Mandatory pension saving and homeownership[*]

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Abstract

Mandatory pension saving and homeownership

We explore the implications of mandatory minimum contributions to tax-deferred retirement accounts over the life cycle. These contributions defer housing market entry and increase loan-to-value ratios. We propose a flexible retirement saving scheme that does not force individuals to build up savings in a tax-deferred retirement account and only requires them to save in either a taxable account, a tax-deferred retirement account, or through home equity if they are undersaving. This flexible retirement saving scheme largely alleviates the unintended side effects of mandatory minimum contributions and simultaneously ensures that individuals build up sufficient savings for retirement.

Key Words: retirement saving, homeownership, pension system design, loan-to-value ratio, housing market entry
JEL Classification Codes: E21, G11, H23

1 Introduction

Saving for retirement is among the most important financial challenges individuals face throughout their lives. At present, increasing life expectancies combined with decreasing birth rates and low interest rates impose huge challenges on finding suitable ways to sustain a reasonable level of retirement benefits. Most countries around the world impose some form of mandatory retirement saving scheme on their citizens, often financed via a constant share of labor income used to fund the system, such as under the current U.S. Social Security system, (1) because forced saving can help individuals overcome lack of retirement planning or self-control problems (Samuelson (1975); Feldstein (1985); Moser and Olea de Souza e Silva (2019)) and (2) to overcome the Samaritan's dilemma caused by the government's inability to commit to not helping the elderly experiencing poverty.

We set up a realistically calibrated life cycle model which aims to shed light on the side effects of mandatory retirement savings on housing decisions, in particular housing market entries and loan-to-value ratios, and incorporates many important features of models from the literature, including stochastic labor income (e.g., Cocco, Gomes, and Maenhout (2005)), a rent-versus-own decision (e.g., Cocco (2005); Yao and Zhang (2005)), and taxable as well as tax-deferred retirement accounts (e.g., Dammon, Spatt, and Zhang (2004); Fischer and Gallmeyer (2017)). In our model, individuals must make informed decisions about their preferred consumption, their homeownership status, the size of the home they want to live in, the contribution to or, after attaining retirement age, withdrawal from the tax-deferred retirement account, and about the shares of wealth invested into stocks and bonds in the taxable as well as the tax-deferred retirement account.

Existing pension systems of the defined benefit type, in which participants are promised fixed annual benefits for their contributions, face increasing funding problems. As a result, this study focuses on pension systems of the defined contribution type, to which individuals contribute according to a pre-determined schedule, while benefits depend on the amounts of contributions made and their profits earned. Currently, such pension systems already cover large shares of the population's pensions in, e.g., Denmark, the Netherlands, and Sweden.

Retirement accounts are typically set up as tax-deferred accounts. Contributions to these accounts are (within certain limits) deductible from taxable income, and profits earned from them are generally tax-exempt, while withdrawals during retirement age are subject to income taxation.[1]

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[1] Few countries, including Denmark and Sweden, impose taxes on profits earned in tax-deferred accounts. However, the tax rate is low compared to that applicable in a taxable account. Withdrawals prior to

Whereas existing funded retirement saving schemes typically provide individuals with a degree of freedom in their asset allocation, they usually impose harsh restrictions on minimum contributions. In practice, individuals are often required to contribute a constant minimum share of their labor income to a retirement saving scheme. To explore the implications of such minimum contribution requirements for tax-deferred retirement accounts, we compare a setting with minimum contributions with a setting without mandatory contributions.

Intuitively, mandatory minimum contributions could delay housing market entry, because they render it more challenging for young adults, who are typically severely liquidity constrained, to build up sufficient liquid savings for a down payment. Consistent with this intuition, our model predicts that minimum contributions delay the average age of first home buyers by more than two years. Simultaneously, individuals facing minimum contribution requirements face higher loan-to-value ratios. In essence, these individuals incur the cost of the interest margin on mortgage debt by borrowing their own money.

To counteract the undesirable side effects of mandatory minimum contributions, we propose a flexible retirement saving scheme, which builds on the intuition that it is not important through which channels individuals save for retirement, as long as they build up sufficient total wealth. Intuitively, it may make sense to prioritize savings outside the tax-deferred retirement account at a younger age to facilitate making the down payment required for the acquisition of a home. Our flexible retirement saving scheme builds on this intuition and only forces individuals to save, if they have not built up sufficient savings in either ordinary taxable accounts, as home equity, or through pre-existing tax-deferred retirement savings. More specifically, our scheme only requires individuals to build up savings if they have not built up sufficient wealth in the past, but does not require savings to be held in the tax-deferred retirement account.

Compared to the pension system with mandatory minimum contributions, our flexible retirement saving scheme, which ensures a similar build up of savings, has two key advantages. First, it allows individuals to repay their mortgages before building up savings in the tax-deferred retirement account, thus avoiding paying the interest differential between the borrowing rate and the investment rate. Second, it allows for earlier homeownership. In sum, the flexible retirement saving scheme leads to an increase in welfare compared to the pension system with mandatory minimum contributions while simultaneously ensuring a similar level of savings.

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retirement age are generally not possible or subject to substantial penalty taxes, thus rendering early withdrawals highly undesirable. Hence, an important difference between taxable accounts and tax-deferred retirement accounts is the illiquidity of the latter.

Our work contributes to a growing strand of literature investigating optimal retirement savings decisions over the life cycle. An important early contribution is the work of Carroll (1997), which studies the optimal life cycle profile of savings when individuals do not have access to tax-deferred retirement accounts. Cocco, Gomes, and Maenhout (2005) extends this work by allowing for a stochastic labor income stream, which is calibrated to socio-demographic data. Studies examining optimal savings decisions with taxable accounts as well as tax-deferred retirement accounts include: Amromin (2003); Shoven and Sialm (2003); Dammon, Spatt, and Zhang (2004); Garlappi and Huang (2006); Huang (2008); and Fischer and Gallmeyer (2017). We contribute to this line of literature by highlighting the undesirable side effects of minimum contribution requirements and by proposing a new flexible retirement saving scheme, that largely alleviates the unintended side effects, while simultaneously ensuring that individuals build up sufficient savings.

Our work is also related to a strand of literature exploring optimal pension system design (e.g., Dahlquist, Vestman, and Setty (2018)). Larsen and Munk (2022) and Schlafmann, Setty, and Vestman (2021) also investigate optimal pension plan design in a framework with a taxable account as well as a tax-deferred retirement account, but abstract away from explicitly accounting for housing. The former documents that individuals who undersave or do not invest into stocks can benefit from mandatory pension saving. The latter advocates age- and retirement wealth-to-labor income dependent contribution rates to retirement savings plans, but do not account for wealth held outside retirement plans in determining their contribution rates. Our work has another focus and differs from those two papers in several regards. First, we explicitly model a rent-versus-own decision and mortgages. Our results show that mandatory pension saving delays housing market entry and leads to higher loan-to-value ratios. To the best of our knowledge, our manuscript is the first to investigate the implications of pension system design for homeownership decisions and loan-to-value ratios. Second, our work proposes a flexible retirement saving scheme that (1) only requires saving from individuals that have not built up sufficient wealth, and (2) does not require mandatory savings to be located in the tax-deferred retirement account, if, e.g., repaying an expensive mortgage is more desirable. This flexible retirement saving scheme leads to earlier housing market entry, lower loan-to-value ratios, and higher welfare than the pension system with mandatory minimum contributions. While other manuscripts have investigated different contribution rules to retirement saving schemes, our manuscript is, to the best of our knowledge, the first to propose a savings rule that does not solely focus on savings in tax-deferred retirement accounts, but also takes other forms of savings into account. Consistent with economic intuition, our results show that savings outside retirement savings accounts are important for determining how much to save for retirement.

