Quantitative Economics 15 (2024), 1249–1301 1759-7331/20241249

Differences in euro-area household finances and their relevance for monetary-policy transmission

Thomas Hintermaier
Department of Economics, University of Bonn

Winfried Koeniger
Department of Economics, University of St. Gallen, CESifo, CFS, IZA, and Swiss Finance Institute

This paper quantifies mechanisms through which heterogeneity in household finances affects the transmission of monetary policy, considering housing tenure choices over the life cycle. Our analysis also identifies challenges for monetary policy related to housing busts. It focuses on the four largest economies in the euro area: France, Germany, Italy, and Spain. Through the lens of our model, we find that home ownership and endogenous transitions from renting to owning are key elements for the extent of cross-country asymmetries in aggregate consumption responses to changes in the real interest rate. Across groups with different housing tenure, we find that the consumption response of homeowners to interest rate changes tends to be larger than the response of renters, particularly if these homeowners are indebted and do not adjust their illiquid housing wealth.

Keywords. Consumption, household portfolios, housing, monetary policy transmission.

JEL classification. D14, D15, D31, E21, E43, G11.

1. Introduction

Differences in household finances are large across the euro area. Table 1 shows that less than 20% of households are renters in Spain. In contrast, more than 50% of households rent their home in Germany. The differences in home ownership imply that the portfolios of Spanish households are much more tilted toward housing assets. This affects the country-specific exposure to housing busts, and through the financing cost of housing, also the exposure to interest rate changes.

Thomas Hintermaier: thomas.hintermaier@uni-bonn.de
Winfried Koeniger: winfried.koeniger@unisg.ch
Thomas Hintermaier gratefully acknowledges support through the project ADEMU "A Dynamic Economic and Monetary Union" funded by the European Union's Horizon 2020 Program under Grant Agreement 649396. This paper uses data from the Eurosystem Household Finance and Consumption Survey (HFCS). The results published and the related observations and analysis may not correspond to results or analysis of the data producers. We thank participants at various seminars, the CESifo conference on *Macroeconomics and Survey Data*, an ECB workshop of the Household Finance and Consumption Network, the annual conference of the Society of Economic Dynamics 2018 and the Swiss Macro workshop for very helpful comments, and Edouard Mattille, Stephan Minger, Andrin Pelican, Simon Vischer, and Carlo Zanella for research assistance. Winfried Koeniger thanks EIEF for its hospitality while working on the paper.

Available at http://qeconomics.org. https://doi.org/10.3982/QE2068

TABLE 1. Household finances in the euro area.

	Germany	France	Italy	Spain
Wealth composition				
Housing wealth (main residence)	69,474	88,922	105,278	93,708
+ Other wealth	83,237	78,775	60,214	79,062
= Net worth	152,711	167,697	165,492	172,770
Housing renter share (percent)	53.3	41.1	32.2	18.8

Note: Means for households aged 26–75. Units for wealth are euro per adult equivalent and inflation adjusted to euro in the first wave using the factor published in the HFCS methodological report. Other wealth is the consolidated position of all assets and liabilities other than the value of the main residence. Source: Authors' calculations based on the first and second wave of the Household Finance and Consumption Survey (HFCS), 2009–2014.

This paper quantifies mechanisms through which the observed differences in household finances shape the response of consumption to changes in the real interest rate and house prices. The size of the consumption response to changes in the real interest rate is crucial for the effect of monetary policy on aggregate demand, and housing busts may trigger accommodating monetary policy responses to stabilize the economy. An essential part of our contribution is that we employ a structural model that considers key features of housing tenure choices over the life cycle such as the option to rent housing, costs for adjusting housing wealth, and the pass-through of interest rate changes to the rent-price ratio.

The model with heterogeneous households and uninsurable risk generates endogenous distributions. This allows us to assure credibility by matching cross-sectional statistics capturing key differences in household finances, as observed in household-level micro data provided by the euro-area Household Finance and Consumption Survey (HFCS). Our analysis links the cross-country differences of the aggregate consumption responses in the euro area to the country-specific composition in household characteristics.

Based on the calibrated model, we infer the aggregate consumption response to an unexpected fall of the real interest rate by 25 basis points. The consumption response on impact is between 0.35% in Germany and 0.44% in Spain. This implies an extent of relative cross-country differences of $(44\text{bp} - 35\text{bp})/35\text{bp} = 0.257$, that is, of up to more than a quarter of the responses. Our structural model allows us to analyze the mechanisms underlying these responses further, disentangling the roles of housing tenure dynamics triggered by a shock and asset-composition-dependent marginal propensities to consume.

Comparing the heterogeneous behavior of different housing-tenure groups, we find that the consumption response of homeowners to interest rate changes is larger than the response of renters, particularly if these homeowners are indebted and do not adjust their illiquid housing wealth. We further find that a decrease of the interest rate, without pass-through to the rent-price ratio, strongly increases home purchases. This effect matters quantitatively for the consumption responses. There is a significant difference in the consumption response of those *pre-shock* renters who are triggered by the interest rate shock to become owners. This introduces an asymmetry in the consumption response to decreases relative to increases of the interest rate, as households over their life cycle have a tendency to transit from rented to owned housing, and only few households transit back into rented housing. Thus, a model that endogenizes the choice between renting and owning housing is essential for analyzing consumption responses and the mechanisms driving them at the household level.

The recent, steep increases of interest rates have raised concerns that further house price corrections may loom. The size of the consumption responses to changes in the house price has received considerable attention after the housing busts associated with the Great Recession in the U.S. and the subsequent economic crises in euro-area countries such as Spain. When using our model as a lab for a scenario of a 10% house price drop, our results imply an elasticity of consumption with respect to the house price between 0.08 for Germany and 0.12 for Spain. These elasticities are roughly of similar size as estimates by Guren, McKay, Nakamura, and Steinsson (2021) for the U.S. They are a bit lower than the model-implied elasticity of 0.2 in Kaplan, Mitman, and Violante (2020b) for the U.S. and the range of empirical estimates for the U.S. of 0.25 to 0.4 in Kaplan, Mitman, and Violante (2020a), possibly associated with the lower leverage of most households in euro-area countries relative to the U.S.

In terms of methods applicable to the solution of structural life-cycle models with portfolio choice, we contribute in this paper by combining the approach of Iskhakov, Jørgensen, Rust, and Schjerning (2017) with the technique from Hintermaier and Koeniger (2010). This makes situations where discrete choices (e.g., the decision to either rent or own housing) need to be combined with portfolio choice amenable to an endogenous-grid-method (EGM) type of solution. In the solution of our model, we allow for continuous portfolio choices to accurately capture the portfolio positions and for an interest-rate spread (between lending and borrowing), which are important features for an accurate computation of the consumption responses.

Our analysis proceeds in the following steps. In Section 2, we construct a model with a financial asset and a housing asset that can be rented or owned. In Section 3, we calibrate the model, accounting for cross-country differences in pay-as-you-go pensions, taxation and social transfers, age profiles and risk of labor income, and demographics. The calibration targets properties of household finances and indebtedness as well as their age profiles for the four largest euro-area countries: France, Germany, Italy, and Spain. These countries account for three quarters of GDP in the euro area and are characteristic examples for the observed heterogeneity in household finances across the euro area. In Section 4, we then compute the consumption responses after changes in the real interest rate and the house price for these four countries.

1.1 *Related literature*

Our paper contributes to the literature on differences in household finances and consumption responses to changes in real interest rates and house prices. The relationship between heterogeneity in wealth and heterogeneity in marginal propensities to consume has been analyzed in environments with uninsurable idiosyncratic risk as, for example, in Carroll, Slacalek, Tokuoka, and White (2017). The marginal propensity to consume together with the exposure to price changes determines the size of the consumption response, as demonstrated by Auclert (2019) for changes in the interest rate and by Berger, Guerrieri, Lorenzoni, and Vavra (2018) for changes in the house price.

Kaplan and Violante (2014) have shown that the marginal propensity to consume crucially depends on the composition of wealth, distinguishing liquid and illiquid assets. The marginal propensities to consume in our life-cycle model also depend on household balance sheets. We account for the substantial heterogeneity in home ownership across euro-area countries (see Table 1), distinguishing housing, and other wealth in household portfolios. Differences in household finances then change the marginal propensity to consume as well as the exposure to price changes, and thus also influence the consumption responses to price shocks.

Auclert (2019), Kaplan, Moll, and Violante (2018), Wong (2019), and Kinnerud (2022) investigate the distributional and aggregate effects of unexpected changes in the interest rate on consumption for the U.S. Cloyne, Ferreira, and Surico (2020) compare the respective consumption responses in the U.S. and the U.K. Jappelli and Scognamiglio (2018), Martin, Paul, and Tischbirek (2021), and Flodén, Kilström, Sigurdsson, and Vestman (2021) provide evidence for Italy, Norway, and Sweden, respectively. We contribute to this literature by analyzing the dependence of these responses on the observed differences in household finances across the euro area. In doing so, we highlight the interaction between housing tenure decisions and consumption responses over the life cycle.

