Tax Incentives, Portfolio Choice, and Macroprudential Risks*

Janosch Brenzel-Weiss[a] Winfried Koeniger[b,c]
Arnau Valladares Esteban[b]

November 10, 2023

Abstract

We use a rich lifecycle portfolio choice model to analyze how tax incentives shape household indebtedness, portfolio allocation and macroprudential risks. We gauge the effects of tax incentives by exploiting the fact that homeownership rates and credit supply conditions are similar in Germany and Switzerland, whereas tax incentives for amortising mortgage debt and voluntary pension contributions differ. We find that tax incentives have quantitatively strong effects on mortgage incidence and portfolio allocation, although their impact on aggregate tax revenue is negligible. Tax deductions for mortgage interest payments, which exist in many developed economies, shift the tax burden from the young and indebted to the old and wealthy homeowners. At the same time, more generous tax deductions for voluntary pension contributions shift the portfolio towards less liquid pension savings. The macroprudential implication, considering a bust with a house price correction of 20%, is that the consumption slump in the economy with tax deductions is 0.34 percentage points (pp) smaller on average, relative to the decrease of 6.3% in the benchmark economy. The average hides heterogeneity across age groups: for young homeowners the consumption slump is 1.24 pp smaller whereas it is 0.44 pp larger for homeowners close to retirement.

Keywords: Mortgage amortization, Tax incentives, Household consumption, Portfolio choice, Housing busts, Economic stability, Macroprudential policy.

JEL Codes: D14, D15, D31, E21, G11, G21, H24.

---

*Janosch Brenzel-Weiss and Winfried Koeniger gratefully acknowledge support by the SNSF, Switzerland under project number 1000018-200917. We thank colleagues and participants at seminars and conferences for their helpful comments. [a]: Federal Social Insurance Office (FSIO); [b]: Department of Economics, University of St. Gallen, SEW-HSG, Varnbüelstrasse 14, 9000 St. Gallen, Switzerland; [c]: CESifo, CFS, IZA, Swiss Finance Institute. Email addresses of authors: janosch.brenzelweiss@gmail.com, winfried.koeniger@unisg.ch, arnau.valladares@gmail.com .

1 Introduction

Home equity and pension savings are two key portfolio items through which households accumulate wealth for retirement. The incentives for homeowners to amortise their mortgage and accumulate pension wealth differ widely across countries. In the U.S., the Netherlands or Switzerland, mortgage interest payments can be tax deducted, but that is not the case in Germany or France (OECD, 2020). In the Netherlands and Switzerland, homeowners pay taxes on the imputed rent of their residence, whereas they do not in the U.S., Germany or France. The extent to which voluntary contributions to pension accounts can be tax deducted also varies across countries (OECD, 2007).

We contribute to the literature by analysing quantitatively how observed differences in tax incentives shape portfolio choices and, thus also, macroprudential risks. Using a rich lifecycle model with portfolio choice, we show that tax incentives change the speed with which homeowners amortise their mortgages and determine the size of their pension wealth despite having a low impact on aggregate tax revenue. We show that the portfolio shifts induced by tax incentives have relevant consequences for macroprudential risk. A housing bust has a smaller impact on aggregate consumption in economies where tax deductions reduce young homeowners' debt burden.

The model features an endogenous portfolio decision between amortising the mortgage or accumulating risk-free liquid assets or pension savings. Homeowners earn stochastic income until retirement. The dynamic portfolio choice of agents in each period has important implications for their tax burden. We pay particular attention to modeling the dynamic incentives of the tax system, which determine the portfolio allocation.

We calibrate the model to Germany and study the tax differences between Germany and Switzerland. These two countries are excellent stand-in prototypes to gauge the effect of tax incentives on portfolio allocation. Both countries are very similar regarding homeownership rates and (mortgage) credit supply. This allows us to zoom in on the effect of tax incentives on the demand side with a focus on the homeowners' portfolios, which are of major interest to macroprudential regulators because most debt is mortgage debt (e.g., Eurosystem Household Finance and Consumption Network, 2013). At the same time, both countries differ substantially in the tax incentives relevant to portfolio choice. In Germany, households cannot tax-deduct mortgage interest payments, and the extent to which voluntary pension contributions are deductible is very limited. Instead, in Switzerland, mortgage interest payments are deductible, there is a generous deduction for voluntary pension contributions, and homeowners have to add imputed rent to their taxable income.[1]

The calibrated model replicates the main characteristics of homeowners' portfolios over the lifecycle well. In particular, it generates similar patterns of mortgage incidence, loan-to-value ratios, net worth, and the allocation of wealth across home equity, pensions, and liquid assets to those observed in the data.

We use the model to assess how much of the differences in mortgage incidence, portfolio allocation, and wealth accumulation between Germany and Switzerland can be accounted for by the differences in tax incentives. In our counterfactual economy, German households have to impute rent to their taxable income, can deduct mortgage interest payments, and benefit from a generous deduction for voluntary pension contributions as in Switzerland. We find that tax incentives alone explain around one-fourth of the difference in mortgage incidence and the average loan-to-value ratio of homeowners before retirement. At the same time, the tax incentives increase the weight of voluntary pensions as a share of net worth by ten percentage points. We thus find a quantitatively strong effect on homeowners' portfolios, although the change in the average income tax required for a revenue-neutral shift that incorporates these tax incentives is only 0.7 pp at the average income.

Concerning the macroprudential implications of different tax incentives, we find that the consumption of German homeowners would react less to house prices if they had the Swiss tax incentives. In the counterfactual economy, in which German homeowners face the Swiss tax incentives, the consumption response of homeowners, after a bust with a house price correction of 20%, is 0.34 pp lower on average than in the benchmark economy, in which consumption falls by 6.3%. We find sizable heterogeneity across age groups: the response is 1.24 pp lower for homeowners aged 35 to 45, 0.46 pp lower for those aged 45 to 55, but 0.44 pp higher for those close to retirement with ages 56 to 65. The key driver for these different changes is the tax deduction of mortgage interest payments, which allows young and relatively more indebted households to afford more consumption because the tax burden shifts to old, relatively wealthy households.

Our analysis brings together the following strands of literature. We build on the literature that analyses how tax incentives shape households' portfolio

[1] See Section 2 for further details.

choices and may affect households' welfare. See, for example, Poterba (2001), Amromin, Huang, and Sialm (2007), Alan, Atalay, Crossley, and Jeon (2010), Sommer and Sullivan (2018) and Karlman, Kinnerud, and Kragh-Sørensen (2021).[2] We also contribute to the literature that investigates how balance sheets of households affect the consumption response to macroeconomic shocks, such as Kaplan and Violante (2014), or Laibson, Maxsted, and Moll (2021) who focus on homeowners as we do in this paper. Our analysis of the consumption response to house-price changes relates to analyses by Berger, Guerrieri, Lorenzoni, and Vavra (2018) and Guren, McKay, Nakamura, and Steinsson (2021) for the U.S. We also contribute to the literature on macroprudential policies (e.g., Bianchi and Mendoza, 2018; Jeanne and Korinek, 2019) and the related recent research by Balke, Karlman, and Kinnerud (2023) who investigate the effect of tighter loan-to-value ratios on household portfolios and consumption responses. Finally, our research relates to the literature on comparative household finance, surveyed in Badarinza, Campbell, and Ramadorai (2016). Connecting these strands of the literature allows us to show how tax incentives may have macroprudential consequences by changing wealth accumulation and portfolio choices.

We proceed as follows. In Section 2, we document the differences in the incidence of mortgage debt in Germany and Switzerland. We also describe the features of the respective institutional environment that are most relevant to our analysis. In Section 3, we present the dynamic portfolio choice model of homeowners. We discuss the calibration in Section 4 and show in Section 5 to which extent the different observed household portfolios in Germany and Switzerland can be attributed to different tax incentives. We then illustrate the macroprudential implications in Section 6 by showing how the consumption response to house price changes depends on tax incentives before we conclude in Section 7.

2 Facts on mortgages, portfolios and tax incentives

Households in Germany and Switzerland differ in their portfolio choices. We present the facts and the institutional background which also motivate why we focus on tax incentives in our analysis to explain these differences.

[2] Baumberger (1999) and Morger (2014) analyse the effects of a change in the taxation of imputed rents in the Swiss context, providing a qualitative discussion of the incentive effects, distributional effects and the effect on total tax revenues. In our dynamic model, such a reform also affects liquidity through the intertemporal reallocation of resources.

2.1 Household leverage and portfolios

Household leverage differs widely across developed countries (e.g., Bover et al., 2016). The difference is particularly striking between Germany and Switzerland. Household debt per GDP in 2018 has been 129% in Switzerland which is more than twice the value of 54% reported for Germany.[3] Given that most of the household debt is mortgage debt, it is remarkable that the very different mortgage debt levels are associated with similar homeownership rates in the two countries.

In Tables 1 and 2 we provide descriptive evidence on the leverage of homeowners and their portfolios based on household surveys. The evidence shows that the higher household debt in Switzerland compared to Germany is associated with less amortization of mortgages by Swiss homeowners compared to German homeowners, as we now explain in further detail.

Table 1: Leverage of homeowners

	Fraction of homeowners with a mortgage		*Loan-to-value ratio of*	
			homeowners	*mortgagors*
	Ages		Ages	
	36 – 45	56 – 65	56 – 65	56 – 65
	(1)	(2)	(3)	(4)
Germany (*HFCS*)	0.71	0.41	0.12	0.33
Germany (*SHARE*)	-	0.35	0.09	0.27
Switzerland (*SHARE*)	-	0.90	0.38	0.42
Switzerland (*HABE*)	0.95	0.93	-	-

Sources: HFCS 2014 / SHARE 2015 / HABE 2015. Notes: The SHARE samples households with a head above age 50. The HABE does not provide information on stocks such as mortgage amounts but only on payment flows. In the main text, we discuss further existing evidence on LTV ratios at mortgage origination for Germany and Switzerland.

We present evidence based on three household surveys: the Household Finance and Consumption Survey (HFCS), which is available for Germany but not for Switzerland; the Survey of Health, Ageing and Retirement (SHARE), which is available for Germany and Switzerland but only for households with a head older than age 50; and the Household Budget Survey (HABE), which provides information on payment flows and thus allows us to infer the incidence of mortgagors in

[3] See the global debt database of the IMF at https://www.imf.org/external/datamapper/datasets/GDD, accessed in September 2020.

Switzerland also at younger ages. We provide further information on the surveys in Appendix A.

The results reported in Table 1 show that the incidence and extent of leverage is higher in Switzerland than in Germany, and that the difference in the incidence of leverage is larger closer to retirement at ages 56 to 65. The different leverage is not associated with differences in the ownership of the first residence. The homeownership rate in Germany and Switzerland is similar at ages 36 to 65. It is 49% or 51%, depending on the survey data in the SOEP or HFCS for Germany; and 44% or 51%, respectively, in the survey data of the HABE and SHP for Switzerland. Furthermore, the transition from being a renter to becoming a homeowner occurs at age 45 – 46 on average in both countries (Koeniger et al., 2022).

Let us now comment in more detail on the differences in household leverage. In column 1 of Table 1, we see that most homeowners (95%) have a mortgage at ages 36 to 45 in Switzerland compared with 71% in Germany. Column 2 shows that most Swiss homeowners (90 – 93%) still have a mortgage at ages 56 to 65 whereas this is the case for only 35 – 41% of homeowners in Germany, indicating that Swiss households amortize less than German households.[4] This also shows at the intensive margin for the loan-to-value (LTV) ratios, as reported in columns 3 and 4 for households with heads aged 56 to 65 for which comparable data are available. In column 3, we report the LTV ratio of homeowners. This ratio is smaller than the LTV ratio of mortgagors in column 4 because some homeowners own their home outright and thus do not have a mortgage, as shown in column 2, because they have fully amortized their mortgage before retirement. In column 4, we report the LTV ratios for mortgagors, thus focusing on the intensive margin of mortgage debt.[5]

Comparable data on the size of leverage is scarce for young households in Germany and Switzerland because the SHARE interviews only households with a head older than age 50, and Switzerland is not included in the HFCS. For Germany, data provided by the European Central Bank (2009), table 2, reveals that

[4]These results are robust if we compute these statistics using data in the SHP and SOEP. 84% of homeowners in Switzerland in the SHP have a mortgage at ages 36 to 45 compared with 77% in Germany in the SOEP. At ages 56 to 65, 81% of homeowners in the SHP still have a mortgage relative to only 41% in the SOEP. We use the same survey year 2015 for comparison.

[5]The observed higher LTV ratios for older age groups in Switzerland compared to Germany cannot be explained by lower house price growth in Switzerland. Many households aged 56 to 65 in 2015 have purchased their homes in the 1990s. Given that house prices have increased *more* in Switzerland than in Germany in the 2000s (Schneider and Wagner, 2016), the mechanical effect of the stronger house price increase would imply *lower* LTV ratios for homeowners in Switzerland than in Germany.

the typical LTV ratio for first-time buyers is 70%. Evidence reported in Basten and Koch (2015), table 3, shows that the LTV ratio of 74-75% at mortgage origination is very similar in Switzerland. The similar LTV ratios at mortgage origination in both countries, together with the lower LTV ratios at retirement in Germany compared to Switzerland, reported in Table 1, suggest that homeowners in Germany amortize their mortgage more until retirement than homeowners in Switzerland.

Table 2: Net worth and portfolio shares of homeowners at retirement

		Portfolio shares of homeowners at ages 56 to 65		
	Net worth	Home equity (main residence) / Net worth	Other real estate / Net worth	Voluntary pension savings / Net worth
	(1)	(2)	(3)	(4)
Germany *(HFCS)*	350,677	0.57	0.13†	0.08
Germany *(SHARE)*	265,568	0.64	0.09	-
Switzerland *(SHARE)*	821,321	0.52	0.10	0.17

Sources: HFCS 2014 / SHARE 2015. Notes: Net worth is equivalized to account for differences in household size, and is denominated in units of local currency. In 2015, the euro exchanged aproximately for 1.0-1.1 CHF.
† *The HFCS provides information on the other real estate assets and the associated liabilities. Computing the ratio of other real estate equity to net worth for Germany, we obtain a ratio of* 0.11.

In Table 2 we provide descriptive evidence on portfolios of homeowners in Germany and Switzerland at, or close to, retirement. Column 1 of Table 2 shows that the average net worth of German homeowners aged 56 to 65 is estimated to be much larger in the HCFS than in the SHARE. Because the main purpose of the HFCS is to provide accurate information on household wealth, the HFCS oversamples the wealthy because the wealth distribution is very skewed. The more accurate measurement of wealth in the upper tail of the wealth distribution increases the estimates for net worth compared to the sample in the SHARE. Columns 2 and 3 in Table 2 show that the portfolio shares of home equity for the main residence and other real estate, for which we have information for Germany both in the HFCS and the SHARE, are less different across the two surveys.[6] The statistics on the incidence of mortgages and the average LTV ratios, reported in columns 2 to 4 of Table 1 are also quite robust when such information exists for more than one survey.