This paper proceeds as follows: section 2 outlines our life cycle model and presents its calibration, while section 3 presents the model predictions. Next, section 4 introduces our flexible retirement saving scheme, and section 5 concludes.

2 The model

In this section, we outline our life cycle model of optimal consumption, savings, and housing decisions. In our model, individuals work from age 20 to 65 and build up savings for retirement (accumulation phase). At age 66, they are retired and use their accumulated savings during their remaining lifetime. In our model, individuals face a rent-versus-own decision. They can build up savings in both a taxable and a tax-deferred retirement account, and they can invest in a risk-free asset, a risky asset representing a stock market index, and an owner-occupied home. We let the Cocco, Gomes, and Maenhout (2005) labor income process calibrated for high school graduates determine the individual's labor income during working age. That is, we allow for an age-dependent trend as well as stochastic income shocks.

Individuals are subject to mortality risk and make their decisions in order to achieve the objective of maximizing expected lifetime utility. The individual's preference function is given by recursive Epstein-Zin preferences (Epstein and Zin (1989)) to enable a separation between the individual's degree of relative risk aversion, γ, and its elasticity of intertemporal substitution, ψ.

2.1 Mandatory contributions

Our goal is to investigate the impact of mandatory minimum contributions to the tax-deferred retirement account, irrespective of whether the account is run by a mandatory public pension system, such as the U.S. Social Security system, a mandatory occupational pension system, such as those widespread in Scandinavian countries, or a mandatory private pension system. We deliberately do not try to replicate a specific retirement savings scheme in a particular country, but aim at contributing to a better understanding of the broader consequences of mandatory minimum contributions.

To investigate the impact of mandatory contributions, we compare two settings with each other. In our benchmark case, individuals are faced with a minimum contribution requirement to a tax-deferred retirement account, corresponding to a constant share, $\xi \in$

$(0, 1]$, of the individual's labor income, L_t, at time t during working age:

$$Z_t \geq \xi L_t, \quad t < t_{ret}, \tag{1}$$

in which Z_t denotes the individual's contribution to the tax-deferred retirement account, and t_{ret} denotes the first time at which the individual is retired. Requiring minimum contributions, which are a constant share of labor income, is a widespread phenomenon in many pension systems around the world. Notable exceptions are mandatory occupational pension systems in Switzerland, for which the minimum contribution rate typically increases with age - from 7% at age 25 to 18% at 65 (see OECD (2021), in particular the country profile of Switzerland). The age-dependent contribution requirements only apply to the mandatory occupational pension systems. Contribution rates to Switzerland's mandatory state pension insurance are constant, begin at the age of 17 and end at retirement age.

We compare this benchmark case with a setting, in which the minimum contribution during working age is zero, i.e.:

$$Z_t \geq 0, \quad t < t_{ret}. \tag{2}$$

We deliberately do not allow for early withdrawals from the tax-deferred retirement account, because such withdrawals are either impossible or subject to substantial tax penalties, thus rendering early withdrawals undesirable.

Since contributions to the tax-deferred retirement account during working age are typically tax-deductible, they are usually limited by an upper bound, $\phi \in (0, 1]$, of the individual's labor income:

$$Z_t \leq \phi L_t, \quad t < t_{ret}, \tag{3}$$

in which $\xi \leq \phi$.

2.2 Housing

In our model, individuals face a rent-versus-own decision, i.e., they can either live in a rented place or an owner-occupied home. The return on investments in owner-occupied homes, r_t^H, from time t to time $t + 1$ is lognormally distributed, with mean μ_H and standard deviation σ_H.

Owner-occupied homes serve a dual role as an asset and a durable consumption good. That is, when owning a home, individuals simultaneously derive utility from living in their home and expose themselves to changes in its value. Following earlier work with owner-occupied housing, such as Cocco (2005), Yao and Zhang (2005), Fischer and Stamos (2013), and Kraft, Munk, and Wagner (2018), we employ a Cobb-Douglas utility function, u, defined over consumption and housing.

Following Kiyotaki, Michaelides, and Nikolov (2011), we account for the preferences of individuals to live in owner-occupied housing, by allowing for a higher utility per home unit when they own it. For that purpose, we multiply the size of the individual's residence, Q, by a factor $1+\zeta h$, in which ζ determines the strength of the preference for living in an owner-occupied home, and h is an indicator variable, taking the value of one if the individual lives in an owner-occupied home, and zero otherwise. Hence:

$$u\left(C,Q\right)=C^{1-\theta}\left(Q(1+\zeta h)\right)^{\theta}, \tag{4}$$

in which C is the amount consumed, and θ is the relative preference over housing consumption.

Both owners and renters face costs for housing consumption. These costs can be divided into recurring and nonrecurring costs. The former depends on whether the individual lives in an owner-occupied home or a rented place. If H_t denotes the price per housing unit at time t, renters pay an annual rent, $m_r Q_t H_t$, that is assumed to be a constant share, m_r, of the value of their residence, $Q_t H_t$. Owners also face recurring costs, such as property taxes and maintenance costs of $m_o Q_t H_t$, in which m_o is a constant share of the value of their home. The rate of recurring housing costs, m, from time t to $t+1$ can be expressed as

$$m\left(h_t\right)=h_t m_o+\left(1-h_t\right)m_r. \tag{5}$$

Nonrecurring housing expenses, n, occur when the individual acquires a new home. In that case, the individual faces transaction costs of $f_p Q_t H_t$, in which f_p denotes the percentage cost of acquiring homeownership. This cost includes fees to be paid to a real estate agent and taxes. Individuals face these costs when changing homeownership status from renter to owner ($h_t\left(1-h_{t-1}\right)=1$) or when remaining a homeowner, but changing home size, i.e., when moving from one owner-occupied home to another ($h_t h_{t-1}\chi_{\{Q_t\neq Q_{t-1}\}}=1$), in which $\chi_{\{Q_t\neq Q_{t-1}\}}$ is an indicator variable taking the value one, if $Q_t\neq Q_{t-1}$, and zero otherwise.[2]

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[2] In our model, no costs occur when selling a home, i.e., changing homeownership status from owner to renter is not associated with any costs to the seller. In our model, the buyer covers the costs.

Nonrecurring transaction costs, n, from time t to $t+1$ can then be summarized as follows:

$$n\left(Q_t, h_t, h_{t-1}\right) = f_p Q_t H_t \left(h_t \left(1 - h_{t-1}\right) + h_t h_{t-1} \chi_{\{Q_t \neq Q_{t-1}\}}\right). \tag{6}$$

These transaction costs result in no-trade regions, in which the costs from adjusting the home size outweigh the benefits. That is, trading costs render frequent changes in home size undesirable.