We focus on the consumption response to changes in the real interest rate. This response is an important part of monetary-policy transmission in general. For our emphasis on cross-country and within-country heterogeneity, this is the key part. Such a focus separates the effects of cross-country heterogeneity in consumer finances from the potential influence of cross-country differences in inflation. In the case of open economies within a monetary union, country-specific inflation dynamics would need to be aligned with features such as cross-country flows of goods and capital, country-specific labor market institutions, and country-specific reactions of fiscal policies. Such differences and their explanation are beyond the scope of the present paper. Our focus on the transmission of changes in real rates is supported by empirical evidence in Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) who show that the transmission of monetary policy shocks to the yield curve of nominal rates is similar across the largest euro-area countries. Thus, those parts of monetary policy transmission, which affect real rates, do not seem to be a quantitatively important source of cross-country asymmetries in consumption responses.

Beraja, Fuster, Hurst, and Vavra (2018) uncover regional heterogeneity in the transmission of changes in the interest rates to consumption for the U.S. They show that a lower interest rate in the Great Recession benefited those regions more in which households held higher home equity. These households were able to take advantage of the lower interest rates by refinancing the mortgage while this option was not available to households with low or even negative home equity. Because mortgage lending has been much more restrictive in the euro area with loan-to-value ratios below 80%, households have positive home equity and potentially can take advantage of refinancing. A difference to the U.S. is that refinancing is more costly in some of the considered countries of the euro area. In Section 4.1, we relate our findings further to analyses of the refinancing channel of monetary policy for the U.S. (e.g., Berger, Milbradt, Tourre, and Vavra (2021), Eichenbaum, Rebelo, and Wong (2022), Wong (2019), Kinnerud (2022)).

Slacalek, Tristani, and Violante (2020) provide back-of-the-envelope calculations to assess the importance of household balance sheets for consumption responses in the euro area. As in their Figure 7, we also find that the stronger role of housing in portfolios of households in Italy and Spain increases the consumption response in these countries.

The results of Slacalek, Tristani, and Violante (2020) suggest that the indirect general equilibrium effects after changes of the interest rate contribute less than the direct effects to the aggregate consumption responses in Germany and France. The contribution of the indirect effects is larger for Italy and Spain. Recent empirical evidence by Martin, Paul, and Tischbirek (2021), based on detailed administrative household-level data in Norway, shows that the direct effect of interest rate changes on consumption dominates the indirect general equilibrium effect over a horizon of 2 years after the shock.[1] This suggests that the direct effect of interest rate changes shapes the consumption response over shorter horizons that are the focus of our paper.

The chosen focus allows us to analyze the transmission from changes in real interest rates to consumption in a relatively detailed life-cycle model with illiquid housing and financial constraints. The model is well suited to answer our question of interest, that is, to which extent differences in housing across euro-area countries affect monetary policy transmission, given that home ownership tends to follow a pronounced life-cycle pattern. For the quantitative analysis implemented here, we thus follow the life-cycle literature in considering a nontrivial, empirically informed life-cycle profile of the earnings process to be of first-order importance, while abstracting from the potential dependence of the earnings process on monetary policy actions. More generally, our analysis is agnostic to the specific types of shocks and various causes that may drive changes in interest rates and house prices, leaving further modeling of equilibrium effects in a monetary union and their consequences for cross-country asymmetries to future research.

The analysis of the consumption response to changes in relative house prices builds on work by Berger et al. (2018), Guerrieri, Lorenzoni, and Prato (2020), Kaplan, Mitman, and Violante (2020b), and Guren et al. (2021) who analyze the consumption response to changes in house prices in the U.S., and the empirical analysis of Mian and Sufi (2011) and Mian, Rao, and Sufi (2013). Piazzesi and Schneider (2016) provide an excellent overview of the literature. Recent empirical work for the euro area by Calza, Monacelli, and Stracca (2013) and Corsetti, Duarte, and Mann (2022) reveals heterogeneity in

[1] Andersen, Johannesen, Jørgensen, and Peydró (2023) also show, based on Danish administrative data, that the effect of a policy rate change on disposable income increases during the first 2 years after the change. The effects are stronger at higher income levels but the effects on income equality are less clear cut for other countries, as shown in Coibion, Gorodnichenko, Kueng, and Silvia (2017) for the U.S. or Amberg, Jansson, Klein, and Picco (2022) for Sweden. Further literature has analyzed the distributional effects of monetary policy on the wealth distribution in the euro area (e.g., Bayer, Kriwoluzky, Müller, and Seyrich (2023)) or the distributional effects of monetary policy across generations (Bielecki, Brzoza-Brzezina, and Kolasa (2022)).

the transmission of monetary policy to aggregate consumption and house prices across countries. The heterogeneity is associated with differences in the housing market.[2]

An important related literature has tried to uncover the determinants for the large observed differences in household finances. Guiso, Haliassos, and Jappelli (2003) document and analyze the differences in stock-market participation between the U.S. and European countries. Ampudia, Cooper, Le Blanc, and Zhu (2024) analyze how differences in stock market participation across major euro-area countries affect consumption responses to monetary policy. Cocco (2004) and Chetty, Sándor, and Szeidl (2017) have analyzed to which extent different portfolio shares of risky assets are associated with housing. Christelis, Georgarakos, and Haliassos (2013) decompose the observed differences in household finances across the U.S. and European countries into differences resulting from the economic environment and from population characteristics. They find that differences in the economic environment are important to explain the observed differences in household finances across European countries, which we try to capture in our calibration. Arrondel et al. (2016) and Bover et al. (2016) have performed similar decompositions based on the HFCS to understand the heterogeneity of assets and liabilities of households in the euro area. Adam and Zhu (2016) and Adam and Tzamourani (2016) build on the seminal paper by Doepke and Schneider (2006) for the U.S. and assess empirically the distributional effects of inflation and asset-price changes resulting from the heterogeneity of wealth portfolios across euro-area countries observed in the HFCS.

Taking a structural approach based on a life-cycle model with one asset and heterogeneous agents, Pham-Dao (2019) investigates the effect of differences in the social security systems across euro-area countries on wealth inequality. We perform our analysis in a framework with household portfolio choice, also accounting for differences in the design of social security across euro-area countries. Kindermann and Kohls (2018) analyze the extent to which differences in rental-market efficiency in the euro area can explain differences in home ownership, with higher homeownership rates implying lower wealth inequality. Kaas, Korchakov, Preugschat, and Siassi (2021) argue that lower transaction costs for housing in the U.S. compared with Germany are an important factor for explaining the higher homeownership rates in the U.S. Our structural approach is similar to these papers but we focus on the question of what the observed differences in household finances imply for the transmission of price changes to consumption, building on the literature of life-cycle models with housing (e.g., Li and Yao (2007), Li, Liu, Yang, and Yao (2016)). In our calibration of the model, we find, as Kindermann and Kohls (2018) and Kaas et al. (2021), that rental efficiency and differences in transaction costs are important to match the home ownership and its different incidence across the four analyzed euro-area countries.

[2]Calza, Monacelli, and Stracca (2013) and Corsetti, Duarte, and Mann (2022) also provide a New–Keynesian DSGE model with household types (borrowers and savers) to interpret their empirical findings. See their paper for further references to the literature on housing markets within this framework.

2. The model

We use a life-cycle incomplete-markets model with household portfolio choice for our quantitative analysis. This section describes all building blocks of the model, introducing model structure and features along with the notation for variables and parameters. The specific choices of parameter values used for the quantitative analysis—and, in particular, country-specific differences in the relevant parameter values—are discussed in Section 3.

Choices

We implement a version of the life-cycle model, which combines discrete choices and continuous choices. In order to capture the mutually exclusive decision of renting versus owning and the illiquidity of housing, the three discrete choice options in our model are the following: *owning-and-not-adjusting*, deciding to own a positive housing quantity that is non-adjusted relative to the housing quantity owned when entering a decision period; *owning-and-adjusting*, deciding to own a positive housing quantity, which is adjusted relative to the zero or positive housing quantity owned when entering a decision period; *renting*, deciding to rent some housing quantity, instead of owning it. Based on any of these three discrete choice options, the remaining choices of nonhousing consumption, of financial assets, and of relevant housing quantities are allowed to be continuous. The financial asset is the model counterpart for the residual wealth category *other wealth* in the data, given our portfolio choice problem with owner-occupied housing and another asset.