[6] The HFCS allows to compute the equity in other real estate for Germany, which we report in the notes of Table 2.

Column 1 of Table 2 further shows that Swiss homeowners have more net worth than German homeowners. The higher LTV ratios of Swiss homeowners shown in Table 1 imply that they hold a smaller share of their wealth in home equity for the main residence (Table 2, column 2). The share of wealth in other real estate is more similar to German homeowners (Table 2, column 3). As we discuss below, the tax incentives differ for the amortization of mortgages associated with the main residence. Swiss homeowners also have a larger share of their portfolio in voluntary pension savings (Table 2, column 4).

The descriptive evidence in Tables 1 and 2 raises the question about the causes of the different leverage, portfolio choices and implied portfolio diversification of German and Swiss homeowners. We now present the institutional background in both countries to motivate why we focus on tax incentives to answer this question, given that the supply side in the mortgage market in terms of lending criteria is similar across both countries. We also provide background on the pension system in both countries that is relevant for our analysis.

2.2 Mortgage markets

The description of the mortgage markets below draws on information by the European Central Bank (2009) for Germany and by the Swiss National Bank (2018) for Switzerland. The lending criteria applied in Germany and Switzerland at mortgage origination are similar. When buying a house, it is typically required that the future homeowner holds home equity of at least 20% of the home value. The remaining 80% can be financed with a mortgage. The implicit maximum LTV ratio is not legally binding but usually imposed by the bank because mortgages with higher LTV ratios trigger stricter capital requirements. The typical LTV ratios at mortgage origination are thus smaller than in the U.S. where the LTV ratio for the median purchased home is 89% on average.[7] The relatively conservative lending criteria imply that mortgage delinquency and negative home equity after house price corrections are less relevant for Germany and Switzerland than for the U.S.

In Switzerland, amortization of the mortgage is required until the LTV ratio is 65−70% (the ratio of the mortgage relative to the home evaluated at the purchase price) and this amortization has to occur during 15 years or until the owner's

[7] See the information on LTV ratios provided by CoreLogic at https://www.corelogic.com/ , accessed in September 2020.

retirement. In Germany, banks typically offer mortgages with repayment plans that amortize the loan until retirement. Mortgage loans to households at older ages are a relatively recent phenomenon. To the best of our knowledge, there are no legal requirements that constrain amortization of mortgages.

A further lending criterion applied in Switzerland at mortgage origination, which we do not explicitly model, is that the mortgage debt service payments cannot be larger than 30% of household labor earnings when applying an annual interest rate of 5%. Given that market mortgage interest rates have been much lower than 5% in the last decade, this criterion further illustrates the conservative lending practices in international comparison.

In both countries the majority of mortgages are fixed-rate mortgages and refinancing or prepayment of mortgages before maturity is costly. Slicing of mortgages into more than two tranches to hedge the refinancing risk is becoming more common among newly originated mortgages but is less relevant for the stock of outstanding mortgages. We abstract from these financing details in our analysis because they would substantially complicate our analysis and they do not seem crucial to understand the differences in leverage between German and Swiss homeowners.

Mortgages in Switzerland are typically assumable, implying that heirs can assume the mortgage together with the inherited home if they satisfy the requirements of the lender. Such mortgages are not common in Germany where most owners repay their mortgage until retirement.

2.3 Tax incentives for portfolio choices

Tax incentives for mortgage amortization and portfolio choices in Germany and Switzerland differ and we will gauge their quantitative importance for household portfolio choices in our analysis. Mortgage interest payments on the main residence can be tax deducted in Switzerland and the imputed rents for that main residence are taxed. This is not the case in Germany for the main residence but mortgage interest payments can be tax deducted for housing that generates taxable (rental) income, i.e., not for owner-occupied housing. Thus, mortgages on homes that are rented out can be attractive for tax reasons. For German households, home equity in real estate other than the main residence may thus be a substitute for tax-incentivized pension savings.[8]

The tax deductability of contributions to voluntary pension plans in Germany (within the so-called *Riester-Rente*) is capped at 2,100 euro, which is much less generous than what Swiss households can deduct for voluntary pension savings in the second or third pillar of the Swiss pension system.[9]

Homeowners can tax deduct interest payments on their main residence in Switzerland but, differently to the U.S. where mortgage interest payments also can be tax deducted, they have to pay taxes on the imputed rent which could be earned by renting their home. In theory, this tax treatment avoids distortions of the homeownership choice but in practice the calculation of the imputed rent is based only on a fraction of the housing value, which is 70% in most cantons and, by ruling of the federal court, cannot be lower than 60%.[10] As long as the distortions are not too large, the approximate neutrality of the tax treatment for the home ownership choice justifies our focus on homeowners when we analyze the effect of the tax incentives on portfolio choices.

2.4 Pension systems

The German pension system mainly consists of a pay-as-you go component with net replacement rates between 45% and 60% depending on the income level, as documented in OECD (2007), p. 35. As mentioned previously, additional voluntary pension contributions are only tax deductable up to 2,100 euro.

The Swiss pension system is composed of three pillars: a pay-as-you-go pension plan with more progressive replacement rates than in Germany, a funded pension plan and a private pension scheme, as documented in OECD (2007), p. 190, and Section 4. For employed households, it is compulsory to participate in the first two pillars. Additional voluntary contributions can be made to the second pillar, if there is a gap between the current pension wealth in that pillar and the contributions at the current income that would have accrued from age

[8] In the calibration for Germany we treat home equity in real estate other than the main residence as a substitute for tax-incentivized pension savings. We do not model it separately to economize on the number of state variables in our portfolio choice problem.

[9] In the calibration, we increase the deduction to 2,500 euro for Germany to capture subsidies to other illiquid saving instruments such as the *vermögenswirksame Leistungen*.

[10] Furthermore, the valuations used by the tax authorities may not coincide with the current market valuation. More detailed information is in Eidgenössische Steuerverwaltung (2015). An example for the canton of Berne concerning the calculation of the imputed rent is provided by Steuerverwaltung des Kantons Bern (2016).

24. Voluntary contributions to the third pillar can be tax deducted up to a maximum amount of CHF 6,826 (corresponding to 6,322 euro in September 2020) for households also contributing to the second pillar.

Pension savings are much less liquid than in the U.S. They remain illiquid until retirement but for the exception that the savings are withdrawn or used as collateral for the purchase of the first residence (Bütler and Stadelmann, 2020), or if the household becomes self employed. Once the savings are withdrawn from the third pillar before retirement, they are taxed separately from income at much lower tax rates of $3-6\%$ depending on the region. The withdrawal can be spread over the last few years prior to retirement so that tax smoothing is possible.

3 Model

We analyze the effect of the different tax incentives in Germany and Switzerland on the portfolio choice of homeowners. We focus on homeowners for at least two reasons. Firstly, there is no empirical evidence or theoretical prior that the different tax incentives across Germany and Switzerland should have strong effects on home ownership in our quantitative application. Empirically, Germany and Switzerland have very similar ownership rates, as discussed in subsection 2.1. Theoretically, it is not obvious that the different tax incentives in Switzerland, described in subsection 2.3, make home ownership more attractive. On the one hand, Swiss homeowners can deduct interest payments from taxable income, which makes home ownership more attractive. On the other hand, the imputed rent increases the taxable income of Swiss homeowners, which makes home ownership less attractive. In fact, the different tax treatment in Switzerland should not affect the home ownership choice if the housing value, which is applied in the computation of the imputed rent, did not deviate from the current market value.[11]

Secondly, the focus on homeowners allows us to model their portfolio choices in more detail, by allowing wealth accumulation in two types of assets. We thus allocate the computational burden to capture those features which seem crucial for our analysis. See Campbell and Cocco (2003) or, more recently, Laibson et al. (2021) for a similar strategy.

[11] Gruber et al. (2021) provide empirical evidence that home ownership does not respond to changes of mortgage-interest tax deductions even if the imputed rent is smaller than the true rental income that would be generated by the home.

In our dynamic model, homeowners with a mortgage have the choice between accumulating home equity and illiquid tax-incentivized pension assets. As we will illustrate in subsection 3.2, the possibility of accumulating a pension asset opens an important channel through which tax incentives affect mortgage amortization. We model the degree of illiquidity by specifying at which point in the life cycle pension assets generate consumption flows. We implicitly assume that mortgages are more liquid than pension assets, by considering the illiquid pension assets together with a liquid second asset, which has the interpretation of (mortgage) debt when this position is negative.

The model features two endogenous state variables determined by the portfolio choice for the two assets and a stochastic state variable determining labor income. Stochastic labor income implies that agents value liquidity of assets to smooth consumption after unexpected, persistent changes in labor income. We solve the model by applying the endogenous gridpoint method, as further explained in Appendix A.1.

We consider the problem of an owner of a house with a size h. At each age j, the homeowner has the portfolio choice between (i) accumulating asset a, which implies amortizing the mortgage if $a < 0$, and (ii) accumulating pension wealth a_p by making a voluntary pension contribution.

The asset a denotes debt if $a < 0$ and assets if $a \geq 0$. We assume an interest spread $\zeta_\ell > 0$ for loans ($a < 0$). This allows us to model mortgage debt and liquid assets parsimoniously with one endogenous state variable. The benefit is thus that we can reduce the portfolio choice problem to two dimensions which reduces the computational burden. The cost is that the position of (mortgage) debt is also influenced by liquidity considerations. Mortgage amortization may be more attractive in our model than in reality because agents amortize also to have sufficient liquidity to self insure against shocks.

For agents close to the borrowing limit, amortization for precautionary reasons makes it harder to detect the effect of tax incentives on amortization behavior. Precautionary savings will induce amortization until the agent has enough liquidity buffer but then tax incentives shape the portfolio choices of agents. When interpreting the results, we thus have to keep in mind that liquidity considerations are important for the choice of the debt position $a < 0$ of consumers close to borrowing limit. In the calibrated model, we find that the incidence of the borrowing limit is at most 3% across age groups.

3.1 The portfolio choice problem

We solve the problem by backward induction. So, although the focus of our analysis is on the effect of tax incentives on portfolio choices prior to retirement, we first characterize the continuation value at retirement.

3.1.1 The continuation value at retirement

The continuation value at retirement depends on accumulated net worth and labor income prior to retirement. We provide a parsimonious characterization in closed form for the continuation value assuming that the agent liquidates all assets at retirement and then consumes a fraction of the resources as implied by permanent income theory. Define net worth at retirement as

$$x \equiv \phi_{\text{ret}} h + a_p + a - \upsilon \frac{a^2}{2} \mathbb{1}_{a<0} \ , \tag{1}$$

with ϕ_{ret} denoting the relative house price at retirement in units of the consumption numeraire, and a cost of debt at retirement with $\upsilon > 0$.

The cost is quadratic, differentiable and approaches zero as debt becomes infinitesimally small. The indicator function $\mathbb{1}_{a<0}$ takes the value of 1 if the homeowner has debt ($a < 0$) at retirement and the value of 0 otherwise. The cost of debt at retirement captures costs that homeowners may face, for example, if they bequeath a house with a mortgage. In Germany, most mortgages are not assumable, i.e., the heir cannot assume the mortgage together with the inherited house, whereas most mortgages are assumable in Switzerland. For the purposes of the calibration presented below, the parameter υ gives the model some additional flexibility to match the incidence and size of homeowners' debt observed for homeowners over their life cycle in Germany.

From the retirement age J^{ret} onwards, homeowners also receive income $\chi y_{J^{ret}}$ in each period through the public pension system, with $0 < \chi < 1$. Thus, a permanent income consumer with (approximately) infinite horizon in the post-retirement period without uncertainty, discounting the future at the interest rate ι, consumes the taxable income flow

$$y_{\tau}^{ret}(x, y(J^{ret})) \equiv \iota x + \chi y(J^{ret}), \tag{2}$$

net of the deducted taxes.[12] The value function at retirement is thus

$$V_{J^{ret}}(x, y(J^{ret})) = \xi u\left(y_\tau^{ret} - T(y_\tau^{ret})\right). \tag{3}$$

The parameter ξ scales the strength of the continuation value in the calibration. Denoting the subjective discount factor with β, we allow ξ to deviate from $(1-\beta)^{-1}$, the factor which would multiply the period utility during retirement if homeowners had an infinite horizon and no bequest motive. A shorter horizon or the strength of the bequest motive may affect the value derived from accumulated wealth at retirement.

3.1.2 The optimization problem prior to retirement

In the recursive problem prior to retirement, we have to distinguish the case $a' \geq 0$ and $a' < 0$ because of (i) the different tax treatment of interest paid on debt and on assets, and (ii) the interest spread which implies different prices for debt and assets. The recursive problem of the homeowner with a house of size h is:

$$V_j(a, a_p, y; h) = \max_{c, a', a'_p} u(c) + \beta \mathbb{E}_{y'} V_{j+1}(a', a'_p; y', h') \tag{4}$$

$$\text{s.t} \quad c^{a' \geq 0} = y - T(y_\tau^{a' \geq 0}) - (q_p a'_p - a_p) - (q_a a' - a) \tag{5}$$

$$c^{a' < 0} = y - T(y_\tau^{a' < 0}) - (q_p a'_p - a_p) - (q_\ell a' - a) \tag{6}$$

$$y_\tau^{a' \geq 0} = y + (\iota + \zeta_h)\omega h_0 \phi_0 - (q_p a'_p - a_p) + \iota q_a a' \tag{7}$$

$$y_\tau^{a' < 0} = y + (\iota + \zeta_h)\omega h_0 \phi_0 - (q_p a'_p - a_p) + (\iota + \zeta_\ell) q_\ell a' \tag{8}$$

$$q_a = 1/(1+\iota); q_\ell = 1/(1+\iota+\zeta_\ell); q_p = 1/(1+\iota+\zeta_p) \tag{9}$$

$$a' \geq -\mu_j h \phi / q_\ell, \tag{10}$$

$$(\bar{p} + a_p)/q_p \geq a'_p \geq a_p/q_p \tag{11}$$

$$y(j) = \exp\left(\psi_0 + \sum_{i=0}^{4} \psi_i \cdot j^i + \hat{y}\right) \tag{12}$$

$$\hat{y}' = \rho \hat{y} + \epsilon, \text{ where } \epsilon \sim N(0, \sigma_\epsilon) \tag{13}$$

[12]A finite horizon T at retirement could be accommodated with an additional factor $1 - \beta^{T+1}$ multiplying period utility and an additional factor $1/(1-(1+\iota)^{-(T+1)})$ multiplying net worth x. For our analysis the parsimonious version in the main text has enough degrees of freedom to capture a continuation value at retirement that depends on accumulated wealth.

The problem has two endogenous state variables (a, a_p), the stochastic state variable y and a home of size h. Given that we analyze the portfolio choice conditional on home ownership, the value of h is taken as given.