2.3 Capital markets

Apart from investing in owner-occupied homes, individuals can invest into a representative stock market index for which the pre-tax return, r_t^S, from time t to $t+1$ is lognormally distributed with mean μ_S and standard deviation σ_S. Returns on investments into the stock market index and owner-occupied homes may be correlated, reflecting that they may depend on common risk factors, such as the evolution of the economy. When τ_g denotes the tax rate applicable to returns on equity investments in the taxable account, the gross returns on an investment in the stock market index in the taxable and the tax-deferred retirement account from time t to $t+1$ are given by $G_{T,t} = 1 + r_t^S \left(1 - \tau_g\right)$ and $G_{R,t} = 1 + r_t^S$, respectively.

In addition to the stock market, individuals can invest into a risk-free asset paying a constant pre-tax interest rate of r. When τ denotes the income tax rate applicable to labor income, including interest earned in the taxable account, and to withdrawals from the tax-deferred retirement account after attaining retirement age, the gross returns on investments into the risk-free asset in the taxable and the tax-deferred retirement account are given by $R_T = 1 + r\left(1 - \tau\right)$ and $R_R = 1 + r$, respectively. Since profits are taxed on a nominal basis, it is important to explicitly account for inflation. We assume a constant inflation rate, which we denote by i.

Homeowners can use their home as a collateral and borrow up to a share, $\delta \in [0, 1]$, of its value, whereas renters are barred from this borrowing opportunity. When B_t denotes the amount invested risk-free ($B_t \geq 0$) or borrowed ($B_t < 0$), it holds that:

$$-B_t \leq \delta h_t Q_t H_t. \tag{7}$$

To avoid tax arbitrage opportunities by deducting mortgage interest expenses, while simultaneously earning interest in a tax-deferred retirement account tax free, we assume that borrowers face an interest rate margin, i.e., the after-tax interest burden from borrowing exceeds the after-tax interest earned on investments in the risk-free asset. When R_D denotes the gross after-tax borrowing rate after accounting for the tax deductibility of mortgage interest expenses, it thus holds that $R_D > R_R$.

2.4 Optimization problem

In our model, in every period, t, individuals must simultaneously make seven interrelated decisions: 1) how much to spend on nondurable consumption; 2) how much to contribute to (or, after attaining retirement age, withdraw from) their tax-deferred retirement account, Z_t; 3) the share of retirement savings invested in stocks, $\alpha_{R,t}$; 4) the size of the home they want to live in, Q_t; 5) their homeownership status, h_t; 6) how much of their wealth in the taxable account to invest in stocks, S_t; and, finally, 7) the amount of wealth to invest in bonds or the size of their mortgage, B_t.

In setting up the individual's optimization problem, $f(t)$ denotes the individual's survival probability from time t to $t+1$ and β denotes its time preference factor. The terminal period in our model is denoted by N. $W_{T,t}$ is the amount of wealth in the taxable account at time t. Retirement savings at time t before (after) contributions/withdrawals are denoted by $W_{R,t-}$ ($W_{R,t+}$). Total wealth, W_t, that effectively belongs to the individual after accounting for the fact that savings in the tax-deferred retirement account are still subject to taxation upon withdrawal can be expressed as:

$$W_t = W_{R,t-}(1-\tau) + W_{T,t} + h_{t-1}Q_{t-1}H_t. \tag{8}$$

The individual's optimization problem is then:

$$\max_{\{C_t,Z_t,\alpha_{R,t},Q_t,h_t,S_t,B_t\}} V_t\left(X_t\right) =$$

$$\left(\left(1-\beta\right)\left(\left(\frac{C_t}{\left(1+i\right)^t}\right)^{1-\theta}\left(Q_t\left(1+\zeta h_t\right)\right)^{\theta}\right)^{1-\frac{1}{\psi}}+\beta\left(f\left(t\right)\mathbb{E}_t\left[V_{t+1}\left(X_{t+1}\right)^{1-\gamma}\right]\right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}}\right)^{\frac{1}{1-\frac{1}{\psi}}}, \tag{9}$$

subject to

$$W_{R,t-} = W_{R,(t-1)+}\left(\alpha_{R,t-1}G_{R,t-1}+\left(1-\alpha_{R,t-1}\right)R_R\right) \tag{10}$$

$$W_{R,t+} = W_{R,t-} + Z_t \tag{11}$$

$$\begin{aligned} W_{T,t} &= \left(1-\tau\right)L_t + S_{t-1}G_{T,t-1} + B_{t-1}\left(\chi_{\{B_{t-1}\geq 0\}}R_T + \chi_{\{B_{t-1}<0\}}R_D\right) \\ &= C_t + S_t + B_t + m\left(h_t\right)Q_tH_t + n\left(Q_t,h_t,h_{t-1}\right) + h_tQ_tH_t - h_{t-1}Q_{t-1}H_t + Z_t(1-\tau) \end{aligned} \tag{12}$$

$$C_t, Q_t > 0, S_t \geq 0, \alpha_{R,t} \in [0,1], W_{R,t+} \geq 0, \tag{13}$$

and Equations (3) to (7), in which $X_t = [t, W_{R,t-}, W_{T,t}, L_t, Q_{t-1}, h_{t-1}]$ is the vector of state variables for this optimization problem. Depending on whether or not we are investigating the optimal consumption-investment strategy with mandatory contributions to the tax-deferred retirement account, the individual's optimization problem is solved subject to the constraint given in Equations (1) or (2). Appendix A explains the more technical details on how we simplify and solve the optimization problem.

2.5 Calibration

This section summarizes the calibration of our model. Individuals enter the life cycle at age 20 ($t = 1$), work until age 65, are retired at age 66 ($t_{ret} = 47$), and die at the latest at age 100. Therefore, the accumulation period is 46 years, and the maximum investment horizon is $N = 81$ years. We let one period correspond to one year. Prior to age 100, we use the life table published by the Centers for Disease Control and Prevention (Arias and Xu (2018)) to determine the survival probabilities for men for another year.

We compare two different settings: In one setting, individuals do not face any mandatory contribution requirements for a tax-deferred retirement account, i.e., $\xi = 0\%$. In the other setting, individuals face minimum contribution requirements. The exact level of mandatory minimum contributions imposed differs between countries. Some countries, such as the U.S.

and Germany, also split mandatory contributions between employer and employee contributions. While this difference may be important for employees' net salaries, the exact source of funding is mostly an accounting issue and not of primary importance for exploring the economic implications of minimum contribution requirements for housing decisions. If the employer has to bear parts of retirement contributions, he will account for these costs in the wage, he is willing to offer. That is, the employee's net salary after retirement contributions should not rationally depend on whether retirement contribution are legally borne by the employee, the employer, or shared between them. Total mandatory retirement contributions are 12.4% in the U.S., around 15% in Scandinavian countries and as high as 18.6% in Germany. We deliberately stay at the lower range of these values and set mandatory minimum contributions to $\xi = 12.4\%$.[3] The upper bound for contributions to the tax-deferred retirement account is set to $\phi = 100\%$ of labor income in both settings.

The pre-tax risk-free rate is set to $r = 3.7\%$, the average one-month Treasury Bill rate between 1946 and 2019. The expected annual pre-tax return on the S&P 500 between 1946 and 2019 was 12.4% and its standard deviation $\sigma_S = 16.9\%$. While the historical equity premium was quite high (Mehra and Prescott (1985); Dimson, Marsh, and Staunton (2002)), there are doubts as to whether such a high level will also apply in future periods. As a result, we follow the current consensus, which is around three to four percentage points (Claus and Thomas (2001)) and set the expected return of stocks to $\mu_S = 7.8\%$, implying an equity premium of around four percentage points. Inflation is set to its average value between 1946 and 2019, i.e., $i = 3.7\%$, implying a real risk-free rate of zero.