Preferences

This building block specifies the time horizon and the preferences over consumption streams. We use a life-cycle model with J periods, indexed by $j = 1, \dots, J$. Households maximize their expected discounted utility over the life cycle. They apply a discount factor β on future period utilities. Expectations take into account survival probabilities, idiosyncratic risk in earnings, and aggregate risk in future returns on financial assets.[3]

The relevant consumption items for our analysis are nonhousing consumption c_j and housing services $\hat{s}_j$, obtained by choosing either to own or to rent housing. We assume a period utility function that is log-separable in nonhousing consumption and housing services:[4]

$$u(c_j, \hat{s}_j) = \theta \log c_j + (1-\theta) \log \hat{s}_j.$$

The flow of housing services for owners of a house of size $\hat{h}_{j+1}$ is

$$\hat{s}_j = \phi \hat{h}_{j+1}.$$

[3]The steady-state calibration will abstract from aggregate risk. In the MIT-shock experiments that follow later, we will consider a probabilistic structure for the interest rate to switch back to its steady-state value, for capturing the degree of persistence of the shock.

[4]The notation with hats used here distinguishes physical housing as a utility-generating quantity from its valuation, which will be used for the recursive formulation.

If choosing to rent a house, the service flow is related to the rented housing quantity $\hat{f}_j$ by

$$\hat{s}_j = \phi_R \hat{f}_j.$$

In the calibration $\phi > \phi_R > 0$ allows to capture a smaller per-unit service flow from housing for renters compared to owners, as a commonly used reduced form for utility losses resulting from moral-hazard or hold-up problems in the rental market.

For the event of death, households consider a warm-glow bequest motive with utility $\Psi(\flat)$ from bequeathing an amount of resources $\flat$, whose relation to the bequeather's asset positions is specified in the section on portfolio items below. The bequest utility function takes the form

$$\Psi(\flat) = \psi_0 \log(\psi_1 + \psi_2 \flat).$$

This standard functional form captures the strength of the bequest motive with the parameter $\psi_0 > 0$, and the extent to which bequests are a luxury good with the parameter $\psi_1 > 0$. We show in the Supplemental Appendix D (Hintermaier and Koeniger (2024)) that $\psi_0 = 1/(1-\beta)$, ψ_1 equals average earnings of the offspring, and $\psi_2 = r - g$, if the bequeather is thought of as considering the consequences of the annual payment flows generated by the bequest for a long-run real interest rate r and an annual income growth rate g. Determining the bequest parameters this way, as a function of other model parameters, allows for an immediate economic interpretation and reduces the number of parameters required for the calibration.

Earnings

Uncertainty in the model is captured by a Markov process. We denote the realization of the Markov state at age j by s_j, and the implied household earnings by $y_j(s_j)$.

Earnings in the model during working age capture labor earnings after taxes and transfers, and during retirement they capture public pensions net of taxes. During working age, labor earnings are subject to stochastic variation each period. During retirement age, they are determined by household-specific working-age earnings. These sources of idiosyncratic background risk cannot be fully insured against, and thus matter for the life-cycle profiles of asset accumulation and portfolio composition. To accurately capture this effect, as further explained in Section 3, we will calibrate the earnings variables for each country and obtain country-specific life-cycle profiles and risk resulting from country-specific features of taxation, social security, and pay-as-you-go pensions.

Portfolio items: Costs, returns, constraints

An important difference between rented and owned housing is that the quantity of owned housing can only be adjusted at a cost, reflecting the illiquidity of housing as an asset. To generate inaction ranges and lumpy adjustment patterns,[5] we specify an ad-

[5]In a previous version, we allowed for an additional fixed-cost component to generate such patterns. A fixed cost did not turn out to be essential, given that the smallest house chosen by the agents in the calibrated model already implies adjustment costs of hundreds of euros.

justment cost function for which costs are proportional to the quantities sold or bought, with p_t denoting the relative price of housing:

$$\boldsymbol{\alpha}_p(\hat{h}_j, \hat{h}_{j+1}) = \alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1}.$$

These costs have to be paid if the household at age j chooses to adjust to a new quantity $\hat{h}_{j+1} \neq \hat{h}_j$ of owned housing. The cost structure is motivated by two components: $\alpha_1 p_t \hat{h}_j$ from selling the existing $\hat{h}_j$, and $\alpha_2 p_t \hat{h}_{j+1}$ from purchasing the new $\hat{h}_{j+1}$.

This description of the adjustment cost structure accommodates special cases in which the existing housing quantity $\hat{h}_j$ or the new housing quantity $\hat{h}_{j+1}$ are zero. A household, which does not own housing when entering the decision period, meaning that $\hat{h}_j = 0$, for example, because of having decided to rent in the *previous* period, and now in the current decision period chooses the option of *owning-and-adjusting*, is affected by the adjustment cost on the purchasing branch only. A household which owns a positive housing quantity when entering the decision period, and now in the current decision period chooses the option of *renting*, is affected by the adjustment cost on the selling branch only. A household whose existing housing quantity is zero (e.g., because of having rented in the *previous* period) and who is *renting* in the current period, such that $\hat{h}_j = 0$ and $\hat{h}_{j+1} = 0$, implying that $\hat{h}_{j+1} = \hat{h}_j$, has to pay no adjustment cost. This is in line with the fact that the previously mentioned condition $\hat{h}_{j+1} \neq \hat{h}_j$ for triggering adjustment cost does not hold in that latter case.

Relevant features of portfolio items appear also in the budget constraint and in the collateral constraint. The following general description of the budget constraint nests all specializations for the three discrete choice options, which in addition to the conditionality of adjustment cost also impose a restriction of either $\hat{f}_j = 0$ or $\hat{h}_{j+1} = 0$:

$$c_j + a_{j+1} + p_t \hat{h}_{j+1} + \mathbf{1}_{\hat{h}_{j+1} \neq \hat{h}_j}(\alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1}) + q_t \hat{f}_j = y_j(s_j) + (1 + r_{t-1}) a_j + p_t \hat{h}_j,$$

where r_{t-1} denotes the safe interest rate promised at calendar time $t-1$, when the decision maker was of age $j-1$ and invested in the financial asset position a_j, and current age earnings are denoted by $y_j(s_j)$. Concerning the interest rate, we allow for a spread between an interest rate of r^- for debt positions and a rate of r^+ on positive financial asset positions. We assume that this spread is positive such that $r^- > r^+$. The expenditures on the left-hand side include the level of financial asset holdings a_{j+1} chosen in period j as well as rental expenditures $q_t \hat{f}_j$, that is, the product of the rental price q_t and the quantity of housing obtained by renting.

For the discrete choice option of *owning-and-not-adjusting*, where it is the case that $\hat{h}_{j+1} = \hat{h}_j$ and $\hat{f}_j = 0$ because housing is obtained by owning instead of renting, the budget constraint becomes

$$c_j + a_{j+1} = y_j(s_j) + (1 + r_{t-1}) a_j,$$

thus revealing that consumption and chosen financial asset holdings must be in line with the liquid resources available.

For the discrete choice option of *owning-and-adjusting*, where it is the case that $\hat{h}_{j+1} \neq \hat{h}_j$ and $\hat{f}_j = 0$ because housing is obtained by owning instead of renting, the budget constraint specializes as

$$c_j + a_{j+1} + p_t \hat{h}_{j+1} + \alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1} = y_j(s_j) + (1 + r_{t-1}) a_j + p_t \hat{h}_j.$$

Finally, for the discrete choice of *renting*, where it is the case that $\hat{h}_{j+1} = 0$ because housing is obtained by renting instead of owning, the budget constraint simplifies to

$$c_j + a_{j+1} + \alpha_1 p_t \hat{h}_j + q_t \hat{f}_j = y_j(s_j) + (1 + r_{t-1}) a_j + p_t \hat{h}_j.$$

If renting in period j and also having rented housing in the previous period $j-1$, therefore entering decision period j with $\hat{h}_j = 0$, terms involving $\hat{h}_j$ drop out. This applies to the selling part of adjustment costs, as elaborated on above in the adjustment-cost section, and to the resources available from selling any existing quantity of owned housing.

Rental prices q_t are specified in relation to prices for ownership as

$$q_t = k_t p_t,$$

where the fraction k_t is referred to as the *rent-to-price ratio*. We allow for variation of the rent-to-price ratio by considering it as the sum of a noninterest component $\underline{k}$ and the (lending) interest rate r_t^+ prevailing at time t,

$$k_t = \underline{k} + r_t^+,$$

and we refer to this specification as *pass-through* (of interest rates to the rent-to-price ratio). If k_t in the previous specification is held constant when we analyze the effects of an interest change, we call this a situation with *no pass-through*.[6]

Portfolio choices, and in particular debt positions, are also restricted by a collateral constraint that limits borrowing:

$$(1 + r_t) a_{j+1} \geq -\mu p_t \hat{h}_{j+1} - g_{y,j+1},$$

where the parameter μ represents the loan-to-value (LTV) ratio. The parameter $g_{y,j+1}$ denotes that part of borrowing capacity, which is not related to housing collateral. For the discrete choice option of *owning-and-not-adjusting*, such that $\hat{h}_{j+1} = \hat{h}_j$, the existing housing quantity directly determines the borrowing constraint. For the discrete choice of *renting*, which goes along with zero owned housing from decisions of period j, such that $\hat{h}_{j+1} = 0$, the borrowing constraint reduces to $(1 + r_t) a_{j+1} \geq -g_{y,j+1}$.