The amount of debt held by the homeowner is limited by the collateral constraint (10). The term $\mu_j h\phi$ denotes the maximum loan that households can hold at age j for a home with value $h\phi$ accounting for interest payments. The loan-to-value ratio μ_j, with $1 \geq \mu_j \geq 0$, may vary with age to capture required amortization.[13] For example, the maximum loan-to-value ratio may decrease because the second mortgage has to be amortized until retirement.

The stochastic idiosyncratic income shocks are persistent as shown in (13), with a persistence parameter ρ, with $0 \leq \rho \leq 1$. Equation (12) shows the common decomposition of income y into a stochastic component $\hat{y}$ and a deterministic hump-shaped life-cycle profile, which we estimate using the household panel data from the SOEP for Germany and SHP for Switzerland.[14] In equations (7) and (8) this income is converted into taxable income. We take into account how the portfolio positions of households may affect taxable income because of the imputed rent $(\iota + \zeta_h)\omega h_0 \phi_0$ based on the house value $\omega h_0 \phi_0$ determined by the parameter ω as specified in the regulation, interest income on the liquid assets $\iota q_a a'$ if $a' \geq 0$, deductions of mortgage interest payments $(\iota + q_\ell)q_\ell a'$ if $a' < 0$, and deductions of pension contributions $q_p a'_p - a_p$, with prices of the assets defined in (9) as for a zero-coupon bond given our timing assumption which we discuss next. In our quantitative application, the taxable income in equations (7) and (8) simplify for Germany because imputed rents are not taxed and mortgage interest payments of the main residence cannot be tax deducted, which we discussed in subsection 2.3.

As usual in models with discrete time, we have to make a timing assumption about the accrual of the interest rate. We choose the timing so that households

[13]In the model, agents have some flexibility when to amortize, as may be achieved with the possibility of indirect amortization available in mortgage markets. This type of amortization allows households to accumulate pension assets instead of amortizing each period. The accumulated pension assets are pledged as collateral to the bank and are used to amortize the loan amount at the point in time at which this is required, instead of amortizing through payments each period over the life of the loan. This gives households more flexibility in their portfolio choices. The model accounts for this by not imposing a minimum amortization constraint for payments each period but by allowing for a tighter maximum loan-to-value ratio μ_j at specific stages of the life cycle, which in turn imply amortization payments for the outstanding debt amounts until specific maturity dates.

[14]We provide further information on the data in Appendix A.2, and on the estimation of the income process in Appendix A.3.

can optimize their tax burden by choosing their portfolio after the income draw and reap the immediate gain of the tax optimization in the current period before the next shock occurs. We assume that choices are made at the beginning of each period so that interest on the asset positions accrues until the end of the period. The constraints in the recursive problem reflect this timing assumption. Given the timing, the interest payment on debt $\iota + \zeta_\ell$ for taxable income in (8), for example, is multiplied by the value of the chosen debt position $q_\ell a'$. In the collateral constraint (10), the value of debt is restricted by the required collateral. The constraints in (11) make explicit that tax deductable pension contributions cannot be negative and are capped at $\bar{\mathrm{p}}$.

We allow for interest spreads in problem (4) where the interest rates in our model should be interpreted as risk-adjusted rates.[15] The spread $\zeta_p > 0$ denotes the spread between the interest rate on pension wealth and the rate ι on liquid assets. The spread $\zeta_\ell > 0$ denotes the spread between the interest rate for mortgages and the rate ι on liquid assets. For the imputed rent in (7) and (8) we allow for a spread $\zeta_h > 0$. The parameter ω, with $1 \geq \omega > 0$, captures the fraction of the home value that is specified in the tax law to impute the rent.

Pension assets are illiquid before retirement.[16] They cannot be consumed until retirement, directly or indirectly by collateralizing them. Home equity is liquid instead. In a stylized way, this captures that housing and the associated mortgage liability is more liquid than pension assets in Germany and Switzerland. Empirically, some households tap into home equity in Germany and Switzerland although this less common than in the U.S. (European Central Bank, 2009; Basten and Koch, 2015).

3.1.3 Optimal choices

We now characterize the optimal choices at interior optima and provide a simple example to illustrate how tax incentives affect the portfolio choice of households. The first-order conditions for the choice of the portfolio (a', a'_p) at interior optima are

[15]The model thus does not capture that some homeowners may desire to leverage their house to invest into risky assets. Adding risky assets to our model, would require further modeling twists to avoid counterfactual predictions related to the portfolio allocation puzzle: for plausible values of risk aversion, the empirical equity premium implies too large portfolio shares of risky assets held compared with the data (Heaton and Lucas, 1997).

[16]We allow homeowners to accumulate pension assets until the last period before retirement. We thus impose $a'_p = 0$ in the last period before retirement, in which both assets would have the same liquidity.

$$a' : \quad \frac{\partial u(c)}{\partial c}\left(-q_k - \frac{\partial y_\tau}{\partial a'}\frac{\partial T(y_\tau)}{\partial y_\tau}\right) + \beta\frac{\partial \mathbb{E}_j V_{j+1}(a', a_p'; y', h')}{\partial a'} = 0 \;, \tag{14}$$

where $k = \ell$ if $a' < 0$ and $k = a$ if $a' \geq 0$, and

$$a_p' : \quad \frac{\partial u(c)}{\partial c}\left(-q_p - \frac{\partial y_\tau}{\partial a_p'}\frac{\partial T(y_\tau)}{\partial y_\tau}\right) + \beta\frac{\partial \mathbb{E}_j V_{j+1}(a', a_p'; y', h')}{\partial a_p'} = 0 \;, \tag{15}$$

with

$$\frac{\partial y_\tau^{a'\geq 0}}{\partial a'} = q_a \iota \;, \; \frac{\partial y_\tau^{a'<0}}{\partial a'} = q_\ell(\iota + \zeta_\ell) \;, \; \frac{\partial y_\tau}{\partial a_p'} = -q_p \;. \tag{16}$$

The envelope conditions at interior optima are

$$\frac{\partial V_j(a, a_p, h, y)}{\partial a} = \frac{\partial u(c)}{\partial c} \;, \tag{17}$$

and

$$\frac{\partial V_j(a, a_p, h, y)}{\partial a_p} = \frac{\partial u(c)}{\partial c}\left(1 - \frac{\partial T(y_\tau)}{\partial y_\tau}\right) \;, \tag{18}$$

with

$$\frac{\partial y_\tau}{\partial a} = 0 \;, \; \frac{\partial y_\tau}{\partial a_p} = 1 \;. \tag{19}$$

3.2 Tax incentives and portfolio choice: an illustrative example

Before we numerically solve and calibrate the life-cycle model, it is instructive to consider an example to illustrate how tax incentives shape portfolio choices of homeowners before retirement.

We illustrate key differences in the returns of the portfolio items by considering agents with linear utility who only care about the (expected) returns of the portfolio items. Uncertainty and (il)liquidity thus do not play a role in this example but will be accounted for in the calibrated model.

Let us first consider the case without tax incentives in which portfolio choices are not distorted by taxes. The plausible assumption that the risk-adjusted interest spread is higher for mortgage debt than for pension assets, i.e., $\zeta_\ell > \zeta_p > 0$, then implies that agents prefer to accumulate home equity by amortizing the mortgage because $q_\ell < q_p < q_a$. Home equity has the highest return and thus the lowest price.

We now illustrate how tax incentives may change this portfolio choice. Agents prefer to accumulate pension assets rather than to amortize their mortgage if the after-tax prices for the assets, implied by the first-order conditions (14) and (15) together with the assumptions of linear utility and no uncertainty, are such that

$$q_p \frac{1 - \frac{\partial T(y_\tau)}{\partial y_\tau}}{1 - \frac{\partial T(y'_\tau)}{\partial y'_\tau}} < q_\ell \left(1 + (\iota + \zeta_\ell)\frac{\partial T(y_\tau)}{\partial y_\tau}\right) < q_a \left(1 + \iota \frac{\partial T(y_\tau)}{\partial y_\tau}\right) . \tag{20}$$

The two stylized cases without and with tax incentives illustrate how the different portfolio choices may occur that we documented for Germany and Switzerland in Section 2.

We now provide further intuition for the inequalities in (20) by deriving, for example, the critical marginal tax rate at which homeowners prefer to accumulate pension assets rather than home equity. For this purpose, it is useful to consider proportional taxes with a tax rate τ, for which the inequalities in (20) simplify to

$$q_p < q_\ell \left(1 + (\iota + \zeta_\ell)\tau\right) < q_a \left(1 + \iota\tau\right) . \tag{21}$$

It then follows that homeowners prefer to accumulate pension assets rather than home equity if

$$\tau > \frac{\zeta_\ell - \zeta_p}{\left(1 + \iota + \zeta_p\right)(\iota + \zeta_\ell)} \equiv \tau^*_{\ell,a_p} , \tag{22}$$

where we have substituted the prices of the different assets using (9).

Homeowners prefer to accumulate home equity rather than liquid assets if

$$\tau < 1 \equiv \tau^*_{\ell,a} \, , \tag{23}$$

and they prefer to accumulate pension assets rather than the risk free asset at any tax rate if $\zeta_p > 0$.

In the illustrative example with linear utility and without uncertainty, accumulating asset a is dominated once the debt is paid back because accumulating the pension asset offers a higher return. Consumption is a perfect substitute across time for generating utility (but for discounting) so that homeowners do not value the higher liquidity which asset a offers if they do not have motives for consumption smoothing or precautionary saving. The portfolio choice then simplifies to a choice between home equity and the pension asset if $a' < 0$, where the choice depends on the strength of tax incentives. The pension asset dominates if the agent wants to accumulate wealth after the debt has been paid off.

The illustrative example highlights the important role of tax-incentivized pension contributions, which change the portfolio choice in a crucial way. If we abstracted from these contributions, homeowners with tax incentives as in Switzerland would prefer to accumulate home equity rather than to accumulate the risk-free asset (for any tax rate below 100%). Despite the different tax incentives, the model then would predict similar levels of leverage of homeowners in Switzerland as in Germany, which is at odds with the stylized facts presented in Section 2.

With tax-deductible voluntary pension contributions, homeowners facing tax incentives as in Switzerland and a tax rate $\tau > \tau^*_{\ell,a_p}$ instead accumulate pension assets rather than home equity and thus do not amortize their mortgage. Only if they reach the maximum tax-deductible pension contribution and have fully amortized the mortgage, it is optimal for them to accumulate risk-free assets.

How high does the marginal tax rate need to be to make homeowners prefer tax-deductible pension contributions over mortgage amortization? If we consider plausible values for the spreads $\zeta_\ell = 0.015$, $\zeta_p = 0.005$, an interest rate $\iota = 0.02$, the critical value in (22) is $\tau^*_{\ell,a_p} = 0.28$. That is, homeowners prefer to accumulate pension assets rather than home equity if they face a marginal tax rate larger than 0.28. If the spread for the mortgage interest rate decreases to $\zeta_\ell = 0.01$ so that the difference between the spreads $\zeta_\ell - \zeta_p$ is smaller, the critical value decreases to

$\tau^*_{\ell,a_p} = 0.16$, as is intuitive given that the after-tax return to mortgage amortization falls.

Furthermore, (22) shows that amortization becomes relatively more attractive relative to pension contributions at a *lower* interest rate ι. For example, if the interest rate decreases to $\iota = 0.01$, keeping the other parameters at their values $\zeta_\ell = 0.015, \zeta_p = 0.005$, the tax threshold increases to $\tau^*_{\ell,a_p} = 0.39$. The intuition is that the interest rate ι and the marginal tax τ enter in a complementary fashion in the factor, which multiplies q_ℓ in (21) and determines the size of the after-tax return of mortgage amortization relative to pension contributions.

Extensions.– If taxation is progressive, then the factor

$$\phi_\tau \equiv \frac{1 - \frac{\partial T(y_\tau)}{\partial y_\tau}}{1 - \frac{\partial T(y'_\tau)}{\partial y'_\tau}} \tag{24}$$

in (20) makes accumulation of pension assets through tax-deductible contributions more attractive if $\phi_\tau < 1$, i.e., if the marginal change of the tax burden after an increase of taxable income in the current period is higher than in the future period. Hence, agents with currently high income who expect lower income in the future have an additional motive to use accumulation of pension assets for tax smoothing purposes.

Further effects become relevant at corners, i.e., when the amortization choice is constrained or when the pension contributions of the agents reach the cap $\bar{p}$. Denoting with η_u the multiplier of the constraint in (11) that pension contributions are capped by $\bar{p}$, the optimality conditions including the multipliers then imply that accumulation of the tax-incentivized pension asset today becomes more attractive if $\eta'_u > 0$, i.e., if the cap for pension contributions is binding in the next period. Intuitively, limiting the extent to which agents can take advantage of tax deductions for their pension contributions tomorrow, makes it more attractive to exploit the tax deductibility for pension contributions today.

The illustrative example in this subsection is based on the strong assumptions of linear utility and no uncertainty. With strictly concave utility and shocks to labor income, the liquidity of asset a also allows homeowners to smooth consumption and to self insure in the period until retirement. We now turn to the calibrated model which accounts for these motives.

4 Calibration

We solve the model with the endogenous gridpoint method, as explained further in Appendix A.1. Based on the simulation of the model for 100,000 homeowners from age 35 until retirement, we calibrate the model to Germany and then perform a counterfactual experiment, in which we expose the German households to the Swiss tax incentives. We decompose the effect to gauge how much of the differences in portfolio choices across the two countries can be attributed by the model to the differences in incentives associated with the taxation of imputed rents, the cap on tax-deductible voluntary pension contributions, and the tax-deductibility of mortgage interest payments. These are three key ways in which tax incentives for portfolio choices differ across developed countries so that the results of the decomposition should be of interest beyond the concrete application we focus on.

Table 3 summarizes the parameter values for Germany and Switzerland. The top panel of the table displays the externally calibrated parameters, of which some are common across the two countries and others differ. The bottom panel shows the internally calibrated parameters, i.e., the discount factor, the parameter determining the cost of debt at retirement and five initial conditions related to net worth and portfolio choices. As we explain further below, we calibrate these parameters by matching ten moments of homeowners' portfolios at young ages 36 to 40 and close to retirement at ages 61 to 65.