The tax rate on interest income, labor income, and regular withdrawals from the tax-deferred retirement account is set to $\tau = 35\%$ and the tax rate on capital gains is set to $\tau_g = 20\%$, roughly corresponding to the top tax rates in the U.S.

Following Yao and Zhang (2005), we set the housing preference parameter to $\theta = 0.2$, the maximum borrowing rate to $\delta = 80\%$, the annual maintenance rate to $m_o = 1.5\%$, and the transaction costs when acquiring a new owner-occupied home to $f_p = 6\%$. The annual rent rate is $m_r = 6.7\%$, the empirical estimate of Fischer and Stamos (2013). We set the individual's preference for owning over renting to $\zeta = 10\%$, which is in the order of magnitudes chosen in Kiyotaki, Michaelides, and Nikolov (2011) and Fischer and Khorunzhina (2019).

Using the U.S. S&P's CoreLogic Case-Shiller Home Price Index, we estimated the expected nominal return on housing from 1946 to 2019, μ_H, to be 4.6% and its standard

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[3] We also computed results for $\xi = 18.6\%$, which lead - as to be expected - to qualitatively identical, though quantitatively larger effects. These results are available from the authors upon request.

deviation, σ_H, to be 5.2%. Price changes in individual homes are far from perfectly correlated, implying that the House Price Index underestimates the volatility of individual house prices. Case and Shiller (1989) argue that the volatility of individual house prices should be around 15%. Bourassa, Haurin, Haurin, Hoesli, and Sun (2009) provide empirical support. We therefore set the standard deviation of individual homes to $\sigma_H = 15\%$.

To avoid tax arbitrage opportunities, as in Marekwica, Schaefer, and Sebastian (2013), the borrowing rate is set to $r_D = 6.2\%$, corresponding to an after-tax borrowing rate of $(1-\tau)r_D = 4.03\%$, thus exceeding the after-tax risk-free rate in the tax-deferred retirement account of $r = 3.7\%$. Correlation between stock returns and labor income is set to $\rho_{S,L} = 0.047$, correlation between housing return and labor income to $\rho_{H,L} = 0.55$, and correlation between housing and stock returns to $\rho_{H,S} = 0$, which are the empirical estimates from Cocco (2005).

To determine the individual's labor income during working age, we use the Cocco, Gomes, and Maenhout (2005) labor income process estimated for high school graduates. As the goal of our work is to contribute to a better understanding of how contributions to pension systems are best implemented, we require individuals to fully fund their retirement benefits through their own savings. As a result, we do not allow for retirement benefits from other sources and set the replacement ratio to zero, implying that individuals do not receive other income during retirement age besides from their accumulated savings.

Preference parameters are chosen to match empirically observed wealth at retirement age for individuals facing minimum contribution requirements. The degree of risk aversion and the time preference factor are therefore set to $\gamma = 3$ and $\beta = 0.96$, respectively. We set the elasticity of intertemporal substitution to $\psi = 0.15$, which is in the range of estimates in Pakoš (2011), Cashin and Unayama (2016), Gayle and Khorunzhina (2018), and Best, Cloyne, Ilzetzki, and Kleven (2020). Table 1 summarizes our base case parameter choice.

3 Results

3.1 Model predictions

It is important to ensure that our simulated model predictions are able to match key features in the data, which is why we begin the presentation of our results by comparing wealth in the Panel Study of Income Dynamics (PSID) data with model-predicted wealth. For our data analyses examining the model fit, we use data from all available PSID waves after the financial crisis, i.e., the PSID waves from 2011 to 2019. A comparison between model

Description	**Symbol**	**Value**	**Source**
	Preference parameters		
Degree of risk aversion	γ	3	Own choice
Elasticity of intertemporal substitution	ψ	0.15	Own choice
Time preference factor	β	0.96	Own choice
	Financial markets		
Expected nominal return on equity	μ_S	7.8%	Historical estimate
Standard deviation of return on equity	σ_S	16.9%	Historical estimate
Inflation	i	3.7%	Historical estimate
Nominal risk-free rate	r	3.7%	Historical estimate
	Housing market		
Housing preference parameter	θ	0.2	Yao and Zhang (2005)
Maximum borrowing rate	δ	80.0%	Yao and Zhang (2005)
Risk-free borrowing rate	r_D	6.2%	Yao and Zhang (2005)
Annual rent rate	m_r	6.7%	Fischer and Stamos (2013)
Annual maintenance rate	m_o	1.5%	Yao and Zhang (2005)
Transaction costs for purchasing home	f_p	6.0%	Yao and Zhang (2005)
Expected nominal return on housing	μ_H	4.6%	Historical estimate
Standard deviation of return on housing	σ_H	15.0%	Case and Shiller (1989)
Preference for owning over renting	ζ	10.0%	Kiyotaki et al. (2011)
	Taxes		
Tax rate on capital gains	τ_g	20%	Own choice
Tax rate on other income	τ	35%	Own choice
	Correlations		
Stock returns and labor income	$\rho_{S,L}$	0.047	Cocco (2005)
Housing return and labor income	$\rho_{H,L}$	0.550	Cocco (2005)
Housing and stock return	$\rho_{H,S}$	0.000	Cocco (2005)

Table 1: This table summarizes the base case calibration used in our model.

predictions and the data is challenging, because Social Security benefits are not part of wealth reported in the data, and there is an extremely high degree of dispersion of wealth in the PSID data. To address these two issues, we proceed as follows.

We add the present value of Social Security benefits to PSID wealth to allow for a meaningful comparison between model predictions and the data. We calculate the present value of Social Security benefits in two steps. First, we calculate the monthly Social Security benefits individuals can expect when retiring at age 65 by following the calculation procedure provided on the U.S. Social Security Administration website.[4] Second, we calculate the present value of the expected benefits with basic actuarial formulas accounting for mortality rates, as provided by the Centers for Disease Control and Prevention (Arias and Xu (2018)) and using our base case interest rate of $r = 3.7\%$. Appendix B outlines the data selection process and the computation of the present value of the Social Security benefits in more detail.

We use median wealth in the data, which reflects that mean wealth is heavily biased upwards by a few outliers. In the data, self-reported median wealth at age 20 is USD 10,000 and grows to USD 110,000 at age 65. The median present value of Social Security benefits at age 65 is USD 250,035.70, implying a total wealth at age 65 of USD 360,035.70. Hence, total wealth grows by a factor of about 36.0 from age 20 to 65 in the PSID data. Preference parameters in our model are chosen to achieve a comparable growth of wealth. Specifically, with the choice of parameters introduced in section 2.5, the growth of average wealth in our model from age 20 to 65 is 35.55, thus matching the growth of wealth in the data very well.

3.2 Implications of minimum contribution requirements

In this section, we explore the implications of mandatory minimum contributions for the evolution of the wealth of individuals, W_t, their retirement savings, housing market entry, and loan-to-value ratios. Intuitively, mandatory contributions to the tax-deferred retirement account should affect not only the individuals' accumulation of wealth and the location of their savings between the taxable and the tax-deferred retirement account, but they should also affect the rent-versus-own decision and the timing of housing market entry through two counteracting channels. On the one hand, mandatory contributions reduce the individuals' liquid wealth, thus deferring the age at which individuals have accumulated enough savings for a down payment. Hence, from this liquidity channel, mandatory contributions should defer housing market entry. On the other hand, mandatory contributions should lead to a

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[4] `https://www.ssa.gov/oact/cola/Benefits.html`

faster overall accumulation of wealth, enabling individuals to bear possible losses on potential housing investments more easily, without running the risk of retirement poverty. Via this wealth channel, mandatory contributions could prepone housing market entry. In this section, we explore, among others, which of these two counteracting channels dominates.