Finally, given the previous description of portfolio items, costs, and returns, we are in a position to specify the amount of resources bequeathed in the event of death as

$$\flat = (1 + r_t) a_{j+1} + (1 - \alpha_1) p_{t+1} \hat{h}_{j+1},$$

which can be interpreted as liquidable wealth from the portfolio existing at the time of death.

[6]The choice of the lending rate r_t^+ to decompose the rent-price ratio into an interest and noninterest component is without loss of generality. If we had chosen the borrowing rate r_t^- instead, the noninterest component would be scaled in the calibration to account for the interest spread.

Recursive formulation

The numerical solution of the model is based on a recursive formulation of the decision problem. Two steps described below are key for obtaining a version of the recursive formulation that allows for handling our model efficiently: First, our implementation of the recursive solution takes advantage of the fact that the price of housing can be dealt with by introducing an appropriate transformation of variables, instead of having a separate state variable for the house price. Second, we define an appropriate state variable that reduces the number of relevant continuous state variables in important branches of the decision problem.

We define *price-transformed variables* for the service flow, for owned housing, and for the rented housing in the following way:

$$\bar{s}_j = p_t \hat{s}_j, \qquad h_{j+1} = p_t \hat{h}_{j+1}, \qquad f_j = p_t \hat{f}_j.$$

Under the assumption of a constant price-growth factor $\Pi = p_t/p_{t-1}$, which also covers the case of $\Pi = 1$, that is, constant house prices in the steady state, as used later in our calibration, it is possible to have a recursive formulation that for the three variables mentioned above only relies on their price-transformed values. Detailed derivations of the corresponding equivalent transformations of the objective and of the constraints are given in Supplemental Appendix C.1.

We introduce an auxiliary state variable x_j, which may be interpreted as liquidable wealth, defined as

$$x_j = (1 + r_{t-1})a_j + (1 - \alpha_1)\Pi h_j.$$

The definition of this state variable turns out to be convenient for the solution. For two of the three discrete choice options, the maximization problem in the recursive formulation can then be expressed as depending on only one continuous state variable (namely x_j), instead of two (which would be the case if we used the existing assets a_j and h_j directly as state variables). This is the case for the saving problem conditional on *renting*, and very importantly, this also reduces the dimensionality of the state space for the portfolio-choice problem conditional on *owning-and-adjusting*. Supplemental Appendix C.2 contains detailed derivations for rewriting all constraints using liquidable wealth as an auxiliary state variable.

The recursive formulation considers uncertainty as captured by a Markov process,[7] with discrete states $s \in S$, and transition probabilities denoted by $\pi_{s,s'}$, such that for all s we have that $\sum_{s' \in S} \pi_{s,s'} = 1$. The realization of the Markov state at age j is denoted by s_j.[8]

[7]Note that in some of the experiments this Markov state represents the combination of two sources of uncertainty: aggregate uncertainty about the evolution of the risk-free interest rate and idiosyncratic (household specific) earnings uncertainty.

[8]Recall that $\bar{s}$ denotes the price-transformed service flow from housing while s denotes the stochastic state.

The Bellman equation of the recursive problem is

$$W_j(x_j, h_j, s_j) = \max_{d_j, c_j, f_j, a_{j+1}, h_{j+1}} \left[U(c_j, \bar{s}_j) + (1-\iota_j)\beta \sum_{s_{j+1}\in S} \pi_{s_j,s_{j+1}} W_{j+1}(x_{j+1}, h_{j+1}, s_{j+1}) + \iota_j \Psi(x_{j+1}) \right],$$

where $d_j \in \{$*owning-and-not-adjusting, owning-and-adjusting, renting*$\}$ denotes the discrete choice at age j, and the probability of death in period j is denoted by ι_j. The right-hand side maximization is subject to the general form (covering all three discrete choice options) of the budget constraint, now expressed in price transformed units and using liquidable wealth x_j,

$$c_j + a_{j+1} + h_{j+1} + \mathbf{1}_{h_{j+1}\neq \Pi h_j}(\alpha_2 h_{j+1}) + k_t f_j = y_j(s_j) + x_j + \mathbf{1}_{h_{j+1}=\Pi h_j}(\alpha_1 \Pi h_j),$$

and subject to the collateral constraint

$$(1+r_t)a_{j+1} \geq -\mu h_{j+1} - g_{y,j+1}.$$

The discrete-choice options imply the following restrictions: $f_j = 0$ and $h_{j+1} = \Pi h_j$ if *owning-and-not-adjusting*; $f_j = 0$ and $h_{j+1} \neq \Pi h_j$ if *owning-and-adjusting*; $h_{j+1} = 0$ if *renting*.

For the numerical implementation of the solution, we handle the discrete-choice options in the recursive problem according to the approach suggested by Iskhakov et al. (2017), considering the addition of a random component to the valuation of discrete-choice options, that may be interpreted as taste shocks affecting discrete choices, and assuming that this component is distributed according to an extreme-value (type I) distribution. The relevant expectations can then be expressed by using the well-known *log-sum* formula with a scale parameter σ for taste shocks, as spelled out further in Supplemental Appendix C.3.

Conditional on each of the discrete-choice options, we compute the policy functions for continuous-choice variables by using an endogenous gridpoint method (EGM). For the option of *owning-and-adjusting* the EGM algorithm needs to handle portfolio choices, which are not discretized for any of the two assets. For that, we build on the approach we have suggested in Hintermaier and Koeniger (2010): In a first step, we identify portfolio-choice candidates by exploiting the structure of the two Euler equations for the two assets, which both involve the same level of consumption at the time of investment, thus describing an implicit relationship between the two asset positions chosen. In a second step, we determine that level of consumption and pin down the level of the continuous state variable (x_j) that is consistent with the portfolio choice. When applying this approach to the type of model with discrete-choice options, and potential non-monotonicities of policy functions for variables that enter the Euler equations, the algorithm needs to handle the possibility that various candidate solutions for continuous-choice variables are produced at a given level of x_j. This is resolved by computing candidate values of the discrete-choice-specific recursive problem for all continuous-choice candidates relevant at some x_j and selecting the optimal choice.

3. Calibration

3.1 *Approach: Externally versus internally calibrated parameters*

The choices of parameter values for the model fall into two groups. One group of parameters is externally calibrated, in the sense that their fit to data facts is independent of endogenous outcomes from the model. We handle most model parameters this way. The parameter values for the externally calibrated parameters are chosen to match observable properties (e.g., transaction cost, retirement benefit system) of the environment in which life-cycle decisions are made. For our analysis, it is key to capture cross-country differences in properties of the environment in which household financial decisions are made. Section 3.2 describes these choices of externally calibrated parameters.

The remaining group of parameters, which comprises only a few preference parameters, is internally calibrated to optimize the match between model outcomes and data facts on household finances. We calibrate the model to capture key dimensions of the observed heterogeneity in household finances, on which we have detailed data from the Household Finance and Consumption Survey (European Central Bank (2024)). The HFCS is a relatively recent survey for the euro area whose structure largely follows the Survey of Consumer Finances (SCF) in the U.S. The HFCS contains detailed information on household balance sheets but no information on consumption other than food.[9] In Section 4, we will apply the model, as calibrated to match the heterogeneity of household balance sheets, to infer the consumption responses across households with different characteristics. In Section 3.3, we explain in detail, which statistics from the HFCS are targeted for optimizing the preference parameters. The collection of targeted data statistics will be much richer than the summary statistics presented in Table 1 for the introductory motivation of our analysis. In particular, we will employ our life-cycle model to also match age-dependent statistics.

3.2 *Externally calibrated parameters*

Panel A of Table 2 shows the externally calibrated parameters. Our calibration includes a set of cross-country differences regarding the crucial model features for France, Germany, Italy, and Spain: transaction costs for housing, the labor-income profiles, labor-income risk, pension and tax systems, and survival probabilities. Such differences in the economic environment influence household decisions, affecting motives for precautionary and retirement saving and the portfolio composition considered optimal. We also account for differences in the age distribution and the initial wealth of young households at the beginning of their life cycle. Appendix A contains further details on the calibration and the data sources.

[9]Even for food consumption, the HFCS waves have a limited panel component and the survey is only conducted at a frequency of 3 years. This would not allow to estimate responses and distributional implications to those types of changes we analyze, namely responses to aggregate changes at the frequency relevant for monetary policy.

Table 2. Calibrated parameters.