Concerning the common, externally calibrated parameters, we set the preference parameter capturing risk aversion and the intertemporal elasticity of substitution to the standard value of 2. The risk-free rate of 2% corresponds to the (approximately) risk-free return on long-term government bonds in Germany and Switzerland, net of inflation in the pre-crisis period in the 2000s. Compared to that rate, we set the (risk-adjusted) spread of 1.5 pp for mortgages and the rates used for imputing rents, and we set the (risk-adjusted) spread for pension assets to 0.5 pp, broadly in line with evidence reported in European Central Bank (2009) and OECD (2007). Concerning the borrowing opportunities, the maximum loan-to-value ratio is 100%, i.e., $\mu_j = \mu = 1$. This calibration is motivated by the model, in which a consolidates all assets and liabilities but for the pension

Table 3: Parameter values

Panel A: Externally calibrated parameters		
I. Common parameters		
Preferences		
Risk aversion σ	2	
Interest rates		
Liquid asset: ι	0.02	
Spread for pension asset: ζ_p	0.005	
Spread for mortgage: ζ_ℓ	0.015	
Spread for imputing rent: ζ_h	0.015	
Borrowing opportunities: $\mu_j = \mu$	1	
II. Country-specific parameters		
	Germany	Switzerland
Tax incentives for portfolio choices		
Cap for tax-deductible pension contributions per year:		
$\bar{p}$ as percentage of average income	6.81%	13.5%
Imputed rent: fraction ω of house value	0	0.7
Mortgage interest payments	Not tax-deductible	Tax-deductible
AR(1)-process for income: $\ln(y') = \rho \ln(y) + \epsilon$, $\ln y' \sim \mathcal{N}\left(-\frac{\sigma_\epsilon^2}{2(1-\rho^2)}, \frac{\sigma_\epsilon^2}{1-\rho^2}\right)$		
Income autocorrelation ρ	0.806	0.771
Variance of innovations σ_ϵ^2	0.078	0.086
Income age polynomial (4th order)	See graphical illustration in Appendix A.3	
Replacement rate of pay-as-you go pension benefits	57.3%	68.8%
Income taxes		
Income tax $T^y(y) = y - \lambda y^{1-t_y}$	$t_y = 0.174$, $\lambda = 5.020$	$t_y = 0.113$, $\lambda = 2.958$
Panel B: Internally calibrated parameters		
Discount factor β	0.989	
Cost of outstanding debt at retirement υ	0.64	
Initial conditions of homeowners' portfolios	see main text	

Notes: See Appendix A.2 for the data description, Appendix A.3 for the estimation of the income age profile and the calibration of the income process, and Appendix A.4 for the estimation of the tax function.

savings. Thus, the liquid equity position of a contains mortgage debt as well as other debt which homeowners may have access to.

Concerning the country-specific, externally calibrated parameters, we estimate the respective income processes, age profiles of labor income, and tax functions as explained in Appendices A.2 and A.3. We also account for the slight differences in the net replacement rate of the pay-as-you go component of the pension system. We specify different caps on tax deductible voluntary pension contributions, a different tax treatment of imputed rents for owned housing, and a different tax-deductibility of mortgage interest payments, as discussed in Section 2. The estimates of the income-tax functions show that taxes are higher and more progressive in Germany than in Switzerland.

Concerning the internally calibrated parameters, the discount rate allows us to match the observed wealth accumulation of homeowners over the life-cycle. The cost of outstanding debt at retirement helps to match the portfolio composition at retirement.[17] The following five initial conditions for homeowners at age 35 account for the portfolio composition observed at young ages 36 to 40. The calibrated initial share of mortgagors is 82.3%. The average initial debt, i.e., the absolute value of negative liquid equity ($a < 0$), of mortgagors is 90,457 euro, the average liquid equity ($a >= 0$) of non-mortgagors is 33,307 euro, and the average initial position in the pension fund is 12,402 euro for mortgagors and 2,018 euro for non-mortgagors. Starting from these initial conditions, we constrain home equity to be weakly positive, as implied by the maximum loan-to-value ratio of 100%.

[17] The parameter value 0.64 implies that debt at retirement equal to a model unit, which corresponds to 44,000 euro, implies a cost of 23,800 euro. This sizable cost illustrates that German homeowners would hold substantially more (mortgage) debt at retirement if, for example, it were provided by creditors at lower cost.

Table 4: Comparison of the model predictions with the data targets

	Ages 36 to 40		Ages 61 to 65	
	Model	Data	Model	Data
Liquid Equity	-64,961	-64,961	33,578	33,578
(all homeowners)		(-77,841; -52,081)		(24,366; 42,790)
Liquid Equity	-85,264	-86,612	-50,643	-50,644
(mortgagors)		(-96,521; -76,703)		(-61,604; -39,684)
Net Worth	104,488	105,385	230,742	205,186
(all homeowners)		(91,798; 118,972)		(187,322; 223,049)
Net Worth	85,259	85,258	128,888	126,967
(mortgagors)		(74,374; 96,143)		(108,508; 145,425)
Incidence of mortgagors	82.4%	82.4%	40.7%	24.9%
		(74.8%; 90.0%)		(20.0%; 29.9%)

Notes: Values are in euro, except for the incidence of mortgagors. 95% confidence intervals are reported in brackets for the data targets, based on the second wave of the HFCS.

Table 4 shows that the model predicts somewhat more mortgagors at retirement relative to the data but fits the data quite well overall. Table 5 reveals that, by and large, the model also matches non-targeted portfolio shares and the homeowner's leverage across age groups. This is confirmed by Figures A.4 to A.6 in Appendix A.5, which compare the model predictions with the data in more detail across age groups. Table 5 and Figure A.5 show that the model predictions for wealth accumulation in pension funds diverge from the data targets after age 55 because the amount of pension savings of homeowners decreases in the data after that age whereas the model predicts pension savings to increase. Part of the gap may be explained by investments into real estate other than the primary residence, which may be attractive for tax reasons particularly at older ages for German homeowners.[18]

[18]Furthermore, the portfolio share of pension funds may be difficult to measure. The estimate of the portfolio share of pension funds based on the SHARE is higher at 12.2% than the estimate based on the HFCS of 8.4%, and thus closer to the model predictions.

Table 5: Comparison of model predictions and data moments for non-targeted portfolio shares and leverage

	Ages 36 to 40		Ages 61 to 65	
	Model	Data	Model	Data
LTV	44.5%	45.2%	13.1%	8.0%
		(38.6%, 51.8%)		(5.7%, 10.3%)
Share Pension Fund	13.0%	17.8%	18.6%	8.4%
		(13.1%, 22.6%)		(6.3%, 10.4%)
Share Liquid Assets	2.7%	2.6%	14.9%	13.9%
		(0.8%, 4.5%)		(10.5%, 17.3%)
Share Home Equity	84.3%	79.5%	66.5%	77.7%
		(74.8%, 84.2%)		(74.0%, 81.5%)

Notes: Values are in percent. The loan-to-value ratio is computed for all homeowners and thus includes zeros for outright owners. 95% confidence intervals are reported in brackets for the data moments, based on the second wave of the HFCS.

5 The effect of tax incentives on household portfolios

Based on the calibrated model, we analyze how tax incentives change portfolio choices over the life cycle. Our analysis builds on the intuition obtained from the illustrative example presented in subsection 3.2 but takes into account the occasionally binding constraints on portfolio choices in an environment with income uncertainty.

When we perform the experiments, we adjust taxes so that the experiments are revenue neutral where the change in the average income tax required is only 0.7 pp at the average income. The adjustment thus does not matter qualitatively for our main findings but for the quantitative results. Specifically, we solve the model, compute the tax revenues and then adjust the parameter λ in the income tax function in the direction required to achieve revenue neutrality. We then solve the model again and iterate using the bisection method until we have found the value of λ, for which the tax revenue is the same, up to a chosen level of precision. Although different tax incentives thus will not change tax revenues overall, they shift tax revenues across age groups as we discuss further below.

Table 6: The effect of tax incentives on portfolio choices at ages 61 to 65

	(1) Benchmark economy	(2) Taxation of imputed rent	(3) Higher pension cap	(4) Mortgage interest deduction	(5) Joint changes (2)-(4)	(6) Lower debt cost	(7) Data CH
Incidence of mortgagors	40.7%	41.6%	43.9%	47.6%	52.8%	57.3%	66.5% (59.8%, 73.3%)
LTV of homeowners	13.1%	13.6%	13.4%	16.2%	17.7%	23.5%	19.1% (16.2%, 22.0%)
LTV of mortgagors	32.1%	32.7%	30.5%	34.1%	33.5%	40.9%	28.7% (25.4%, 32.0%)
Share pension fund	18.6%	18.8%	25.2%	21.3%	28.3%	31.2%	16.0% (13.8%, 18.3%)

Notes: Starting from the benchmark economy calibrated to Germany in column (1), columns (2) to (4) report the effect of the change mentioned in the header of the column. In column (5) with the header 'Joint changes,' we implement the changes of columns (2) to (4) jointly, thus implementing the Swiss tax treatment of portfolio choices. In column (6) called 'Lower debt cost,' we furthermore reduce the cost of debt at retirement by reducing υ from 0.64 to 0.32. Column (7) reports the data moments for Switzerland. 95% confidence intervals are reported in brackets for the data moments, based on SHARE 2015.

Table 6 shows the results of the experiments. Starting from the benchmark economy calibrated to Germany in column (1), columns (2) to (4) report the effect of the respective change of taxing imputed rents, increasing the cap for tax-deductible voluntary pension contributions, and allowing for tax deductions of mortgage interest payments. In the fifth column, we consider these three changes jointly, thus implementing the Swiss tax treatment of portfolio choices. In column (6), we then also reduce the cost of debt at retirement by reducing υ from 0.64 to 0.32. In the last column, we report the data moments for Switzerland.

The first row of Table 6 shows that, through the lens of the model, tax incentives explain between a quarter and half of the difference in the incidence of mortgagors close to retirement at ages 61 to 65. Comparing columns (5) and (1), shows that the incidence increases by 12 percentage points (pp) if we compare the economy, in which all the tax incentives have been changed jointly, with the benchmark economy. In comparison, the incidence of mortgagors in the Swiss data in column (7) is 26 pp higher than in the calibrated benchmark economy and 42 pp higher than in the German data, as shown in the last row of Table 4. Columns (2) to (4) reveal that the tax deduction of mortgage interest payments has the largest effect on the incidence of mortgagors, increasing it by 7 pp.

The effect of tax incentives on the incidence of mortgagors, reported in the first row of Table 6, is the main driver of the increase in the LTV ratio of homeowners, reported in the second row, because, in line with the data, the LTV ratio conditional on being a mortgagor does not change much as reported in the third row. The last row of Table 6 shows that the Swiss tax incentives for portfolio choices increase the portfolio share of pension funds by 10 pp. This change matches the difference in portfolio shares observed in the data (8.4% in Germany as reported in Table 5 and 16% in Switzerland as reported in Table 6) but the model predicts a too high share in the calibrated benchmark economy, as already discussed in Section 4, and thus also after the changes in the tax incentives.

In column (6) of Table 6, we investigate whether reducing the cost of debt at retirement in Switzerland relative to Germany, additional to the changes implemented in column (5), helps to reduce the residual gap between the model predictions and the data moments. Column (6) shows that reducing the cost (parameter) by half, would increase the incidence of mortgagors from 52% to 57%, closing some of the gap to the 67% observed in the data. The downside is, however, that the reduction of the cost (parameter) implies an increase in the LTV ratio of mortgagors, which we do not observe in the data. It also adds to the increase of the portfolio share of pension funds, which is too strong compared to the data to begin with.

To sum up, the experiments show that tax incentives for portfolio choices explain an economically sizable part of the observed differences in the incidence of mortgage debt between Germany and Switzerland. The results also show that there remains room for other determinants of the cross-country differences in portfolio choices. Anecdotal evidence from Switzerland suggests that some households, which do not repay their mortgage, do not invest into tax-incentivized pension savings but rather hold return-dominated liquid assets. This puzzle is reminiscent of the credit-card debt puzzle in Anglo-Saxon countries and may partly be explained by liquidity needs (Telyukova, 2013). The quantitative importance of this anecdotal evidence at the aggregate level is hard to assess without access to more comprehensive data sources.

The experiments reveal further insights, which we illustrate in Figures A.7 and A.8 in Appendix A.5. Figure A.7 shows that average net worth remains very similar over the life cycle if we change the tax incentives but the portfolio composition changes. The model predicts that the Swiss tax incentives would reduce the share of home equity and liquid assets ($a > 0$) in the portfolio of German homeowners but would increase the share of pension funds. Figure A.8 shows that the Swiss tax incentives would shift the tax revenues from young ages towards retirement so that net income is slight larger at young ages. These differences are also born out in the average consumption profile over the life cycle because non-insurable risk and occasionally binding constraints prevent full consumption smoothing. Thus, Swiss tax incentives imply that homeowners shift their consumption more towards young ages. Figure A.8 further shows that the effect of the Swiss tax incentives on the LTV ratio, conditional being a mortgagor, is moderate. Results, which are not reported for brevity, show that there is no large shift in the distribution of leverage: the share of homeowners with an LTV ratio above 75% by age group increases at most by 1 pp (from 3% to 4%) for younger homeowners between ages 40 and 45.

5.1 Policy relevance

The results of the experiments inform the current policy debate about tax reforms that aim to change tax incentives and thus households' portfolios. For example, there is a continuing discussion in the U.S. on abandoning the tax deductibility of mortgage interest payments (Sommer and Sullivan, 2018). Furthermore, the parliamentary initiative 17.400 in Switzerland proposes to abandon this tax deductibility together with the taxation of imputed rents, at the same time as initiative 20.494, or the related motion 19.3702, proposes to increase the cap for tax-deductible voluntary contributions into the pension scheme.

Our analysis shows that changes of the taxation of imputed rents, the tax deductibility of mortgage interest payments and the generosity of tax-deductible pension contributions have to be discussed and set together because they jointly determine portfolio choices. The larger are the caps for tax-deductible pension contributions, for example, the stronger is the effect of tax-deductible mortgage interest payments on the incidence of mortgagors.

Our analysis further reveals that tax incentives which increase the incidence of mortgage debt do not necessarily imply that more households are in financial difficulties. The larger gross debt positions may be the consequence of portfolio optimization that leaves the total net worth unchanged. Put differently, households do not take on debt to finance consumption but rather to invest into other assets and thus diversify their portfolio.

6 Macroprudential implications

Household debt in developed countries mainly consists of mortgages to finance home purchases and has been associated with boom-bust cycles in the housing market (Jorda et al., 2016). Household leverage may pose a risk to financial and economic stability because of mortgage delinquency after housing busts and the deleveraging of households that results in persistent consumption slumps (Mian et al., 2013).

Our analysis for Germany and Switzerland has illustrated that such a risk has to be weighed against the opportunity for portfolio optimization and diversification which leverage offers. Higher leverage, for example due to slower amortization of mortgages, is not necessarily associated with more household consumption and less accumulation of net worth. Higher leverage may allow households to invest more into assets with higher after-tax returns and help them to strengthen their portfolio diversification. This, in turn, may make them more resilient to shocks, reduce the consumption response to housing busts and thus improve economic stability.

Empirically, households in most developed countries amortize a large part of their mortgage until retirement and thus reduce their leverage much below the amounts, at which they risk mortgage delinquency or face consumption risk in case of a housing bust. We have illustrated that our model replicates this pattern. We have also mentioned that exposing German homeowners to the Swiss tax incentives would induce some young homeowners to increase their leverage, implying more homeowners with LTV ratios above 75%, but that this effect would be moderate.