Figure 1 summarizes our results. Panel A depicts the evolution of wealth over the life cycle and Panel B of retirement savings. Panel C depicts the distribution of first-time housing market entry, while Panel D compares the evolution of loan-to-value ratios over the life cycle. The solid lines report results for individuals facing a minimum contribution requirement, while the dashed lines report no minimum requirement. The dash-dotted and dotted line in Panel A report the results for the first percentile of the wealth distribution from 10,000 simulated paths for minimum and no minimum contributions, respectively. All other results are averages from 10,000 simulated paths.

From Panel A, mandatory contributions have the expected effect of causing individuals to accumulate more wealth. Most importantly, the wealth level of poorer individuals, as measured by the evolution of wealth for the first percentile, also increase. The quality of a pension system, among others, depends crucially on its ability to secure living standard of poorer individuals. In that regards, mandatory contributions are useful. As to be expected, from Panel B, this effect is mainly channeled through retirement savings. Whereas individuals not facing minimum contribution requirements significantly postpone building up retirement savings until their liquidity constraint is less binding, minimum contributions prepone contributions to the tax-deferred retirement account and lead to a higher total amount of retirement savings. While higher retirement savings alone are desirable, as they help in obtaining financial retirement security, they are accompanied by undesirable side effects. Specifically, from Panel C, mandatory minimum contribution requirements lead to deferred housing market entry. With mandatory minimum contributions, the average individual entering the housing market is 2.2 years older than without minimum contributions. That is, our results indicate that the liquidity channel dominates.[5]

Simultaneously, from Panel D, mandatory minimum contributions lead to higher loan-to-value ratios, which is consistent with the empirical evidence in Beshears, Choi, Laibson, Madrian, and Skimmyhorn (2021) that automatic enrollment in a retirement plan increases (second) mortgage debt. Without mandatory minimum contributions, individuals can finance their home with a higher share of equity, thus avoiding the relatively high borrowing

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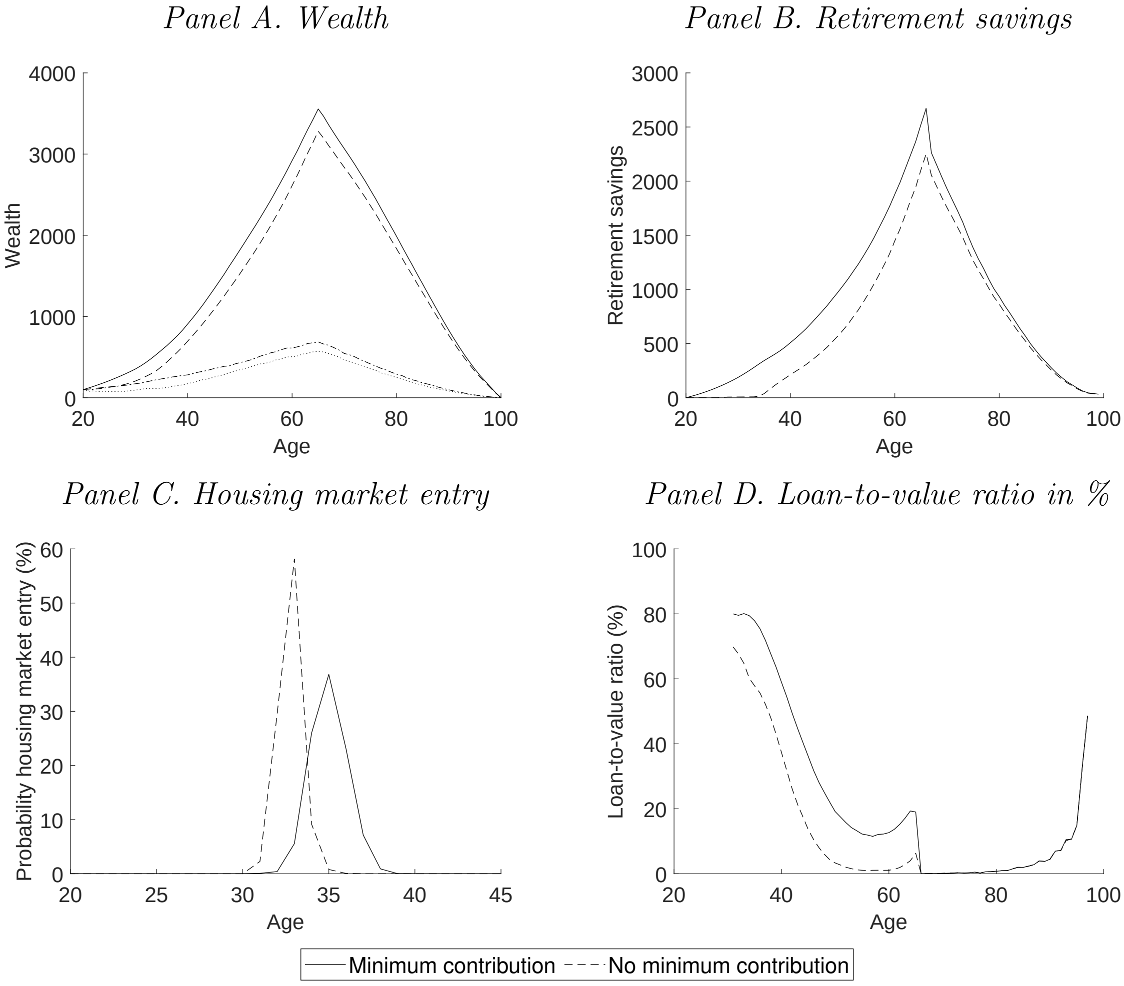
[5] For individuals with the set of preferences studied in our work, housing market entry are concentrated between the age of 30 to 40. Vestman (2019) documents that heterogeneity in preferences leads to higher dispersion in housing decisions.

Figure 1
Base case results



This figure depicts the base case results of our model. Panel A depicts the evolution of wealth over the life cycle and Panel B of retirement savings. Panel C depicts the distribution of first-time housing market entry, Panel D compares the evolution of loan-to-value ratios over the life cycle. The solid lines report results for individuals facing a minimum contribution requirement, while the dashed lines report no minimum requirement. The dash-dotted and dotted line in Panel A report the results for the first percentile of the wealth distribution from 10,000 simulated paths for minimum and no minimum contributions, respectively.

rate. Individuals facing minimum contribution requirements, on the other hand, are forced to borrow more for a comparable home. That is, these individuals invest at a relatively low rate in their tax-deferred retirement account and simultaneously borrow at a relatively high rate. In essence, these individuals incur the cost of the interest margin by borrowing their own money. From the individual's perspective, it may therefore be more desirable to first repay the relatively expensive mortgage before accumulating savings in the tax-deferred retirement account.[6]

Via deferred housing market entry, constraints on the consumption opportunities of young adults, and by forcing them into higher loan-to-value ratios, mandatory contribution requirements are associated with significant welfare costs. A 20-year old facing mandatory minimum contributions needs to be endowed with a 7.7% higher level of lifetime consumption and housing services to attain the same level of expected presently discounted lifetime utility as an individual not facing minimum contribution requirements.