Panel A: Externally calibrated parameters			
I. Common parameters			
μ	0.8		loan-to-value ratio before retirement
μ^{ret}	0.3		loan-to-value ratio after retirement
ξ	0.6		nonhousing component of borrowing limit
ρ	0.95		autocorrelation of income shocks
r^{+}	0.015		lending: real interest rate
r^{-}	0.03		borrowing: real interest rate
r	0.04		long-run real interest rate, applied to bequests
g	0.01		aggregate income growth rate
$\underline{k}$	0.0125		noninterest component of rent-to-price ratio
Π	1.0		price growth factor
σ	0.01		scale parameter of taste shock for discrete choice
α_1	0.025		proportional transaction cost for selling housing
II. Country-specific parameters			
α_2	0.075	Germany	proportional transaction cost for buying housing
	0.080	France	
	0.085	Italy	
	0.105	Spain	
		country-specific	life-cycle age profiles of income
		country-specific	income risk
		country-specific	pensions, tax systems and minimum income benefits
		country-specific	age distribution and survival probabilities
		country-specific	beginning-of-life-cycle asset distribution
Panel B: Internally calibrated preference parameters			
I. Common parameter			
ϕ_R	0.98		rental efficiency
II. Country-specific parameters			
θ	0.80	Germany	weight of nonhousing consumption in utility function
	0.72	France	
	0.78	Italy	
	0.80	Spain	
β-types, weights	0.970, 0.58	Germany	discount factor types and corresponding weights
	0.975, 0.25		
	0.995, 0.17		
	0.900, 0.06	France	
	0.975, 0.47		
	0.985, 0.27		
	0.995, 0.20		
	0.900, 0.14	Italy	
	0.980, 0.22		
	0.985, 0.64		
	0.980, 0.15	Spain	
	0.985, 0.85		

Note: Further details on the calibration such as the implementation of country-specific pension and tax systems, age-income profiles, minimum income benefits, and fees on real estate transactions are contained in Appendix A.

Transaction costs We set the proportional adjustment cost for sellers α_1 to 2.5% of the housing value. The proportional selling cost approximates fees for real-estate agents as in Diaz and Luengo-Prado (2008), for example. As shown in Table 2, we calibrate a higher country-specific cost for the purchaser α_2 because in the considered euro-area countries buyers typically pay the transaction taxes. These taxes differ across countries.[10] The taxes imply that the values displayed in Table 2 are considerably higher than in the U.S. where fees typically amount to 2.5% of the transacted value.

Life-cycle income process We compute the country-specific age profiles and standard deviations of earnings including transfers by regressing the logarithm of these earnings on a quartic age polynomial.[11] Based on the variance of the residuals obtained from these regressions for each country, we obtain the standard deviations of the innovations, reported in Appendix A, for an AR(1) process with an autocorrelation of 0.95. We apply the Rouwenhourst method to approximate the Markov chain with 21 income states. The values for income that we obtain from the HFCS as a common data source are broadly in line with findings reported in Table 2 of Pham-Dao (2019) who reports estimates based on the EU-SILC data set, and with the variances of earnings based on national data sets reported by Fuchs-Schuendeln, Krueger, and Sommer (2010) or Pessoa (2021) for Germany, Jappelli and Pistaferri (2010) for Italy and Pijoan-Mas and Sanchez-Marcos (2010) for Spain.[12]

We account for differences in labor-income taxes across countries by following Guvenen, Kuruscu, and Ozkan (2014). Based on the information in the OECD tax database (OECD (2016)) on tax exemptions and tax rates at different levels of labor earnings, we convert labor earnings into earnings after taxes and transfers. We consider minimum income benefits, requiring that earnings are at least equal to the level of minimum income benefits in each country, as specified in the OECD Social and Welfare Statistics (OECD (2022)) and documented in Appendix A.

While minimum income benefits provide an income floor in Germany, France, and Spain of 4000–5000 euros per year, Italian households bear more income risk because Italy did not provide minimum income benefits during the time period we consider. The calibration of the earnings process for Italy, discretized with 21 earnings states using the Rouwenhorst method, due to the absence of minimum income benefits implies a lowest level of labor income after taxes and transfers that is very close to zero, and thus an order of magnitude smaller than for the other countries. For Italy, earnings at the lowest earnings state of the calibrated and discretized process over the life cycle are in the range of

[10] Kaas et al. (2021) emphasize the importance of transaction taxes to explain the lower home ownership rate in Germany compared to the U.S.

[11] We convert the cross-sectional age profiles into life-cycle income profiles, accounting for cohort effects that result from an average annual income growth of 1%.

[12] Recent evidence of the *Global income dynamics project (https://mebdi.org/global-income-dynamics-project/)* shows that the distribution of changes of log individual gross earnings in the considered countries has skewness and kurtosis that differ from a normal distribution. For Germany, evidence by Pessoa (2021) shows that the normal distribution approximates the distribution of earnings changes better if joint earnings within a household rather than individual earnings are considered, and if government transfers are included. Household earnings after transfers per adult equivalent are the data counterpart of earnings in this paper.

600–1100 euros per year, that is, 50–100 euros per month. In the other countries (Germany, France, Spain), for which a minimum is considered, our calibration implies an incidence of minimum income benefits between 2% and 6% for the working-age population, that is in line with the incidence reported by OECD (2019).

Pensions Concerning income during retirement, we calibrate differences in the pay-as-you-go component of the pension systems using information on the adjustment factor for preretirement earnings (the valorization rate) and the number of earning years used for the calculation of retirement benefits, the growth of benefits during retirement and the net-replacement rates at different levels of net earnings documented in OECD (2007).[13] We calculate pension benefits by approximating the average income for the relevant pre-retirement earning years based on the distribution of income histories associated with the last pre-retirement income draw. See Hintermaier and Koeniger (2011) for further details.

Age distribution, life expectancy, initial wealth For comparability with the survey data, we take into account differences in the age composition across countries, survival probabilities, and the initial distribution of housing and net worth at the beginning of the life cycle. We calibrate the survival probabilities using mortality tables from Eurostat.[14] We use the same age distribution in the model as in the pooled first two waves of the HFCS data. To obtain the initial wealth distribution, we draw from the empirical distribution of net worth and housing wealth observed in the HFCS for households aged 20 to 30. We use data from the first and second wave to draw the distribution and adjust for inflation, converting values into euro of the survey year of the first wave.

Common parameters Those externally calibrated parameters in the model set to common values across countries are summarized in panel A.I of Table 2. We set the real lending rate to 1.5% and the borrowing rate to 3%, implying a spread of 1.5 percentage points. This calibration of interest rates shall capture the environment after the financial crisis with relatively low interest rates and a spread for mortgage loans broadly in line with evidence reported in European Central Bank (2009), chart 21.[15] The long-run interest rate r applicable to bequests, that is, the real rate of return considered relevant after death, is set to 4%. For our specification of the bequest motive explained in Section 2, where one of the bequest parameters is determined as $\psi_2 = r - g$, the higher long-run interest rate ensures that bequests are attractive to generate capital income for the offspring, since it is comfortably higher than the productivity growth rate g of 1%.

[13]Pension savings that are contained in household-specific accounts are reported in the HFCS and are thus part of the targeted net worth that we match in the model calibration.

[14]We use the mortality tables for the reference year 2009, which are available at https://ec.europa.eu/eurostat/web/main/data/database, accessed in May 2020 (Eurostat (2020)).

[15]Given that household debt is secured in our model, the calibrated spread is smaller than the 6 percentage points calibrated in Kaplan, Moll, and Violante (2018) who model net asset positions, thus consolidate housing assets and mortgage debt so that borrowing in their model should be interpreted as unsecured debt. Supplemental Appendix F provides further details on the interpretation and the behavioral implications of the interest spread in our model with housing.

We assume that there is no house price trend in the benchmark steady state, thus setting the price-growth factor $\Pi = 1$, and we set the common rent-price ratio to 0.0275.[16] As explained in Section 2, the rent-price ratio consists of the lending rate and the noninterest component, which are 1.5% and 1.25% in our calibration.[17] The implied price-rent ratio of 36 is broadly in line with empirical evidence for the considered countries.[18]

We set the maximum value of the loan-to-value ratio μ to 0.8, in line with common practice of lenders in the euro area. We restrict the loan-to-value ratio to a lower value of $\mu^{\text{ret}} = 0.3$ during retirement. This shall capture that mortgage contracts typically feature substantial amortization until retirement in the euro area countries we consider, as documented in European Central Bank (2009), page 30, so that loan-to-value ratios are low empirically at the end of the life cycle. For the calibrated economies, it turns out that the tighter specification of μ^{ret} is not binding for most households whose optimal decisions imply substantial amortization even without the tighter maximum loan-to-value ratio during retirement.

We allow agents to borrow up to a fraction $\xi = 0.6$ of the smallest possible labor earnings draw, in addition to borrowing collateralized by housing. Given that the fraction $\mu = 0.8$ of the housing value can be collateralized during working life, this plausibly implies that housing is by far the most important determinant of borrowing capacity.

The scale parameter of taste shocks for the discrete choice, σ, is set to add a small amount of noise to the discrete-choice part of the decision problem, as discussed in Iskhakov et al. (2017). Adding smoothness through such a model feature is convenient for approximating functions in the model solution by interpolation between node points for the continuous state variables.