From a macroprudential perspective, tax incentives for portfolio choices as in Switzerland introduce a trade-off between a higher incidence of hand-to-mouth consumers and shifts of portfolio choices and consumption as the tax burden shifts to older ages. To assess this trade-off quantitatively, we compute the effect of the Swiss tax incentives on the marginal propensities to consume (MPC). The MPC is key, as shown by Berger et al. (2018), because the response of consumption to house price changes equals, as a rule of thumb, the marginal propensity to consume multiplied by the house value prior to the house price change.[19]

[19] Analogously to Berger et al. (2018), we compute the marginal propensity to consume as the change of consumption over the change of net worth implied by the house price change. This is implemented by changing the amount of liquid equity in the policy function of consumption.

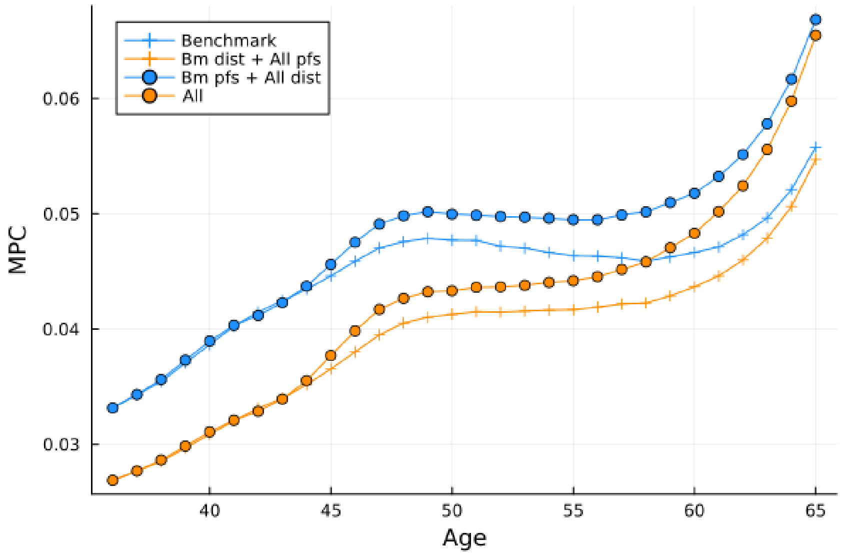


Figure 1: The average marginal propensity to consume by age group across economies with different tax incentives

Notes: The average MPC in the calibrated benchmark economy is labeled as 'Benchmark.' For the economy with the Swiss tax incentives, it is labeled as 'All.' The average MPC based on the policy function for the Swiss tax incentives, averaged using the distribution of assets a and a_p as in the benchmark economy, is labeled as 'Bm dist + All pfs.' Finally, the average MPC based on the policy functions in the benchmark economy, averaged with the distribution of assets a and a_p of the economy with Swiss tax incentives, is labeled as 'Bm pfs + All dist.'

Table 7: Tax incentives, the marginal propensity to consume, and the elasticity of consumption with respect to house price changes

	MPC		Elasticity	
	Benchmark	All	Benchmark	All
Overall	0.046	0.042	0.315	0.298
Young (ages 35 to 45)	0.040	0.032	0.300	0.238
Middle-aged (ages 46 to 55)	0.047	0.043	0.325	0.302
Old (ages 56 to 65)	0.047	0.049	0.311	0.333

Notes: The marginal propensity to consume is computed as the change of consumption over the change of net worth implied by the house price change, implemented by changing the amount of liquid equity in the policy function of consumption. The elasticity is then obtained by multiplying the average MPC of the respective group with the corresponding house value and dividing it by average consumption for the respective group. The calibrated benchmark economy is labeled as 'Benchmark.' The economy, in which homeowners face the Swiss tax incentives for portfolio choices, is labeled as 'All.'

Figure 1 plots the average MPC by age in the calibrated benchmark economy and the economy with Swiss tax incentives. To disentangle the effect of the tax incentives on the policy functions from the effect of the different endogenous joint distribution of the two assets a and a_p, we also plot the average MPC (labeled 'Bm dist + All pfs' in the figure) using the changed policy functions given the Swiss tax incentives for computing the MPC but averaging the MPC using the distribution of assets as in the calibrated benchmark economy. Analogously, we also plot the average MPC (labeled 'Bm pfs + All dist' in the figure) using the policy functions as in the benchmark economy for computing the MPC and averaging based on the distribution of assets of the economy with the Swiss tax incentives.

Figure 1 shows that the average MPC in the economy with Swiss tax incentives decreases relative to the benchmark, where the effect is larger at younger ages. If we average over age groups using the age weights from the HFCS data, the decrease of the MPC is 0.4 percentage points. Table 7 shows that this translates into a smaller elasticity of consumption after house price changes. As an illustration, consider a bust with a house price correction of 20%. In the counterfactual economy, in which German homeowners face the Swiss tax incentives, the consumption response of homeowners would be 0.34 pp lower on average than in the benchmark economy, in which consumption would fall by 6.3%.

We find sizable heterogeneity across age groups. For homeowners aged 35 to 45, the response after a house price correction of 20% is 1.24 pp lower in the economy with tax deductions than in the benchmark economy. For those aged 45 to 55, it is 0.46 pp lower whereas it is 0.44 pp higher for homeowners close to retirement with ages 56 to 65. The key driver for these differences is the tax deduction of mortgage interest payments, which allows young and relatively more indebted households to consume more consumption because the tax burden shifts to old, relatively wealthy households. We now provide further intuition for these findings.

Figure 1 shows that the average size of the MPC varies between 0.03 and 0.06 across age groups. Hence, it is larger than in a permanent income economy, in which the interest rate equals the discount rate so that the MPC would be equal to 0.011. Figure 1 shows that the MPC increases with age but, locally, may be non-monotonic in age. The figure further illustrates that, if we average the MPCs using the distribution of the portfolio for the benchmark economy, the average MPC becomes smaller after age 45 (compare the MPC labeled 'Bm pfs + All dist' and 'Benchmark', or 'All' and 'Bm dist + All pfs'). The effect of tax incentives on the wealth portfolios takes time as it cumulates over the life cycle, and the Swiss tax incentives shift the portfolio towards the illiquid pension asset.

The intuition for the fall of the MPC is that the Swiss tax incentives shift the tax burden to the older ages and thus allow homeowners to consume more at younger ages (see Figure A.8 in Appendix A.5), thus reducing the MPC on average. The intuition for the age pattern of the average MPC in Figure 1 is that the MPC is a non-monotonic function of liquid equity a and homeowners accumulate liquid equity over the life cycle. The non-monotonicity of the MPC as a function of liquid equity, which is qualitatively robust across homeowners with different pension assets or income, implies that tax incentives change the average MPC by changing the distribution of liquid equity.

Figure A.9 in Appendix A.5 illustrates how the MPC depends on the liquid equity a for a young homeowner with middle income at the beginning of the life cycle, across different holdings of pension assets. As is well known (e.g., Kaplan et al., 2018, Figure 2B), the MPC is higher at the borrowing constraint and at the so-called zero kink resulting from the interest spread. At the zero kink, the Euler equation for the liquid equity slack and agents choose $a' = 0$ (Kaplan et al., 2014).

The average MPC is thus higher if the incidence of the borrowing constraint or the zero kink is higher, which in turn depends on the tax incentives that determine the incentive to accumulate liquid equity. Figure A.10 in Appendix A.5 shows that the incidence of the borrowing constraint peaks at age 50 whereas the incidence of the zero kink increases until retirement. Both patterns are more pronounced in the economy with Swiss tax incentives, thus explaining the age pattern of the MPCs in Figure 1.

7 Conclusion

We have shown that common differences in tax incentives for mortgage amortization and the accumulation of pension funds imply economically relevant shifts in the portfolios which homeowners choose over their life cycle. Starting from the benchmark economy calibrated to Germany, we have investigated the effect of different tax incentives, as observed across developed countries. We have used the Swiss tax incentives as a representative example. Differently to Germany, homeowners in Switzerland can tax-deduct their mortgage interest payments on their primary residence, pay taxes on the rent imputed for that residence, and can tax deduct much larger amounts of voluntary pension contributions.

We have found that German homeowners would shift their portfolio from home equity to pension savings but accumulate similar amounts of net worth on average if they were exposed to Swiss tax incentives for portfolio choices in a revenue-neutral fashion. In particular, the incidence of mortgagors close to retirement would increase by 12 percentage points. The macroprudential implication is that the consumption slump after a house price correction of 20% would be 0.34 percentage points (pp) lower, if German homeowners faced Swiss tax incentives, and 1.24 pp lower for young homeowners. The reason is that Swiss tax incentives would allow indebted homeowners to consume more, particularly at younger ages, as the tax burden shifts to older ages.

Further research could investigate the optimal tax policy design given that homeowners do not internalize the aggregate consequences of their portfolio decisions and markets are incomplete. In such an environment, appropriate design of tax incentives may help to achieve portfolio choices and diversification that are socially optimal. Our analysis has shown that the tax incentives may serve as policy instruments for macroprudential regulation, complementing the relatively coarse changes of the maximum LTV ratio which are used in some developed countries.

References

Sule Alan, Kadir Atalay, Thomas F. Crossley, and Sung-Hee Jeon. New Evidence on Taxes and Portfolio Choice. *Journal of Public Economics*, 94(11-12):813–823, 2010.

Gene Amromin, Jennifer Huang, and Clemens Sialm. The Tradeoff between Mortgage Prepayments and Tax-Deferred Retirement Savings. *Journal of Public Economics*, 91:2014–040, 2007.

Cristian Badarinza, John Y. Campbell, and Tarun Ramadorai. International Comparative Household Finance. *Annual Review of Economics*, 8(1): 111–144, October 2016. URL `https://ideas.repec.org/a/anr/reveco/v8y2016p111-144.html`.

Kasper Kragh Balke, Markus Karlman, and Karin Kinnerud. Down-Payment Requirements: Implications for Portfolio Choice and Consumption. *Manuscript*, 2023.

Christoph Basten and Catherine Koch. The Causal Effect of House Prices on Mortgage Demand and Mortgage Supply: Evidence from Switzerland. *Journal of Housing Economics*, 30:1–22, 2015.

Jörg Baumberger. Die volkswirtschaftlichen Auswirkungen bei einem Systemwechsel der Eigenmietwertbesteuerung. *Gutachten zuhanden der Eidgenössischen Kommission Eigenmietwert/Systemwechsel (KES)*, 1999.

David Berger, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra. House Prices and Consumer Spending. *Review of Economic Studies*, 85:1502–1542, 2018.

BFS. Haushaltsbudgeterhebung 2011: Kommentierte Ergebnisse und Tabellen. *BFS Aktuell, July*, 2013.

Javier Bianchi and Enrique G. Mendoza. Optimal Time-Consistent Macroprudential Policy. *Journal of Political Economy*, 126(2):588–634, 2018. doi: 10.1086/696280. URL `https://ideas.repec.org/a/ucp/jpolec/doi10.1086-696280.html`.

Axel Börsch-Supan, Johanna Bristle, Karen Andersen-Ranberg, Agar Brugiavini, Florence Jusot, Howard Litwin, and Guglielmo Weber, editors. *Health and*

Socio-Economic Status over the Life Course. First Results from SHARE Waves 6 and 7. De Gruyter, 2019.

Olympia Bover, Jose Maria Casado, Sonia Costa, Philip Du Caju, Yvonne McCarthy, Eva Sierminska, Panagiota Tzamourani, Ernesto Villanueva, and Tibor Zavadil. The Distribution of Debt across Euro-Area Countries: The Role of Individual Characteristics, Institutions, and Credit Conditions. *International Journal of Central Banking*, 12(2):71–128, June 2016.

Monika Bütler and Sabrina Stadelmann. Building on a Pension: Second Pillar Wealth as a Way to Finance Real Estate? *The Journal of the Economics of Ageing*, 17(C):100261, 2020. URL https://EconPapers.repec.org/RePEc:eee:joecag:v:17:y:2020:i:c:s2212828x20300268.

John Y. Campbell and João F. Cocco. Household Risk Management and Optimal Mortgage Choice. *Quarterly Journal of Economics*, 118(4):1449–1494, 2003.

Eidgenössische Steuerverwaltung. Die Besteuerung der Eigenmietwerte. *Steuerinformationen Schweizerische Steuerkonferenz SSK*, 2015.

European Central Bank. Housing Finance in the Euro Area. Working paper, European Central Bank, Occasional Paper Series, No. 101, 2009.

Eurosystem Household Finance and Consumption Network. The Eurosystem Household Finance and Consumption Survey. Results from the first wave. Technical report, ECB statistics paper, 2013.

Jesus Fernández-Villaverde and Dirk Krueger. Consumption over the Life Cycle: Facts from Consumer Expenditure Survey Data. *The Review of Economics and Statistics*, 89(3):552–565, August 2007. URL https://ideas.repec.org/a/tpr/restat/v89y2007i3p552-565.html.

Nicola Fuchs-Schündeln, Dirk Krueger, and Mathias Sommer. Inequality Trends for Germany in the Last Two Decades: A Tale of Two Countries. *Review of Economic Dynamics*, 13(1):103–132, 2010.

Jan Goebel, Markus M. Grabka, Stefan Liebig, Martin Kroh, David Richter, Carsten Schröder, and Jürgen Schupp. The German Socio-Economic Panel (SOEP). *Journal of Economics and Statistics (Jahrbuecher fuer Nationaloekonomie und Statistik)*, 239(2):345–360, April 2019. URL https://ideas.repec.org/a/jns/jbstat/v239y2019i2p345-360n7.html.

Jonathan Gruber, Amalie Jensen, and Henrik Kleven. Do People Respond to the Mortgage Interest Deduction? Quasi-Experimental Evidence from Denmark. *American Economic Journal: Economic Policy*, 94(11-12):813–823, 2021.

Adam M. Guren, Alisdair McKay, Emi Nakamura, and Jon Steinsson. Housing Wealth Effects: The Long View. *Review of Economic Studies*, 88:669–707, 2021.

Jonathan Heathcote, Kjetil Storesletten, and Giovanni L Violante. Optimal Tax Progressivity: An Analytical Framework. *The Quarterly Journal of Economics*, 132(4):1693–1754, 2017.

John Heaton and Deborah Lucas. Market Frictions, Savings Behavior, and Portfolio Choice. *Macroeconomic Dynamics*, 1(1):76–101, January 1997. URL `https://ideas.repec.org/a/cup/macdyn/v1y1997i01p76-101_00.html`.

Marek Hlavac. *stargazer: Well-Formatted Regression and Summary Statistics Tables*. Central European Labour Studies Institute (CELSI), Bratislava, Slovakia, 2018. URL `https://CRAN.R-project.org/package=stargazer`. R package version 5.2.2.

Olivier Jeanne and Anton Korinek. Managing Credit Booms and Busts: A Pigouvian Taxation Approach. *Journal of Monetary Economics*, 107(C):2–17, 2019. doi: 10.1016/j.jmoneco.2018.12. URL `https://ideas.repec.org/a/eee/moneco/v107y2019icp2-17.html`.