4 A flexible retirement saving scheme

In this section, we propose a flexible retirement saving scheme. This scheme alleviates unintended side effects of mandatory minimum contributions while simultaneously ensuring that individuals save enough for retirement. Our flexible retirement saving scheme builds on the intuition that it does not matter whether individuals build up savings for retirement age in the tax-deferred retirement account, specifically labelled as pension savings, or via other means of saving, as long as they build up sufficient total wealth. Under our flexible retirement saving scheme, individuals are only required to save, if they have not built up sufficient total wealth. Individuals that are required to save do not have to build up savings in their tax-deferred retirement accounts, but can also choose to increase their wealth by (partly) repaying a mortgage or by building up wealth in the taxable account.

From a legal perspective, it is important to ensure that individuals cannot consume their retirement savings before attaining retirement age to prevent the government from having to sustain their living expenses during retirement. In reality, this could be achieved by requiring individuals to label sufficient savings as "for retirement" each period, which may

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[6] Some pension systems around the world, including the German and the Swiss pension system, allow early withdrawals from tax-deferred retirement accounts, if they are used to support the acquisition of a home. Even though the exact conditions under which such early withdrawals escape penalty taxation vary between national tax laws, the general consensus is that only acquisitions of owner-occupied homes qualify. We also explored a setting, in which individuals are allowed to withdraw from their tax-deferred retirement accounts prior to retirement age when acquiring an owner-occupied home. In line with economic intuition, the opportunity of early withdrawals leads to earlier homeownership. However, unlike a pension system with mandatory contributions, the pension system with early withdrawals may not guarantee that individuals are able to build up sufficient retirement savings without imposing further constraints, because (levered) housing investments are subject to substantial volatility. Not ensuring sufficient retirement savings not only renders a direct comparison difficult, it is also undesirable from a legislative perspective, because it may trigger a need for transfer income. Imposing further constraints adds significantly to the already substantial computational complexity of our modeling framework. We therefore do not further pursue this case.

not be spent. These labels could, however, be moved between different asset classes. For instance, after an appreciation of a home and/or the reduction of mortgage debt, more home equity could be labelled as “for retirement”, while wealth in the taxable account could be freed, thus giving the individual more financial flexibility.

The fundamental idea behind building up savings for retirement is to smooth consumption over the life cycle. To attain this goal, an increase in income should result in an increase in savings, whereas an increase in savings, e.g., due to high realized returns in the past, should decrease the need for saving. Building on this intuition, we advocate an (age-dependent) savings rule that depends on the individual's labor-to-wealth ratio. A high labor-to-wealth ratio indicates that an individual has low savings relative to current income and is more in danger of not being able to sustain the consumption level at retirement. To nevertheless reach the goal of smoothing consumption over the life cycle, the individual has to save more and consume less.

For every given age, we therefore impose a maximum labor-to-wealth ratio after expenses, $l_{t,MAX}$, to be attained. This maximum labor-to-wealth ratio should decrease with age reflecting that more savings should already have been built up. When W_t is the investor's wealth level at the beginning of period t, already including its labor income, L_t, earned in this period, and $E_t = C_t + m\left(h_t\right) Q_t H_t + n\left(Q_t, h_t, h_{t-1}\right)$ are non-durable expenses in period t, i.e., consumption, rents, maintenance, and transaction costs, its labor-to-wealth ratio after expenses in period t is $\frac{L_t}{W_t - E_t}$. Imposing a maximum labor-to-wealth ratio after expenses is then equivalent to imposing a maximum expenses-to-wealth ratio:

$$\frac{L_t}{W_t - E_t} \leq l_{t,MAX} \iff \frac{E_t}{W_t} \leq 1 - \frac{\frac{L_t}{W_t}}{l_{t,MAX}} \tag{14}$$

From Equation (14), the maximum expenses-to-wealth ratio decreases in the beginning-of-period labor-to-wealth ratio, $\frac{L_t}{W_t}$, prior to expenses. That is, individuals with high initital labor-to-wealth ratios, $\frac{L_t}{W_t}$, face harsher constraints on their maximum expenses-to-wealth ratios, $\frac{E_t}{W_t}$, than individuals with low initital labor-to-wealth ratios, for whom the expenses constraint is more likely not to become binding.[7]. Our flexible retirement saving scheme does, however, not require new savings to be located in a tax-deferred retirement account. If more desirable, additional savings can, for instance, also be used to repay a relatively

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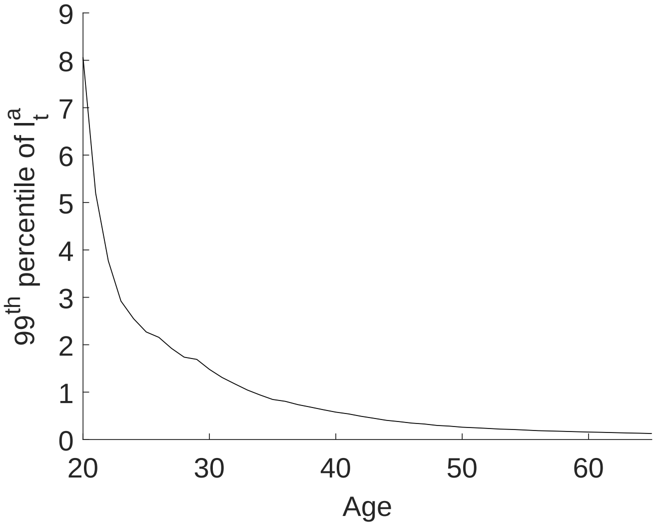
[7] Technically, the right hand side of Equation (14) can take a negative value - for instance, if an individual faces a dramatic decrease in total wealth. In such (very rare) cases, we set the individual's maximum expenses-to-wealth ratio to 10^{-4}. By restricting the individual's maximum expenses-to-wealth ratio, we are imposing a lower bound on its minimum savings, which may be even negative for individuals with very low labor-to-wealth ratios, i.e., individuals with very low labor-to-wealth ratios may even dissave

Figure 2
Evolution of maximum labor-to-wealth ratio after expenses in flexible retirement scheme



This figure depicts the 99^{th} percentile of the labor-to-wealth ratio after consumption, rents, maintenance, and transaction costs, l_t^a, for the case with mandatory minimum contributions, which is used as the age-dependent maximum labor-to-wealth ratio after expenses, $l_{t,MAX}$, in Equation (14) in our flexible retirement scheme.

expensive mortgage before building up other forms of savings.

An important degree of freedom in our flexible retirement saving scheme is the choice and shape of the age-dependent maximum labor-to-wealth ratio, $l_{t,MAX}$, in Equation (14). To facilitate a direct comparison with the setting with mandatory minimum contributions investigated in section 3, the age-dependent maximum labor-to-wealth ratios, $l_{t,MAX}$, are constructed from the 10,000 simulations on the optimal paths under the minimum contribution requirement. Since ensuring the living standards of the poorest individuals is particularly important in pension system design, we compute the age-dependent maximum labor-to-wealth ratio, $l_{t,MAX}$, as the 99^{th} percentile from our 10,000 simulations on the optimal paths under the minimum contribution requirement.