3.3 *Internally calibrated preference parameters*

Only three preference parameters remain to be calibrated: the discount factor β, the weight θ of nonhousing consumption in the consumption basket, and the relative efficiency ϕ_R of renting that determines the service-flow rate from rental housing. We internally calibrate these preference parameters, optimizing their parameter values for an objective. The objective (loss) function which is minimized consists of the weighted sum of squared deviations of model-implied statistics from their corresponding statistics in the HFCS data.

[16]The rent-price ratio approximately equals the return to housing net of expected price growth. Stable house prices together with the common interest rate discussed above, then imply a common rent-price ratio if we assume similar risk premia of housing across countries.

[17]As is common in the literature, we assume that the user cost of intermediaries, which rent out the housing units, consists of the interest rate at which savers deposit their funds and other costs related to the maintenance and administration of the rented units.

[18]See Kindermann, Le Blanc, Piazzesi, and Schneider (2022) for Germany and the global property guide at https://www.globalpropertyguide.com. Note that price-rent ratios are difficult to compare across countries because of heterogeneous data quality, and differences in the types of housing offered on the rental market. Kindermann and Kohls (2018) find quantitatively sizable differences in the wedges between the values of rented and owned square meters in the euro area.

Table 3. Statistics by country in the data and model predictions.

	Germany		France		Italy		Spain	
	Data	Model	Data	Model	Data	Model	Data	Model
Net worth of which:	152,711	145,646	167,697	164,015	165,492	163,766	172,770	169,833
housing wealth	69,474	65,070	88,922	85,082	105,278	94,742	93,708	86,998
Renter share (%)	53.3	51.9	41.1	38.8	32.2	31.2	18.8	23.1
Mortgagor share (%)	11.1	15.0	15.2	20.5	8.3	17.5	23.5	19.8
LTV of mortgagors (%)	36.1	23.6	36.5	29.1	28.9	22.3	39.5	22.8

Note: Units of net worth and housing are euro per adult equivalent. Means for net worth, housing wealth, shares of renters and mortgagors, median LTV of mortgagors.

In that calculation of the objective, we include the following statistics, listed here in two subgroups, (a) and (b): Subgroup (a) consists of the statistics presented in Table 3, that is, (1) net worth, (2) housing wealth, (3) the renter share, (4) the mortgagor[19] share, (5) the loan-to-value ratio of mortgagors.[20] Subgroup (b) consists of age-group specific statistics for all of the statistics (1) to (5) mentioned under (a). Subgroup (b) thus disciplines the analysis by exploiting the implications of our life-cycle model along the age-dimension. For the statistics in subgroup (b) we split the sample into 5 age groups. Summing up, our objective targets a total of 30 statistics per country, of which 5 come from subgroup (a) and 5×5 come from subgroup (b). We use the degrees of freedom provided by 3 preferences parameters to optimize the match of 30 statistics between the model and the data, for each of the countries.

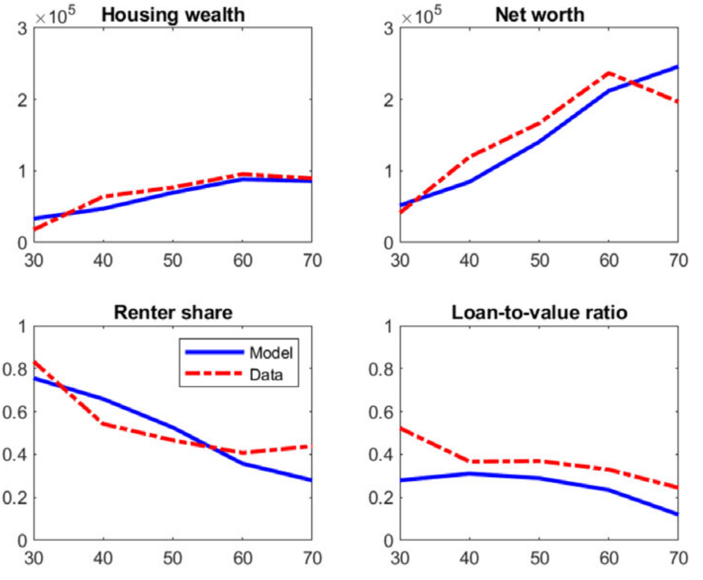
The collection of statistics targeted is richer than the statistics presented in the introductory section in Table 1 because it includes two additional statistics to capture properties of indebtedness. Taking into account these additional statistics is natural for the purpose of our analysis, because patterns of indebtedness are key elements for explaining consumption dynamics. The collection of statistics considered in the objective is also richer than the statistics mentioned here in this section in Table 3 because subgroup (b) for age-group-specific statistics is also targeted, as illustrated in Figures 1 and 2.

The model-implied statistics for each combination of preference parameters are based on using the policy functions obtained from the model solution[21] to simulate

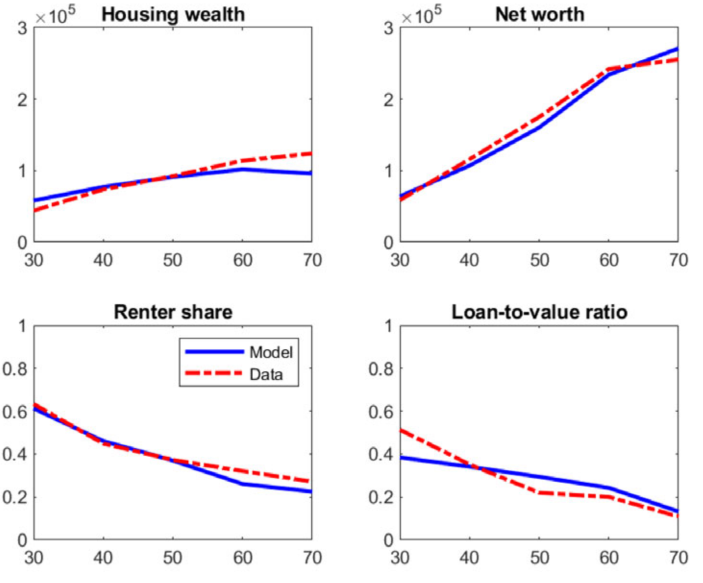
[19]We use the compact label of a *mortgagor*, for a homeowner with a negative financial asset position.

[20]The application of quadratic programming to internally calibrate the preference parameters requires that the population moments can be expressed as weighted averages across the entire population of individual types with different patience. We thus cannot target directly the median LTV ratio of mortgagors reported in Table 3 but a close counterpart: The average LTV, where the necessary surrogate for LTV is set to zero for nonmortgagors.

[21]As emphasized in the model section, we allow for continuous portfolio choices. The recursive solution is implemented with interpolations using 240 node points for housing and 365 node points for the liquid asset in the portfolio. The future marginal utility consequences of any portfolio choice combination are obtained by interpolating on a grid of node points, which is refined by a factor of 3 and 4, respectively, compared to the node points of the two continuous state variables. Consistent with the first-order conditions used in the solution algorithm, the minimum node point for housing is never reached in the simulated choices.

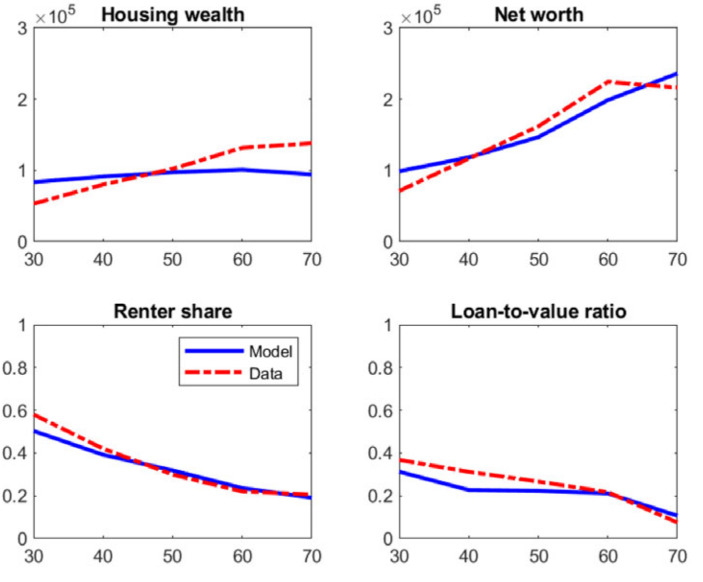


(a) Germany

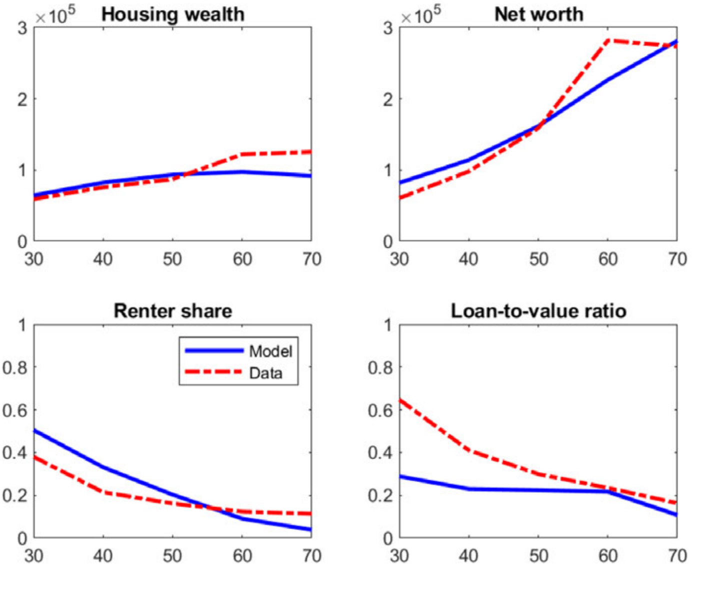


(b) France

FIGURE 1. Age profiles for Germany and France: Data (dashed line) and model predictions (solid line). Notes: Statistics for groups with ages 26–35, 36–45, 46–55, 56–65, 66–75. Units of net worth and housing are euro per adult equivalent. Means for net worth, housing wealth, and shares of renters, median LTV of mortgagors.