Oscar Jorda, Moritz Schularick, and Alan M. Taylor. The Great Mortgaging: Housing Finance, Crises and Business Cycles. *Economic Policy*, 31(85):107–152, 2016.

Greg Kaplan and Giovanni L. Violante. A Model of the Consumption Response to Fiscal Stimulus Payments. *Econometrica*, 82(4):1199–1239, 2014.

Greg Kaplan, Giovanni L. Violante, and Justin Weidner. The Wealthy Hand-to-Mouth. *Brookings Papers on Economic Activity*, 45(1):77–153, 2014.

Greg Kaplan, Benjamin Moll, and Giovanni L. Violante. Monetary Policy According to HANK. *American Economic Review*, 108(3):697–743, 2018.

Markus Karlman, Karin Kinnerud, and Kasper Kragh-Sørensen. Costly Reversals of Bad Policies: The Case of the Mortgage Interest Deduction. *Review of Economic Dynamics*, 40:85–107, 2021.

Winfried Koeniger, Benedikt Lennartz, and Marc-Antoine Ramelet. On the Transmission of Monetary Policy to the Housing Market. *European Economic Review*, 145(C), 4 2022. doi: 10.1016/j.euroecorev.2022.104107. URL https://ideas.repec.org/a/eee/eecrev/v145y2022ics0014292122000496.html.

David Laibson, Peter Maxsted, and Benjamin Moll. Present Bias Amplifies the Household Balance-Sheet Channels of Macroeconomic Policy. Nber working paper no. 29094, NBER, 2021.

Atif Mian, Kamalesh Rao, and Amir Sufi. Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics*, 128 (4): 1687–1726, 2013.

Mario Morger. Anreizmechanismen, Verteilungseffekte und finanzielle Auswirkungen verschiedener Reformoptionen. *Gutachten zuhanden der Eidgenössischen Steuerverwaltung (ESTV).*, 2014.

OECD. *Pensions at a Glance*. OECD, 2007.

OECD. *OECD Affordable Housing Database*. OECD, 2020.

James M. Poterba. Taxation and Portfolio Structure: Issues and Implications. *NBER Working Paper 24196*, 2001.

R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2020. URL https://www.R-project.org/.

Martin Schneider and Karin Wagner. Housing Markets in Austria, Germany and Switzerland. In Hanna Augustyniak, Jacek Łaszek, Krzysztof Olszewski, and Joanna Waszczuk, editors, *Papers presented during the Narodowy Bank Polski Workshop: Recent trends in the real estate market and its analysis - 2015 edition*, NBP Conference Publications, chapter 6. Narodowy Bank Polski, Economic Research Department, 2016. URL https://ideas.repec.org/h/nbp/nbpchp/2-6.html.

Kamila Sommer and Paul Sullivan. Implications of US Tax Policy for House Prices, Rents and Homeownership. *American Economic Review*, 108:241–274, 2018.

Steuerverwaltung des Kantons Bern. Erläuterungen zum steuerlichen Bewertungssystem von Grundstücken und Liegenschaften im Kanton Bern. *Amtliche Bewertung*, 2016.

Swiss National Bank. *Financial Stability Report 2018*, 2018.

Irina A. Telyukova. Household Need for Liquidity and the Credit Card Debt Puzzle. *The Review of Economic Studies*, 80(3):1148–1177, 01 2013. ISSN 0034-6527. doi: 10.1093/restud/rdt001. URL `https://doi.org/10.1093/restud/rdt001`.

Marieke Voorpostel, Robin Tillmann, Florence Lebert, Ursina Kuhn, Oliver Lipps, Valérie-Anne Ryser, Erika Antal, Gian-Andrea Monsch, Nora Dasoki, Hannah S Klaas, and Wernli Boris. *Swiss Household Panel User Guide (1999-2018), Wave 20.* FORS, 2020.

Hadley Wickham, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D'Agostino McGowan, Romain François, Garrett Grolemund, Alex Hayes, Lionel Henry, Jim Hester, Max Kuhn, Thomas Lin Pedersen, Evan Miller, Stephan Milton Bache, Kirill Müller, Jeroen Ooms, David Robinson, Dana Paige Seidel, Vitalie Spinu, Kohske Takahashi, Davis Vaughan, Claus Wilke, Kara Woo, and Hiroaki Yutani. Welcome to the tidyverse. *Journal of Open Source Software*, 4(43):1686, 2019. doi: 10.21105/joss.01686.

A Appendix on the numerical solution, data sources and calibration

We comment on the numerical solution in Appendix A.1. We document the data sources and the construction of the sample in Appendix A.2. In Appendix A.3 we provide details on the estimation of the income process. Appendix A.4 explains how we estimate the tax function. For the analysis of all the data sets, we use the infrastructure provided by the R Core Team (2020), Wickham et al. (2019) and Hlavac (2018, for tables with summary statistics).

A.1 Numerical solution

We check that the problem is concave because the algorithm based on the endogenous grid method requires that the first-order conditions are necessary and sufficient. The problem may be non-concave in some parts of the parameter space because the portfolio choices determine the after-tax return through their effect on taxable income. As confirmed by the numerical checks, this does not turn out to be the case in the parts of the parameter space which are relevant for the calibration.

A.2 Data description

Panel data on income

The Swiss Household Panel (SHP) and the German Socio-Economic Panel (SOEP) are unbalanced, annual panel data sets, consisting of 20 waves from 1999 to 2018 for the SHP and 35 waves from 1984 to 2018 for the SOEP. We use the waves for the sample years since 2000,[20] for which we have information for both countries and which coincide with the sample period after the introduction of the euro. For further description of the two data sets, we refer to Voorpostel et al. (2020) and Goebel et al. (2019) for the SHP and SOEP, respectively.

For both the SHP and the SOEP, we use the cross-national equivalent files (CNEF) which offer standardized variables for their core samples. We use information from the respective core sample on the age of individual, the number of

[20] In the first wave of the SHP (1999), information on social security pensions and total household taxes is not included.

persons and the number of children in the household, education, the employment level of household members, the area of residence,[21] household labor income, household asset income, public transfers received by the household, social security pensions, tax payments and social security taxes, and housing tenure.

The SOEP and SHP consist of 275,340 and 94,939 observations for the household reference person in the considered sample period. We eliminate observations with missing information in any of the variables, and we trim the top and bottom percent of households according to the three income definitions defined below to remove outliers. This reduces the sample to 170,542 and 54,535 observations for the SOEP and SHP. Based on these observations, we consider household reference persons between the ages of 36 and 65 who are working[22] given the focus on homeowners with labor earnings prior to retirement in our analysis. After removing households outside this age group, our sample consists of 125,605 and 41,442 observations for the SOEP and SHP. For the calibration of our model, we focus on homeowners who account for 64,212 and 23,550 observations in the SOEP and SHP.

For our analysis, we construct three income variables:

- *Household labor income*: household labor income after social security contributions and transfers such as unemployment benefits.
- *Taxable income*: the sum of household labor income and asset income.[23]
- *Disposable income*: taxable income net of tax payments.[24]

We use *household labor income* to estimate the life-cycle income profile and the income process, as further explained in Appendix A.3. We estimate the tax function using *disposable income* and *taxable income*, as described in Appendix A.4 .

We adjust household labor income using the *square root equivalence scale* recently adopted by the OECD.[25] This equivalence scale is very similar to scales

[21] This is the *Kanton* in Switzerland and the *Bundesland* in Germany, which are geographical units comparable to the states in the U.S.

[22] We remove all households receiving pension benefits.

[23] Household labor income includes unemployment benefits or other welfare transfers which are taxed in Switzerland and determine the marginal tax rate in Germany.

[24] Total taxes paid by households include social security taxes and direct taxes. Because social security taxes have been deducted already when computing household labor income above, only direct taxes are deducted in this step.

[25] See http://www.oecd.org/economy/growth/OECD-Note-EquivalenceScales.pdf

Table A.1: Summary statistics for the SHP.

	All	Ages 36–65	Homeowners (36–65)
Average household size	2.64	2.75	3.09
Average number of kids	0.68	0.74	0.85
Fraction with tertiary degree	0.46	0.46	0.48
Mean household income	67,713	70,330	74,146
Median household income	63,119	65,536	68,390
Mean disposable income	58,293	60,627	64,578
Median disposable income	55,304	56,935	60,366

Notes: Income equivalized and in CHF. The tertiary education degree is associated to the household reference person.
In 2015, the euro exchanged approximately for 1.0–1.1 CHF.
Source: Swiss Household Panel (2015).

previously proposed in the literature, as for example the benchmark scale reported in Fernández-Villaverde and Krueger (2007), table 1, last column. We thus divide household labor income by the square root of the households' size.

Tables A.1 and A.2 provide summary statistics for the most important variables in our sample. For comparability, we show the statistics for the sample year 2015, given that we use the waves of the SHARE and HFCS for the years 2015 and 2014, respectively.

Tables A.1 and A.2 show that the number of children and the household size is slightly larger in Switzerland than in Germany in the population and also in the sample of homeowners. Educational attainment is also somewhat higher in the Swiss than in the German sample. As is well known, (equivalized) household labor income is much higher in Switzerland than in Germany, where one euro exchanged approximately for 1.0 – 1.1 CHF in 2015. Within each of the two countries, the household size is larger and income is higher on average for homeowners than in the rest of the sample. In Germany, homeowners also have higher education attainment relative to the rest of the sample.

Data on wealth

We use three different data sets to obtain information on wealth: the Survey of Health Ageing and Retirement in Europe (SHARE), the Household Finance and Consumption Survey (HFCS) and the Swiss Household Budget Survey (*Haushalts-*

Table A.2: Summary statistics for the GSOEP.

	All	Ages 36–65	Homeowners (36–65)
Average household size	2.30	2.36	2.72
Average number of kids	0.51	0.51	0.60
Fraction with tertiary degree	0.30	0.29	0.34
Mean household income	29,426	31,130	36,704
Median household income	25,931	27,932	33,032
Mean disposable income	24,543	25,839	30,178
Median disposable income	22,590	24,035	27,808

Notes: Income equivalized and in EUR. The tertiary education degree is associated to the household reference person.
Source: German Socio-Economic Panel (2015).

budgeterhebung or HABE). For comparability, we use data for the years 2014 (HFCS) and 2015 (SHARE, HABE).

The SHARE is an unbalanced panel data set collecting data from around 140,000 individuals at age 50 or above in 28 European countries and Israel. It is harmonized to be comparable with its data-set counterparts in England (ELSA) and the U.S. (HRS). Currently, seven waves are available between 2004 and 2017. We use the data for Germany and Switzerland. Börsch-Supan et al. (2019) provide further description of the data set.

The SHARE consists of 2,704 German and 1,855 Swiss households in the considered sample period. We eliminate households with a measured LTV ratio above one to remove outliers. This leaves us with a sample of 2,694 German and 1,816 Swiss households. The age group 56–65 contains 911 and 635 households for Germany and Switzerland.

The HFCS is a repeated survey collecting detailed data on wealth for the euro area. Currently, four waves are available. We use the data from the second wave in 2014 for Germany given that Switzerland does not take part in this survey. For further information see Eurosystem Household Finance and Consumption Network (2013).

The HFCS consists of 4,461 German households in the considered sample. We eliminate households with a measured LTV ratio above one to remove outliers. This leaves us with a sample of 4,400 German households, of which 582 are in the age group 36–45 and 955 are in the age group 56–65.

To estimate the homeownership rate and the incidence of mortgages for Swiss households below age 50, we use the HABE. This data set contains information on household expenditure and income. We use the information on housing expenditure and mortgage interest payments to infer the homeownership rate and the incidence of mortgages by age group.

The HABE is a repeated cross-sectional data set with survey information on household expenditures and income since 2000. The survey wave in 2015 has 3,469 observations. 651 of these observations are in the age group 36–45 and 672 are in the age group 56–65. For further information on the data set, see BFS (2013).

A.3 Income process

We use the panel data on income from the SHP and the GSOEP to decompose life-cycle income into a deterministic age profile, time effects, and a stochastic, idiosyncratic AR(1) income process. As described in Appendix A.2, household labor income is defined as labor income after social security contributions and transfers, and it is equivalized to account for differences in household size. We estimate the process for households with a reference person in the labor force between ages 36 and 65, and thus for the part of the life cycle before retirement.

We estimate the income process in logs, and assume that the deterministic and stochastic income components are characterized by the following two equations:

$$\begin{aligned} \log y_{i,t,j} &= \alpha_j + \gamma_t + \mathbf{x}'\delta + \tilde{y}_{i,t} \\ \tilde{y}_{i,t} &= \rho \tilde{y}_{i,t-1} + \epsilon_{i,t}, \quad \text{with } \epsilon_{i,t} \sim \mathcal{N}(0, \sigma_\epsilon^2), \end{aligned} \tag{A.1}$$

where α_j denotes age effects that we approximate by a fourth-order polynomial, γ_t controls for time effects that are common across households, and $\mathbf{x}$ includes a vector of controls including a set of dummies for education and the area of residence. The stochastic income component $\tilde{y}_{i,t}$ has persistence given the assumption of an AR(1) process.

Figure A.1 shows the deterministic age-dependent income profile for Switzerland and Germany. The figure displays the fourth-order age polynomial estimated on age-year moving averages of income using bins with a width of three age years. The figure shows that equivalized household labor income reaches its peak at ages in the mid fifties both in Germany and in Switzerland. The respective cumulative income growth during the preceding twenty age years is 16%

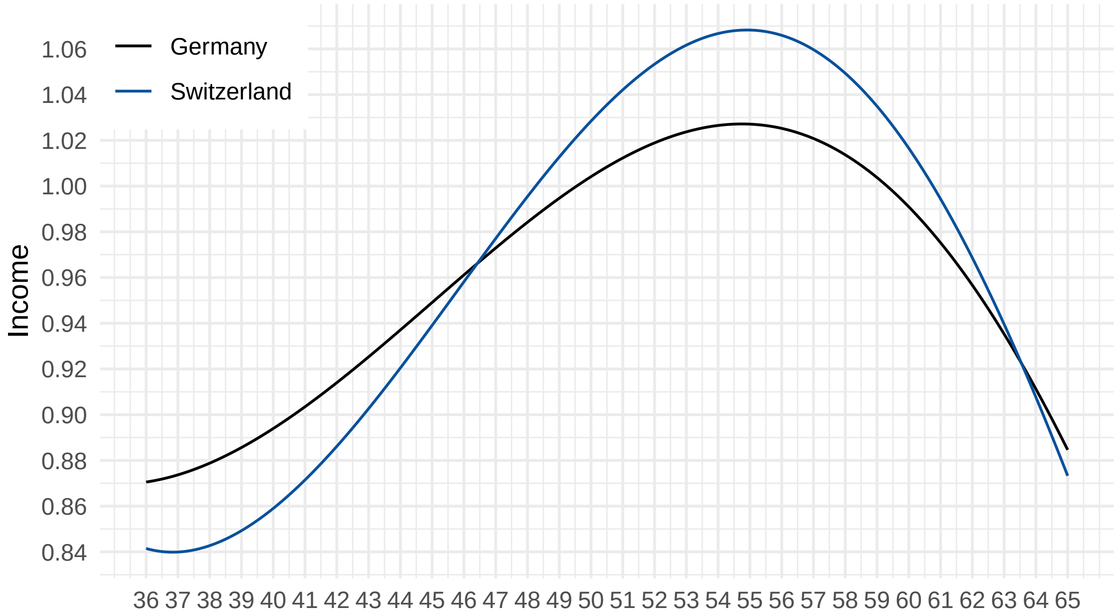


Figure A.1: Labor income profiles.