From Figure 2, the age-dependent maximum labor-to-wealth ratio, $l_{t,MAX}$, shows the expected decline with age.[8] From Equation (14) higher levels of $l_{t,MAX}$ imply less binding expenses constraints. Hence, in line with economic intuition that younger individuals can

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[8] Unlike the labor-to-wealth ratio prior to expenses, $\frac{L_t}{W_t}$, the 99^{th} percentile of the labor-to-wealth ratio after expenses, $\frac{L_t}{W_t - E_t}$, can take values larger than one.

still build up sufficient savings over a longer savings horizon, their higher levels of $l_{t,MAX}$ imply less tightly binding expenses constraints than for older individuals.

The expenses constraint imposed by Equation (14) can unfold its effect in two economically different ways. First, it can be effectively binding, thus increasing savings by force. Second, it can stimulate individuals to build up sufficient savings in advance to avoid ending up facing a tightly binding expenses constraint. Prior to age 30, the expenses constraint binds on more than 90% of the 10,000 simulated paths, indicating that without the expenses constraint individuals would want to choose higher expenses. That is, prior to age 30, the expenses constraint mainly works through the first channel. Beyond the age of 30, the expenses constraint only binds on 1.3% of our simulated paths. That is, beyond the age of 30, the second channel becomes more prevalent.

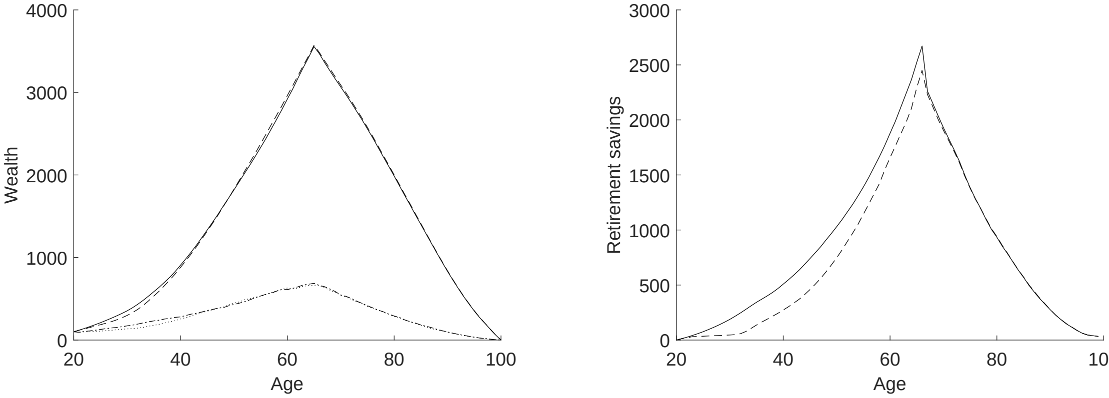
Figure 3, in a similar fashion as Figure 1, depicts the implications of our flexible retirement saving scheme relative to the case with mandatory retirement savings on the evolution of wealth (Panel A), retirement savings (Panel B), first-time housing market entry (Panel C), and loan-to-value ratios (Panel D) over the life cycle. More technically, for the flexible retirement saving scheme, we solve the optimization problem presented in section 2.4 subject to Equations (2) and (14).

Overall, the results in Figure 3 show that our flexible retirement saving scheme leads to an evolution of wealth and retirement savings very similar to that of the pension system with mandatory contributions. Under our flexible retirement saving scheme, total savings at retirement age are almost exactly as high as under the pension system with mandatory contributions - both, on average and for the first percentile.

Panel C shows that our flexible retirement saving scheme prepones first-time housing market entry relative to the system with mandatory contributions to the tax-deferred retirement account. The average housing market entrant is 4.3 years younger when trading under our flexible scheme, implying that our flexible retirement saving scheme even prepones first-time housing market entry relative to the system with no minimum contribution. Panel D shows that our flexible retirement saving scheme also allows our individuals to repay their relatively expensive mortgages at a faster rate. After all, repaying the relatively expensive mortgage before saving in risk-free assets in the tax-deferred retirement account is an obvious arbitrage opportunity that our flexible retirement saving scheme allows individuals to exploit more efficiently than under the pension system with mandatory contributions.

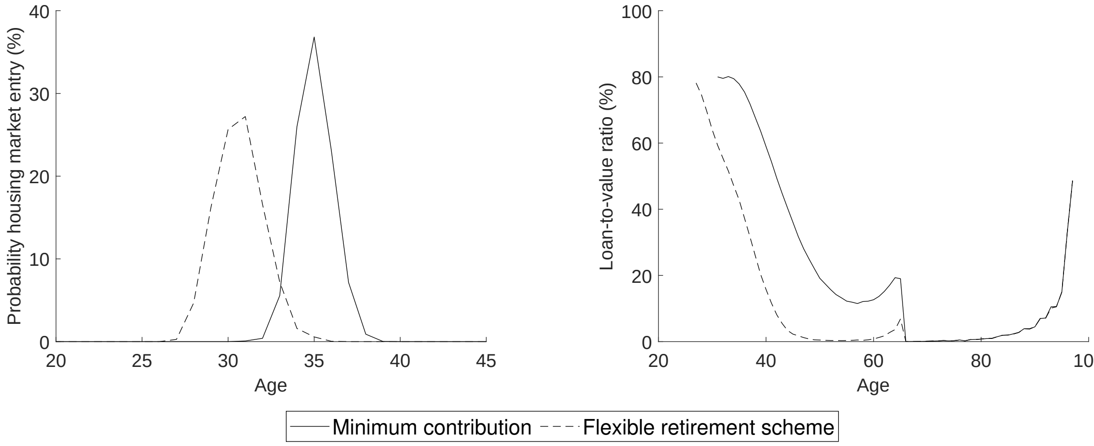
The opportunities available for more flexible saving requirements are early homeownership and lower loan-to-value ratios, both of which lead to positive welfare effects. Compared

Figure 3
Flexible retirement saving scheme results



Panel A: Wealth

Panel B: Retirement savings



Panel C: Housing market entry

Panel D: Loan-to-value ratio in %

This figure compares results under our flexible retirement saving scheme (dashed line) with results under a pension system with mandatory minimum contributions (solid line). Panel A depicts the evolution of wealth over the life cycle and Panel B of retirement savings. Panel C depicts the distribution of first-time housing market entry, while Panel D compares the evolution of loan-to-value ratios over the life cycle. The dash-dotted and dotted line in Panel A report the results for the first percentile of the wealth distribution from 10,000 simulated paths for minimum contributions and the flexible scheme, respectively. All other results are averages from 10,000 simulated paths.

to the base case setting with mandatory minimum contributions, welfare increases by 2.3%. That is, a 20-year old obliged to make contributions under the minimum contribution pension scheme needs to be endowed with a 2.3% higher level of lifetime consumption and housing services, to attain the same level of expected presently discounted lifetime utility as an individual trading under our flexible retirement saving scheme.

5 Conclusion

In this study, we explore the implications of minimum contribution requirements for tax-deferred retirement accounts found in many countries around the world in a realistically calibrated life cycle model. Our results show that minimum contribution requirements have the unintended side effect of delaying housing market entry and of forcing individuals to sustain higher loan-to-value ratios. That is, individuals are forced to pay the higher borrowing rate on their debt, while simultaneously investing at a lower rate in the tax-deferred retirement account. In other words, individuals essentially borrow their own money and face the cost of the interest margin.