(a) Italy



(b) Spain

FIGURE 2. Age profiles for Italy and Spain: data (dashed line) and model predictions (solid line). Notes: See the notes for Figure 1.

life-cycle histories for 120,000 agents. The starting age in the model is age 24. Until retirement age 65, labor income fluctuates stochastically around the mean age profile. Between ages 65 and age 85 agents receive their earnings-dependent pension, calculated as explained above. We draw the income shocks from the stationary distribution. For each country, we build a synthetic survey by sampling households at various ages of their simulated life-cycle profiles. The age-specific sampling weights match the demographic composition of the micro data set for the corresponding country. When comparing the model with the data, we focus on agents between ages 26 and 75 who account for about 90% of the weighted HFCS sample for the considered countries.

We consider model solutions for preference parameters on a grid of plausible ranges: $\beta \in [0.9; 0.995]$, $\theta \in [0.72; 0.82]$, and $\phi_R \in [0.94; 0.98]$ for each country. In the search for a fitting parameterization, we allow for the possibility that a population may be composed of various types of agents, characterized by type-specific preference parameters. The optimal mix of heterogeneous preference-types can conveniently be handled by solving a quadratic programming problem, where type weights matter for the quadratic objective (based on squared deviations of model-implied statistics from their data targets, as mentioned above) and need to satisfy the linear constraint that shares of types sum to one. Supplemental Appendix G contains a detailed explanation of how to map a calibration problem with an optimal mix of heterogeneous types to a quadratic programming problem.

Within-country heterogeneity of household types with different discount factors β turned out to be important in the calibration for matching the targeted statistics. However, within-country heterogeneity in the nonhousing-consumption weight θ or in the relative rental efficiency ϕ_R, and also cross-country heterogeneity in ϕ_R did not improve the model fit much further. Our calibration therefore restricts households to have the same θ within each country and the same ϕ_R within and across countries.

Our calibration with weights for different β-types (i.e., patience types) is based on the the objective[22] with the previously mentioned 30 target statistics. Only those patience types whose optimal weight in the quadratic programming solution is larger than 1% are kept for the calibration.

Panel B of Table 2 shows the preference heterogeneity resulting from the internal calibration.[23] The internally calibrated preference parameters imply a common relative

[22]In the objective, we use relative deviations (i.e., percent deviations) for those statistics, which are not measured in percentage points. The resulting deviations are squared and added with equal weights for the population objective, which then is expressed with reference to type-weights in the quadratic programming problem. We assure that the deviation between the average net worth in the data and the model is less than 5%. For Germany, this requirement is satisfied by letting average net worth enter the objective with a larger weight that is three times the size of the weight attributed to the other average statistics, such as housing wealth or the renter share. For the other countries, the restriction is fulfilled if deviations from the targets in percent or percentage points enter with equal weight in the objective function. The weights of squared deviations in age-group-specific statistics are set to the demographic shares of the corresponding age groups.

[23]Given the parametrization of the bequest motive explained in Section 2 and Supplemental Appendix D, the bequest motive varies across countries because of differences in the discount factor and the average earnings of the offspring.

rental efficiency ϕ_R of 0.98 and some cross-country heterogeneity in the β-types and their weights, and in θ. In terms of model performance, Table 3 and Figures 1 and 2 show that the life-cycle model manages to match most of the targets well by accounting for key differences in the economic environment, that we have explained above, and by allowing for some heterogeneity in the preference parameters.

Although the preference parameters are jointly calibrated, some targets are tightly related to certain parameters. The weight of nonhousing consumption in the consumption basket θ together with the parameter for the rental efficiency ϕ_R allows to match average housing wealth and the renter share.

The discount factor β allows to match average net worth and its age profile. The *distribution* of β-types helps to match at the same time the indebtedness of homeowners, in particular for countries with a lot of renters such as Germany. The intuition is that patient households will transit from renting to owning if they have accumulated so much net worth that they do not have much debt once they are homeowners. Allowing for some less patient households in the population thus implies more transitions from renting to owning by low net worth households that want to benefit from the higher housing service flow obtained from owned relative to rented housing. These low net worth households have relatively higher debt if they are homeowners. Relatedly, Calvet, Campbell, Gomes, and Sodini (2022) and Azzalini, Kondziella, and Rácz (2023) also provide evidence for heterogeneity of patience across households, applying portfolio choice models to analyze Swedish administrative data.

3.4 *Model performance*

Table 3 and Figures 1 and 2 show a good overall fit of our calibrated model to the data. The results also reveal some trade-offs in trying to match the data for heterogeneous households along many dimensions (30 statistics) with mostly exogenously informed parameters and just a few internally calibrated preference parameters. Averages of net worth, its housing component, and the renter share are well matched, despite having targeted properties of indebtedness on top of these classical targets. Regarding indebtedness, the calibration matches the leverage of homeowners quite well. If we disentangle the extensive and intensive margins of leverage over the life cycle, we observe that the predicted LTV ratios conditional on being a homeowner with debt (at the intensive margin) remain a bit below the data counterparts, particularly at young ages, whereas the incidence of mortgagors (at the extensive margin) is higher compared to the data, particularly for Italy, though not for Spain. Our exploration of the parameter space during the calibration has confirmed that these deviations from the data targets could only be reduced at the cost of increasing deviations from other data targets.

Overall the model fit is comparable with the life-cycle model by Kaas et al. (2021) calibrated for Germany. Along a dimension which was not targeted in our calibration, which is naturally related to the key feature of illiquidity of housing in our framework, our calibrated model implies an adjustment incidence of housing of 1.6% per year in the synthetic model-generated data for Germans, which is quantitatively very close to empirical evidence for Germany, reported in Table B.3 of the Online Appendix of Kaas et al.

(2021). The incidence varies from 1.4% in Italy and 1.6% in France to 1.8% in Spain. This is also in line with the empirical evidence on housing tenure transitions for Germany and Italy in Koeniger, Lennartz, and Ramelet (2022). Similar to the empirical evidence in Kaas et al. (2021), Table B.3, we find that 22% of the housing adjustments in Germany result from changes of house size by households who already own a home. This fraction increases to 30% in Spain and 39% in Italy where more households own a home.

In Supplemental Appendix F, we discuss how housing adjustment interacts with the interest spread and highlight some different implications of the spread in our model with housing compared to the literature. Figure 8 in Supplemental Appendix E shows how the country-specific model parameters, displayed in Table 2, contribute to explaining the cross-country differences in the data targets for average net worth, housing and the renter share. Normalizing by the value of the respective statistic for Germany as benchmark, Figure 8 illustrates that differences in the initial conditions and the calibrated preference heterogeneity are quantitatively important to account for the cross-country differences. This may be interpreted as a structural counterpart of a country fixed effect in the reduced-form literature on comparative household finance.

4. Consumption responses

We use the calibrated model to analyze the response of nonhousing consumption to changes in the real interest rate for the considered euro-area countries. We complement the analysis of this key part of monetary policy transmission, by illustrating some of the challenges monetary policy would face if a housing bust occurred.

4.1 *Consumption response to a change in the real interest rate*

The consumption responses in our model depend on the portfolio composition of households, which determines the exposure to interest rate changes. For the aggregate consumption response the distribution of assets therefore matters, for example, whether most households own a home and have a mortgage or whether most households rent and hold mainly liquid assets. The relative contributions of various groups of households to the aggregate consumption response can thus be linked to properties of their balance sheets.