Notes: Age on the horizontal axis in years; labor income in model units of average equivalized household labor income, as defined in Appendix A.2.
Source: SHP / GSOEP 2000–2018.

and 23%, corresponding to 0.75% and 1% annualized income growth between ages 36 and 56.

For the income process in our stationary model economy, we retrieve the estimates of six parameters – the four coefficients for the age polynomial, which we have illustrated in Figure A.1, and the persistence parameter ρ and the variance of innovations σ_ϵ^2 for the stochastic component of the income process, which are reported in Table A.3. The estimated persistence of the income process is 0.77 for Switzerland and 0.81 for Germany, and the variance of the innovations is 0.09 and 0.08, respectively. For Germany, we can benchmark these results to Fuchs-Schündeln et al. (2010, pp. 122–123), who estimate a slightly different income process, with a permanent and transitory component, for the time period between 1984 and 2003. Our estimate for the variance of the innovation is above their estimate of 0.05 for the variance of the permanent component at the beginning of the 2000s, and below their estimate of 0.15 for the variance of the transitory component, as one would expect for our assumption of an AR(1) income process with less than full persistence.

Table A.3: Income Process

	Switzerland	Germany
Income autocorrelation ρ	0.771	0.806
	(0.761, 0.780)	(0.800, 0.811)
Variance of innovations σ_ϵ^2	0.086	0.078

Note: 95% confidence intervals in brackets.
Sources: SHP / GSOEP.

A.4 Estimation of the tax function

We estimate a tax function with constant progressivity as, for example, in Heathcote et al. (2017):

$$T(y_\tau) = y_\tau - \lambda y_\tau^{1-t_y}. \tag{A.2}$$

The tax function is characterized by two parameters, λ and t_y, where λ determines the tax level and t_y the degree of progressivity. This function includes both tax and transfer policies because the tax function evaluates to negative values at sufficiently low levels of income. The income threshold which distinguishes taxpayers from receivers of transfers is

$$y_0 = \lambda^{1/t_y}. \tag{A.3}$$

We define taxable income y_τ and disposable income y_d as described in Appendix A.2. For the tax function above, the relationship between taxable income and disposable income is

$$y_\text{d} = \lambda y_\tau^{1-t_y}, \tag{A.4}$$

which we estimate in logs:

$$\log y_\text{d} = \log \lambda + (1 - t_y) \log y_\tau. \tag{A.5}$$

Table A.4 displays our OLS-estimates for Switzerland and Germany. The estimated tax progressivity is significantly higher in Germany, in line with the statutory tax rates in the two countries.[26]

[26] For comparison, the estimate $t_y = 0.181$ by Heathcote et al. (2017) for the U.S. is based on a sample of households with at least part-time employment. If we imposed the same sample restrictions, the U.S. estimate would lie between the estimate for Germany and Switzerland. We use a different sample for our analysis because the income risk which we approximate with the stochastic income process described in Appendix A.3 includes the risk of unemployment. Hence,

Table A.4: Tax parameters

	Switzerland	Germany
Tax level parameter λ	2.96	5.02
	$(2.91, 3.01)$	$(4.98, 5.06)$
Tax progressivity parameter t_y	0.113	0.174
	$(0.112, 0.115)$	$(0.173, 0.174)$
Income threshold y_0	$14,596$	$10,867$
R-Squared	0.98	0.99

Note: 95% confidence intervals in brackets. Income in local currency.
In 2015, one euro exchanged approximately for 1.0–1.1 CHF.
Sources: SHP / GSOEP.

The top panel of figure A.2 illustrates the empirical fit for Switzerland and Germany, as depicted by the respective grey (blue) line. The intersection with the dashed 45-degree line depicts the income threshold at which net transfer receivers become net taxpayers. The values of the threshold are displayed in the third row of Table A.4. They are broadly in line with the statutory income thresholds of $8,472$ euro and $14,500$ CHF reported in the OECD tax database for both countries in 2015 (see table i1). The empirical fit of the tax function is remarkable, illustrated by the R^2-statistic of 0.98 and 0.99 for Switzerland and Germany. The fit is slightly better than in Heathcote et al. (2017) for the U.S., who report a R^2-statistic of 0.91 for a sample of households with at least part-time employment. The bottom panel of figure A.2 plots the average and marginal tax rates implied by our estimates.

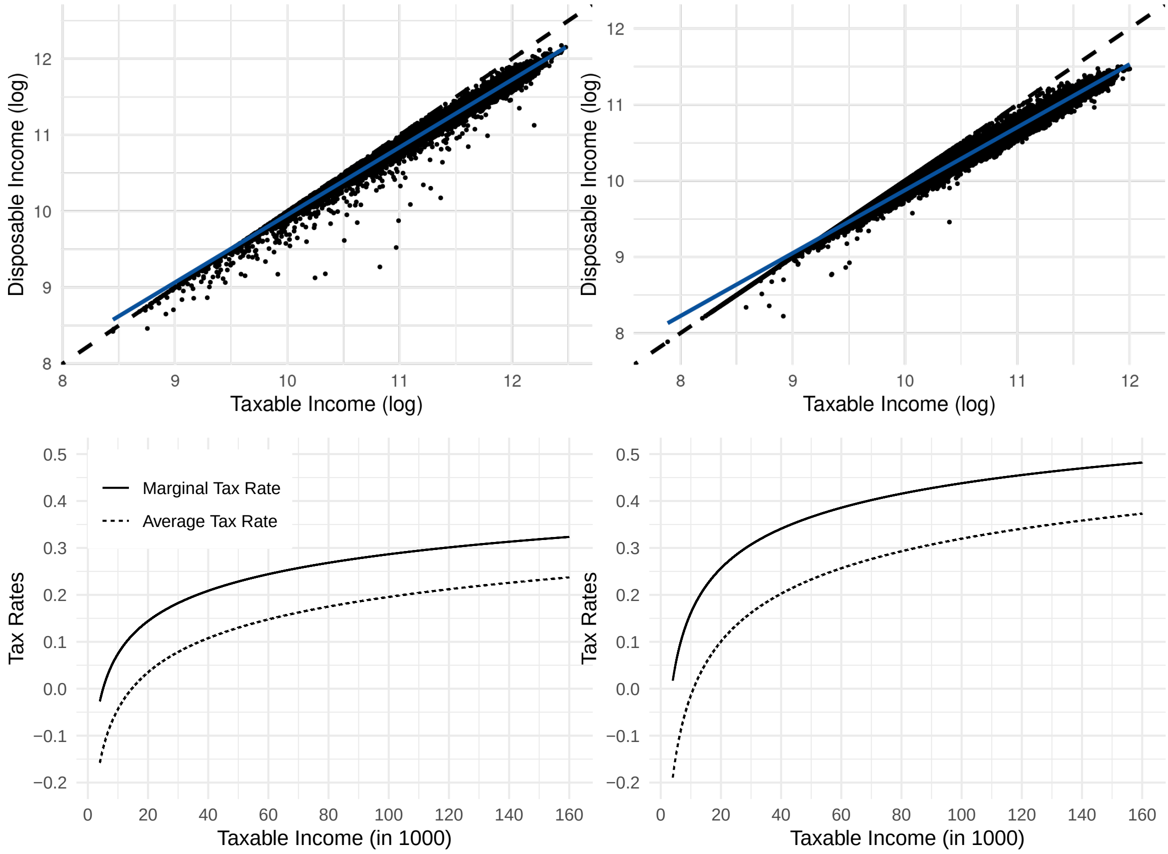
When we normalize income, we adjust the tax function so that the tax rate is invariant to the normalization for a given progressivity. Thus, when normalizing income by some value $\overline{y}$, we require

$$1 - \lambda y_\tau^{-t_y} = 1 - \tilde{\lambda}\left(\frac{y_\tau}{\overline{y}}\right)^{-t_y}, \tag{A.6}$$

where $\tilde{\lambda}$ is the parameter for the adjusted tax function. Thus,

$$\tilde{\lambda} = \lambda \overline{y}^{-t_y}. \tag{A.7}$$

household labor income, defined in Appendix A.2, includes transfers such as unemployment benefits. These benefits are taxed in Switzerland and determine the marginal tax in Germany.



(a) Switzerland (b) Germany

Figure A.2: Estimation of the tax function and implied tax rates.

Notes: Income is equivalized and in local currency. The base year is 2015.
In 2015, one euro exchanged approximately for 1.0–1.1 CHF.
Source: SHP / GSOEP 2000–2018.

A.5 Graphical illustration of the calibration and the results

Figures A.3 to A.6 compare the model predictions with the data across age groups of homeowners.

Figures A.7 and A.8 illustrate the effect of the different tax incentive in Switzerland relative to Germany over the life cycle of homeowners.

Net worth (all homeowners)

Net worth (mortgagors)

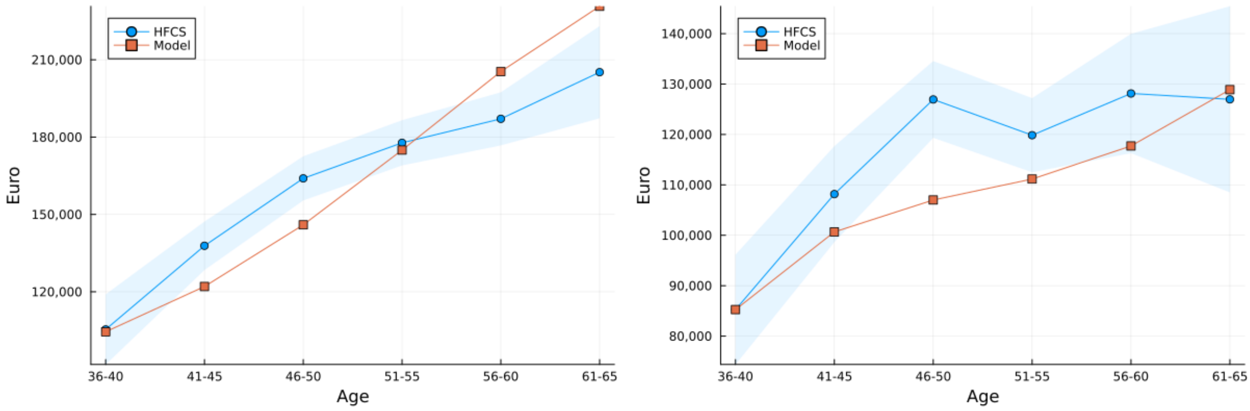


Figure A.3: Age profiles of net worth for homeowners and mortgagors in the model and the HFCS data

Notes: HFCS data averages are plotted with 95% confidence intervals.

Liquid equity (all homeowners)

Liquid equity (mortgagors)

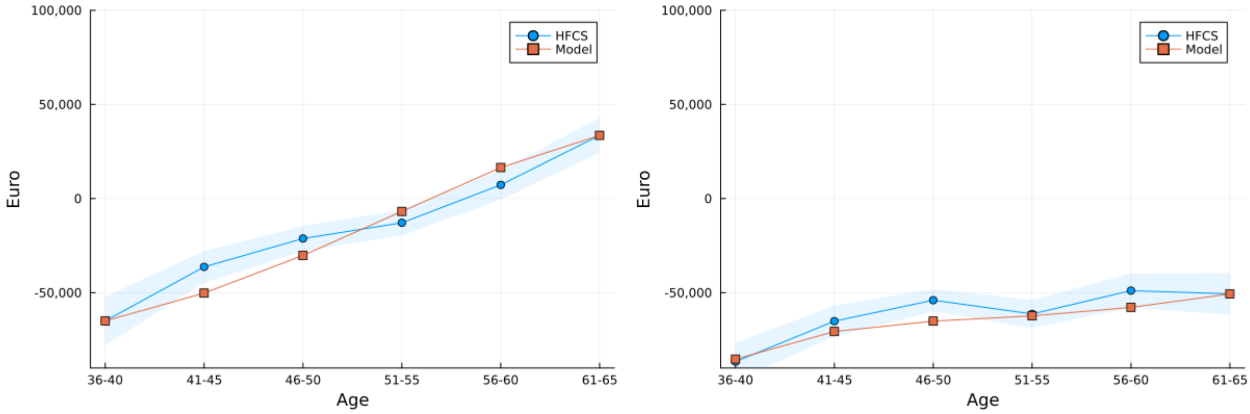


Figure A.4: Age profiles of liquidity equity for homeowners and mortgagors in the model and the HFCS data

Notes: HFCS data averages are plotted with 95% confidence intervals.

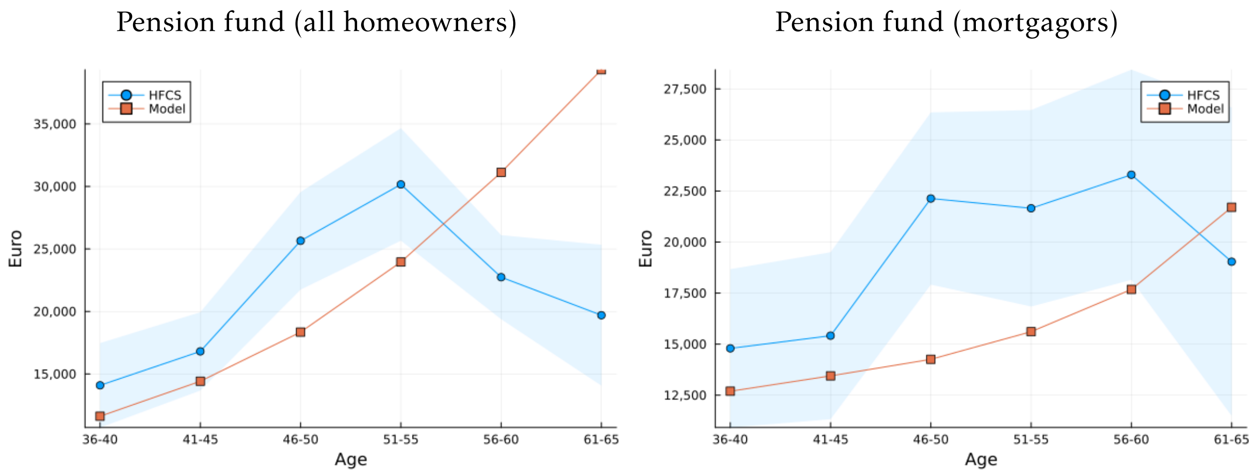


Figure A.5: Age profiles of pension funds for homeowners and mortgagors in the model and the HFCS data

Notes: HFCS data averages are plotted with 95% confidence intervals.