We therefore propose a new flexible retirement saving scheme, which ensures that individuals build up sufficient savings. Intuitively, it should not matter whether individuals build up savings in a tax-deferred retirement account, in a taxable account, or through home equity, as long as they build up sufficient total wealth. Our flexible retirement saving scheme builds on this intuition and only forces individuals to build up savings, if they are undersaving. It does, however, not force individuals to build up (illiquid) tax-deferred retirement savings, if, e.g., repaying an expensive mortgage first is more desirable. Compared to the system with mandatory minimum contributions, the flexible retirement saving scheme results in a similar evolution of wealth and retirement savings, but prepones first-time housing market entry, lowers the loan-to-value ratios, and increases welfare.

In a nutshell, the widespread institutional constraint requiring individuals to contribute a minimum fixed fraction of their income to an illiquid pension savings account throughout their working life induces a suboptimal consumption profile over the life cycle, delayed housing market entry, and forces homeowners into accepting high loan-to-value ratios. Our flexible retirement saving scheme is an attempt to mitigate these issues. Further investigations of the design of optimal pension plans is a fruitful subject for future research.

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Appendix A: Solution of optimization problem

We simplify our optimization by normalizing with aggregate wealth, W_t, that effectively belongs to the individual and does not fall to tax authorities upon withdrawal from the tax-deferred retirement account. Hence, in the normalized optimization problem, $c_t = \frac{C_t}{W_t}$ and $q_t = \frac{Q_t H_t}{W_t}$ are the decision variables that affect utility from immediate consumption of both non-durable and durable consumption. Defining $V_t\left(X_t\right) = v_t\left(x_t\right) \frac{W_t/(1+i)^t}{\left(H_t/(1+i)^t\right)^{\theta}}$, the individual's optimization problem can be rewritten as:

$$\max_{\{c_t,z_t,s_t,b_t,\alpha_{R,t},q_t,h_t\}} v_t\left(x_t\right) =$$

$$\left(\left(1-\beta\right)\left(c_t^{1-\theta}\left(q_t\left(1+\zeta h_t\right)\right)^{\theta}\right)^{1-\frac{1}{\psi}} + \beta\left(f\left(t\right)\mathbb{E}_t\left[\left(v_{t+1}\left(x_{t+1}\right)\frac{\frac{W_{t+1}}{W_t(1+i)}}{\left(\frac{H_{t+1}}{H_t(1+i)}\right)^{\theta}}\right)^{1-\gamma}\right]\right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}}\right)^{\frac{1}{1-\frac{1}{\psi}}}, \tag{A.1}$$

subject to

$$w_{R,t-} = w_{R,(t-1)+}\left(\alpha_{R,t-1}G_{R,t-1} + \left(1-\alpha_{R,t-1}\right)R_R\right) \tag{A.2}$$

$$w_{R,t+} = w_{R,t-} + z_t \tag{A.3}$$

$$\begin{aligned} w_{T,t} &= 1 - w_{R,t-} - (1-\delta)h_{t-1}\frac{Q_{t-1}H_t}{W_t}, \\ &= c_t + s_t + b_t + m\left(h_t\right)q_t + f_p q_t\left(h_t(1-h_t) + h_t h_{t-1}\chi_{\left\{\frac{Q_{t-1}H_t}{W_t}\neq q_t\right\}}\right) + h_t q_t \\ &\quad - h_{t-1}\frac{Q_{t-1}H_t}{W_t} + z_t(1-\tau) \end{aligned} \tag{A.4}$$

$$c_t, q_t > 0, s_t \geq 0, \alpha_{R,t-1} \in [0,1], w_{R,t+} \geq 0, \tag{A.5}$$

in which $w_{R,t-} = \frac{W_{R,t-}}{W_t}$, $w_{R,t+} = \frac{W_{R,t+}}{W_t}$, $w_{T,t} = \frac{W_{T,t}}{W_t}$, $z_t = \frac{Z_t}{W_t}$, $b_t = \frac{B_t}{W_t}$, and $s_t = \frac{S_t}{W_t}$. The new vector of state variables is

$$x_t = \left[t, w_{R,t-}, \frac{L_t}{W_t}, \frac{Q_{t-1}H_t}{W_t}, h_{t-1}\right]. \tag{A.6}$$

We discretize the continuous state variables. The expectation in Equation (A.1) is computed using Gaussian quadrature. Parallel computing is used to expedite our computations.

Appendix B: PSID data and present value of Social Security benefits

This appendix explains in more detail, which PSID data we use in our study and how we calculate the present value of Social Security payments (SSP), individuals can expect to make when working until the age of 65, and being retired at the age of 66.

For our data analyses, we use the biannually available PSID data after the financial crisis from 2011 to 2019, i.e., PSID data from 2011, 2013, 2015, 2017, and 2019. We only consider heads of households (henceforth, individuals) who are high-school graduates to ensure that we only use the wealth of the same individuals whose labor income process we consider. Furthermore, we adjust total wealth and labor income for inflation with an annual rate of 3.7% as in our model.

To calculate the growth of median wealth, we proceed as follows: first, we restrict the inflation-adjusted total wealth of individuals to be positive. Second, we construct two subsamples, one containing all individuals aged 20 and one containing all individuals aged 65. Third, we calculate the median wealth of the total wealth of individuals for the respective subsamples. We find that the median wealth of individuals aged 20 is USD 10,000 and for those aged 65 it is USD 110,000.

To calculate the present value of Social Security benefits for individuals working until the age of 65 and being retired at age 66 we proceed as follows: first, we use inflation-adjusted labor income to calculate the average indexed monthly earnings (AIME). We obtain AIME by calculating the median earnings for each age from 26 to 60, taking the mean of the median earnings, and dividing this value by 12. Our result is USD 3,291.45.

Second, we determine the basic Social Security retirement benefit when retiring at age 62, the earliest age at which an individual is generally eligible for Social Security retirement benefits, by calculating the so-called primary insurance account (PIA): for 2019, the PIA is the sum of 90% of the first USD 926 of the AIME, 32% of the AIME exceeding USD 926 but below or equal to USD 5,785, and 15% of the AIME exceeding USD 5,785. Therefore, our PIA is USD 1,590.34.

Third, as the individuals in our model are retired at age 66 and not already at age 62, we consider cost-of-living adjustments (COLA). We assume the annual COLA to be 1.69%, which is the mean of all COLAs between 2011 and 2019. When taking COLA into account, the PIA for individuals retired at age 66 is USD 1,700.61. Based on these values, we compute a replacement ratio in the data of: $\frac{1{,}700.61}{3{,}291.45} = 51.7\%$.

Fourth, to calculate the present value of SSP, PV_{SSP}, we assume an interest rate of 3.7% (the same as in our model) and use the following formula:

$$PV_{SSP} = \text{average labor income} \cdot \text{replacement ratio} \cdot \sum_{i=0}^{\omega-66} v^{i-1} \cdot {}_{i}\, p_{66}, \tag{A.7}$$

in which ω denotes the technical maximum life time assumed in the life table (100 years), v

the discount factor, and ${}_ip_{66}$ the probability that a person aged 66 survives the next i years. Our result for the present value of the annuity is USD 250,035.70. We do not consider any taxes as Social Security income is (up to certain limits) tax free in the U.S. When adding up the individual's median total wealth right before retirement, i.e., for individuals aged 65, and the present value of SSP, we observe that median total wealth grows by a factor of 36.