentage points
Retirement plans	15
Earnings	2
Life expectancy	8
Total	27

6 Conclusion

This paper documents the increase in inequality in financial wealth for retirees in the U.S. between 1989 and 2016. This paper builds an overlapping generations general equilibrium model to analyze the change in inequality. The effect of three channels are quantified: First, a change in the type of retirement plans utilized in the economy from defined benefit to defined contribution plans explain 36 percent of the increase in inequality. Second, increase in inequality in earnings explain 5 percent of increase in inequality. Third, 19 percent of the increase in inequality can be explained by increase in life expectancy.

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A Data

The Survey of Consumer Finances (SCF) is used for the data analysis. The sample used in the analysis includes men who are at least 66 years old and who are fully retired.

Women are not included in the data analysis because women's labor participation has increased over the time period. In addition a widow's retirement assets often depends on her late husband's earnings. The retirement assets for men, compared to women, are therefore to a less extent influenced by other factors.

Respondents who are still working are excluded from the sample. They are excluded to improve the accuracy of the present value of Social Security and defined benefit payments. Present value is calculated based on the assumption that the respondent continues to receive a consistent amount of payments for the remainder of their life. It is more likely that a respondent who has fully retired are claiming all benefits than one who is still working.

Both variables based on answers to specific questions and aggregate variables in the SCF Bulletin extract data are used in the analysis. The variables in my paper are constructed such that the measures correspond as good as possible to the theory in the paper. When aggregate variables from the SCF Bulletin extract data are used, the variable names are given in parenthesis in the description that follows. Retirement assets in my paper are measured as the present value of expected Social Security benefits, present value of expected defined benefit payments, and the value of defined benefit and IRA accounts. Total financial assets (FIN) in the SCF Bulletin includes a measure of quasi-liquid retirement accounts (RETQLIQ). Financial assets in my paper is equal to financial assets in the SCF Bulletin, subtracting quasi-liquid retirement accounts and adding my measure of retirement assets. Total debt (DEBT) in the SCF Bulletin includes debt related to property (MRTHEL, RESDBT). The measure of debt in my paper is equal to total debt in the SCF Bulletin subtracting the debt related to property. Financial wealth in my paper is measured as finacial assets subtracting debt using the variables just described. See the SCF Bulletin Bricker et al. (2017) for further details regarding the aggregate measures.

Inflation is adjusted by following the calculations in the SCF Bulletin. All dollars are adjusted to 2016 dollars. The "current methods" version for all urban consumers from the Bureau of Labor Statistics is used as the measure for inflation. The timing of asset variables is set to September of the survey year. Income variables are adjusted to an average for the whole year preceding September of the survey year.

The present value of Social Security and defined benefit payments are calculated based on the benefits of the year of the survey. The respondents are assumed to continue to receive the same value of benefits, in real terms, for the remainder of their life. In particular I assume they receive an annuity with a fixed interest rate and with payments at the end of every period. The interest rate is set to the average of 10 years U.S. government bond, subtracting inflation, over the time period 1989-2016. This yields an interest rate of 3.85 percent. Life expectancy is based on the Social Security Administration's actuarial life tables. The life expectancy depends on age and sex. The life tables from the Social Security Administration are not available for all survey years. An estimate of life expectancy is obtained by using linear interpolation for the years available.

Measures of retirement assets are reported for each individual in the survey. However, measures of other assets and debt are reported on the household level. 50 percent of the wealth is assigned to each individual in a couple if the household consists of a couple. Weights in the SCF are given for the household (primary economic unit) level. Because there are no individual weights, the weights for the households are used for the individuals.

Social Security in the U.S. is based on the highest 35 years of earnings. To exclude respondents with a loose attachment to the U.S. labor market I therefore exclude respondents with Social Security payments less than 7000 dollars. Further, respondents with negative financial wealth, not including Social Security assets, and the wealthiest 1.0 percent of the respondents are excluded from the sample.