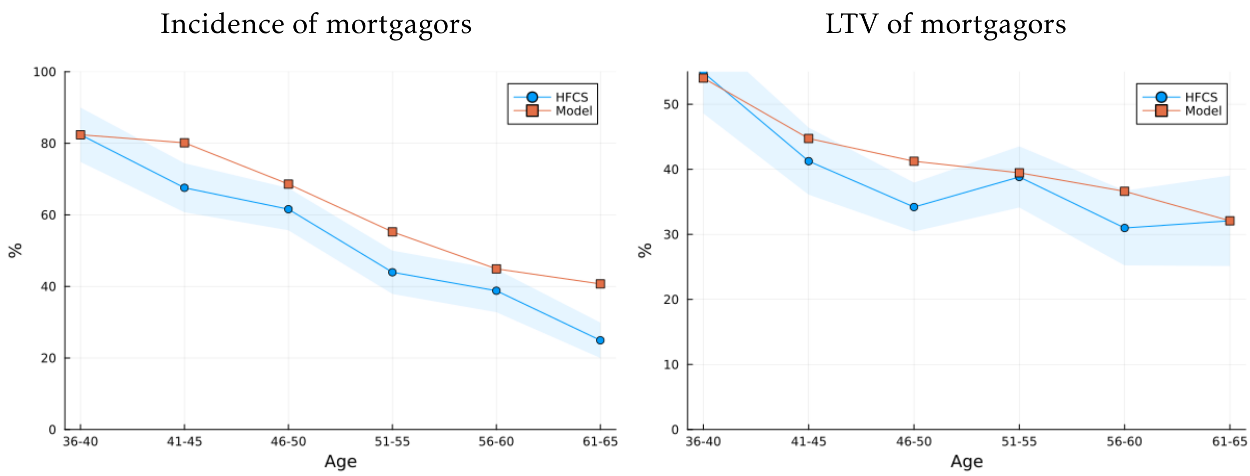


Figure A.6: Age profiles of the incidence of mortgagors and their LTV in the model and the HFCS data

Notes: HFCS data averages are plotted with 95% confidence intervals.

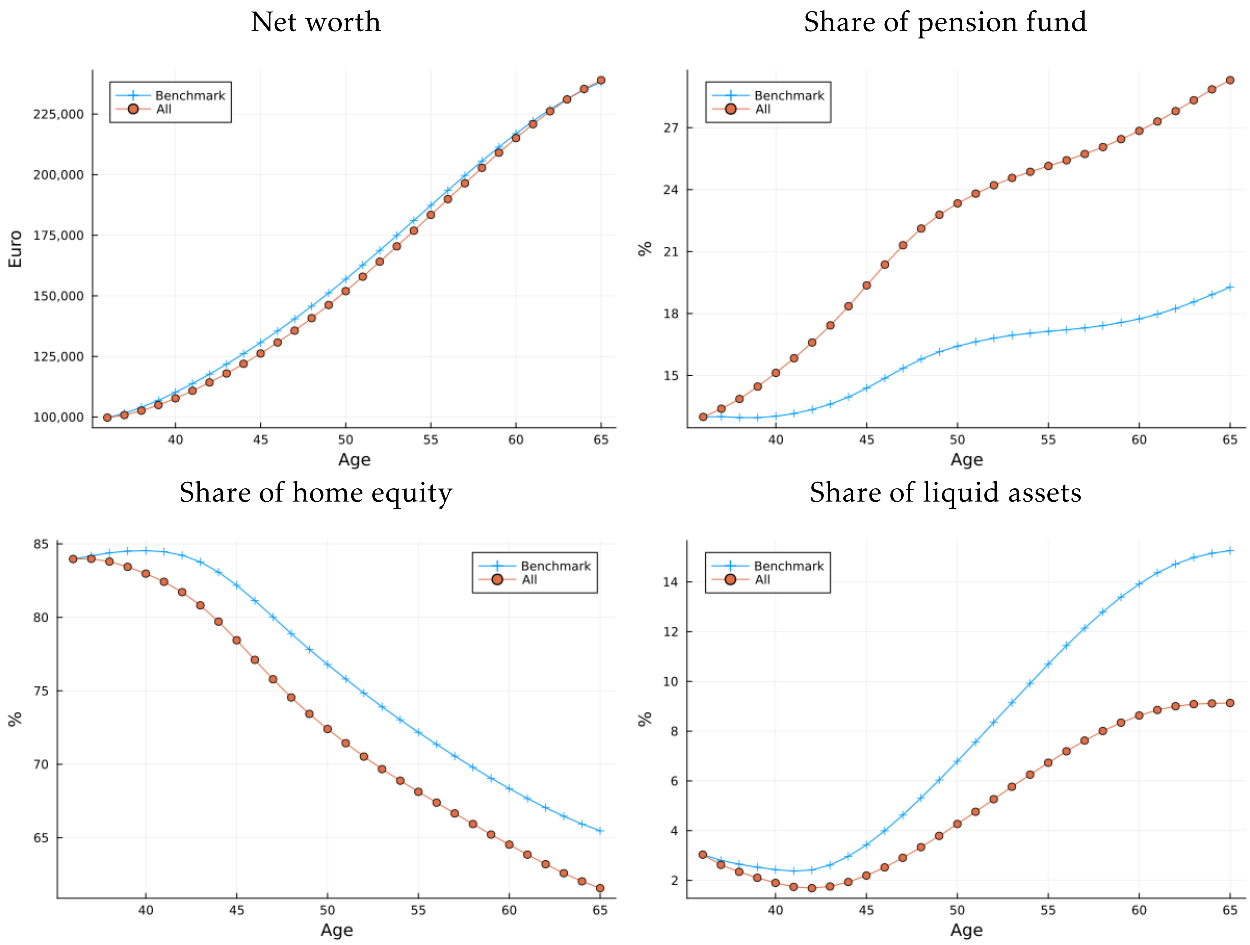


Figure A.7: The effect of tax incentives on portfolio choices over the homeowners' life cycle I: Net worth and the portfolio shares of pension funds, home equity and liquid assets

Notes: The effect of changes of the tax incentives comparing the calibrated benchmark economy (labeled as 'Benchmark' in the figures) with the economy with the joint changes as reported in column (5) of Table 6 (labeled as 'All' in the figures).

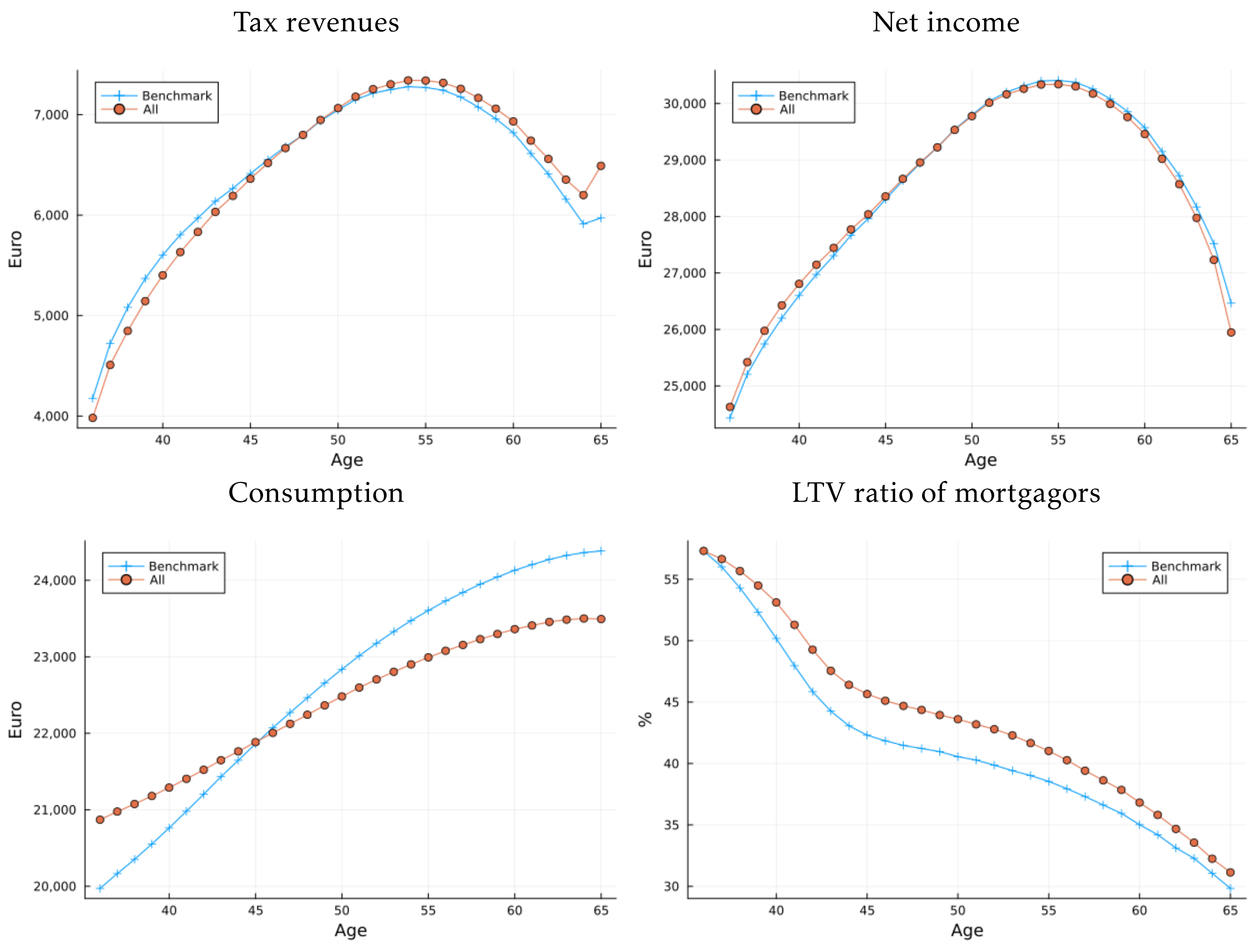


Figure A.8: The effect of tax incentives on portfolio choices over the homeowners' life cycle II: Tax revenues, net income, consumption, and the LTV ratio of mortgagors

Notes: The effect of changes of the tax incentives comparing the calibrated benchmark economy (labeled as 'Benchmark' in the figures) with the economy with the joint changes as reported in column (5) of Table 6 (labeled as 'All' in the figures).

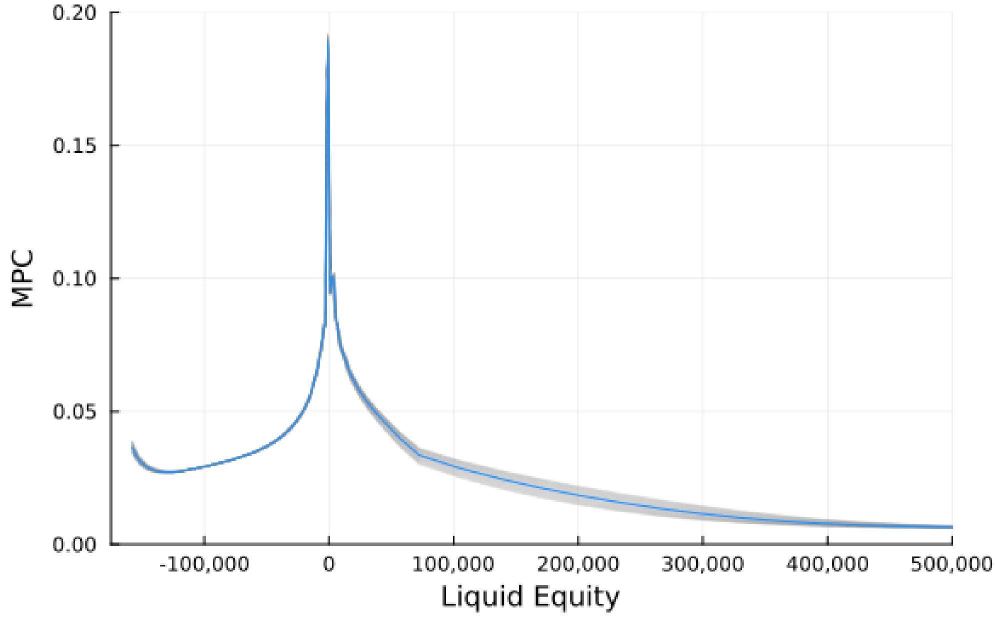


Figure A.9: The marginal propensity to consume as a function of liquid equity a at the beginning of the homeowner's life cycle, conditional on the middle income state and across different values of the pension funds a_p indicated by the shaded bounds

Notes: We compute the marginal propensity consume as the change of consumption over the change of liquid equity in the policy function of consumption.

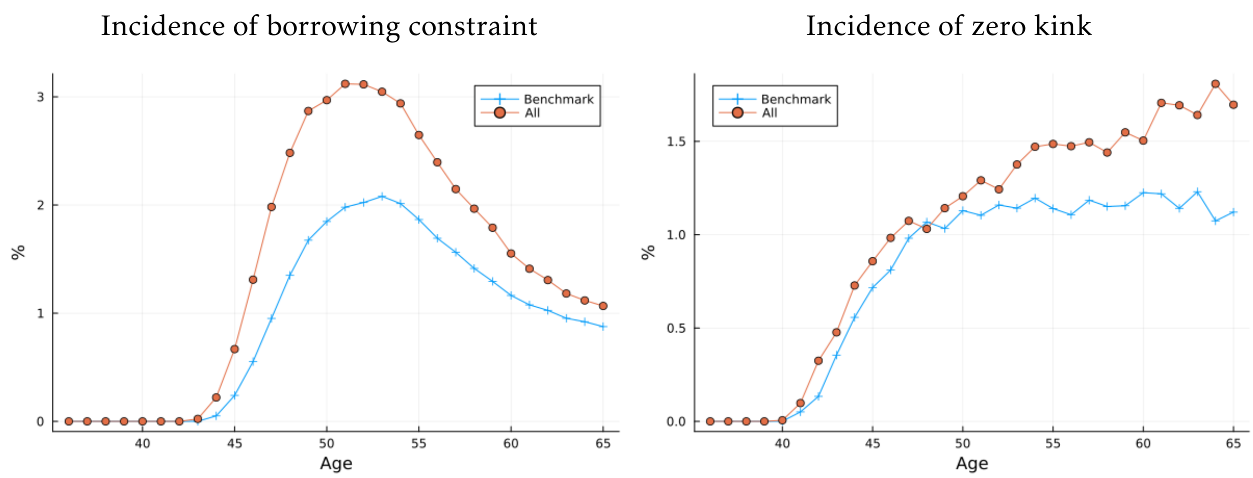


Figure A.10: The incidence hand-to-mouth consumption behavior over the homeowners' life cycle

Notes: The effect of changes of the tax incentives comparing the calibrated benchmark economy (labeled as 'Benchmark' in the figures) with the economy with the joint changes as reported in column (5) of Table 6 (labeled as 'All' in the figures).