4.1.1 *The benchmark* In the benchmark results reported in Figure 3, we assume that there is no pass-through of the real interest rate change to the rent-to-price ratio. Such a lack of pass-through is consistent with elastic supply of real estate units to new owner-occupiers by real-estate investors (Greenwald and Guren (2021)). This assumption is supported by empirical evidence based on household-level data in Koeniger, Lennartz, and Ramelet (2022) who do not find robust evidence for a sizable pass-through of monetary shocks to rents and house prices in Germany and Italy during the first 2 years after the shock. The aggregate evidence for euro-area countries by Corsetti, Duarte, and Mann (2018), Figure 8, also supports our assumption for the pass-through. They find a pass-through of monetary policy shocks to rents and house prices that is modest for the euro-area countries considered in our paper during the first year after the monetary

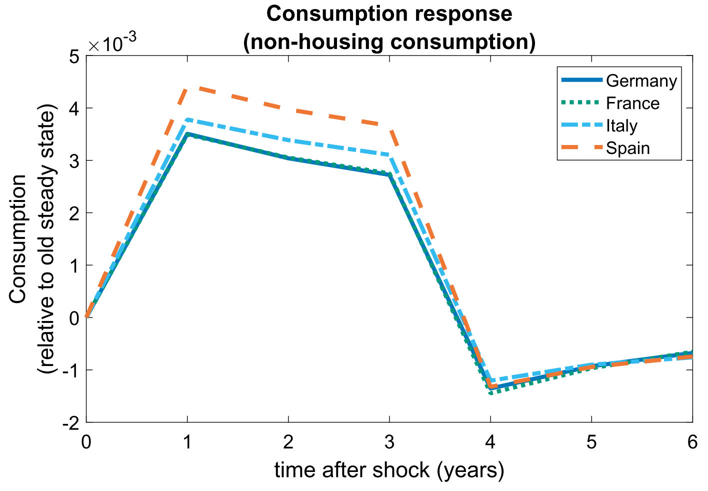


FIGURE 3. Unexpected fall of the real interest rate from 1.5% to 1.25% reversed after 3 years, without pass-through to the rent-to-price ratio.

policy shock. We discuss further below that the extent of the pass-through determines the size and asymmetry of the response of nonhousing consumption to changes in the interest rate.

Figure 3 shows the response of nonhousing consumption for a specific path of the interest rate chosen for illustrative purposes, where the real interest rate decreases by 25 basis points for 3 years and then increases back to its initial value. The duration of the interest rate change is inspired by the evidence on persistent effects of monetary policy shocks on interest rates.[24] The household decisions underlying these experiments are obtained under the assumption that households expect[25] at the time of the initial change, that the interest rate will switch back to its initial level with a probability that implies an expected duration of 3 years. We thus show the consumption response for the case in which the realized reversal of the interest rate occurs at the point in time corresponding to the expected duration after the initial change.[26]

Figure 3 shows that a fall in the real interest rate by 25 basis points (bp), that is expected to be reversed after 3 years, and also happens to be reversed after 3 years, increases nonhousing consumption on impact between 35 bp in Germany and France, to 38 bp in Italy and 44 bp in Spain. These absolute magnitudes of responses, obtained by a given standard magnitude for the interest-rate change, imply an extent of relative cross-

[24] See, for example, Figure 4 in Corsetti, Duarte, and Mann (2022) or Table 2 in Koeniger, Lennartz, and Ramelet (2022).

[25] In an earlier working paper version (Hintermaier and Koeniger (2018)), we exploited in more detail the potential of this framework to capture expectations of households about future policy. Since that version of the paper was written during times when *forward guidance* was of natural concern for monetary policy, Section 4.1.3 in that version of the paper uses the model to address the effects of forward guidance.

[26] The interest rate change is implemented as an MIT shock, introducing a new regime. The transition matrix in the new regime contains the conditional probabilities of the interest rate switching back to its initial level and the complementary event of a low interest rate for another period.

country differences of $(44\text{bp} - 35\text{bp})/35\text{bp} = 0.257$, that is, of up to more than a quarter of the responses.

The size of the consumption responses illustrated in Figure 3 is in the ballpark of the empirical estimate for the aggregate consumption response to a monetary-policy shock of 25 basis points after 1 year in the euro area, as in recent evidence reported in Figures 4 and 6 of Corsetti, Duarte, and Mann (2022), based on high-frequency identification of monetary policy shocks. The consumption responses generated by our model are well within the confidence interval of estimates reported in Corsetti, Duarte, and Mann (2022). Their country-specific point estimates are a bit smaller, which is to be expected because we compute the consumption response to changes of the *real* interest rate whereas Corsetti, Duarte, and Mann (2022) estimate the consumption response to changes of the *nominal* rate, and only part of the change of the nominal rate translates into a change of the real rate. In line with Corsetti, Duarte, and Mann (2022), Figure 6, we find that the consumption response is largest in Spain and smallest in Germany. The larger quantitative differences in the responses between some of the countries in Corsetti, Duarte, and Mann (2022) suggest that there are additional channels, possibly related to indirect effects, through which monetary-policy shocks affect consumption beyond the changes in the real rate captured in our model. We will comment on the dynamics of the consumption responses, visible in Figure 3, after the following discussion of the disaggregated consumption responses on impact.

Disaggregating the consumption response In order to understand the mechanisms behind the aggregate results, we analyze the heterogeneity of individual responses on impact, which is underlying the aggregate responses. Our analysis of the relevant household heterogeneity builds on housing tenure groups, which are a key feature of our model. We show how the *pre-shock* exposure to interest rate changes and the marginal propensity to consume (MPC), which have been established to shape the consumption responses in related model environments,[27] differ across housing tenure groups.

We show that the consumption responses do not only depend on *pre-shock* exposure and MPC but are also systematically related to the *post-shock* discrete choices of renting versus owning, where the latter may go along with adjusting or not adjusting housing. These discrete choices related to housing tenure are as endogenous as consumption behavior itself, and may equally be affected by any shock to the decision-making environment.

In order to disentangle the role of discrete-choice dynamics induced by the shock, we identify subgroups of households according to their combination of two discrete choices: First, the (*post-shock*) discrete choice made given that the shock has hit. Second, the hypothetical (*without-shock*) discrete choice that would have been made in the absence of the shock. For example, such subgroups separate the consumption responses of those *pre-shock* renters who would have chosen to become homeowners even in the absence of an interest change, for example, because of typical life-cycle patterns, from

[27] As in Auclert (2019), the consumption responses are shaped by the MPC and the unhedged interest exposure, but in our model, also by the persistence of the interest rate shock, the change of the ownership decision because of the shock, and the anticipation of possible future housing adjustment.

the consumption responses of those *pre-shock* renters whose transition to homeownership was actually triggered by the interest rate change.

Table 4 illustrates some of the heterogeneity in the consumption responses on impact for Germany, after an unexpected fall of the interest rate. The top row shows the aggregate response. The middle part provides results for the three housing tenure groups based on the state variables before the shock: renters ($h_j = 0$), outright owners ($h_j > 0$ and $a_j \geq 0$), and mortgagors ($h_j > 0$ and $a_j < 0$). For each of these groups, we distinguish subgroups based on their discrete choices after the shock and in a hypothetical scenario without the shock. In the bottom part of the table, we provide results for groups of households that are defined according to the size of their MPC, considering the three terciles of the MPC distribution in the economy.

Table 4 decomposes the aggregate consumption response by reporting in the first column the consumption response of the considered group to the interest rate change (relative to the consumption of that group before the shock), then the incidence of that group in the second column, the share of consumption accounted for by that group in the third column, the contribution of the group to the aggregate consumption response in the fourth column, the average marginal propensity to consume (MPC) of the group in the fifth column,[28] and the group's unhedged interest rate exposure relative to consumption (relative URE) in the last column.[29]

Table 4 delivers a key message. The consumption response to interest rate changes depends on three main determinants in our model: the exposure to interest rate changes and the MPC, in line with the analytic results provided by Auclert (2019) in a related framework, and the housing tenure decision including the decision of whether to adjust housing or not. Renters, for example, tend to have a high MPC but have relatively small asset or liability positions in the interest-bearing asset. Hence, their exposure to interest changes is minor, as is illustrated by the low relative URE. The consumption response of renters with their small exposure to interest rate changes is thus smaller than the consumption response of homeowners although homeowners have a much smaller MPC on average than renters. The consumption response is highest for mortgagors who have a negative exposure on average and nearly all of them choose to not adjust their housing.[30] The bottom part of Table 4 shows that the consumption response to the fall in the interest rate is largest in the middle tercile of the MPC distribution, where both the MPC and the relative URE take intermediate values.

Table 4 reveals a remarkable heterogeneity in the consumption response of households that have been renters before the interest rate shock. The consumption *de*creases

[28]Based on the policy function, we compute the MPC as the fraction consumed out of additional 10 euro, which we consider a reasonable approximation for the change of consumption after a *marginal* change of liquid resources.

[29]Following (Auclert (2019)), the unhedged interest rate exposure in our setting equals $y + (1 + r)a - c$. The relative URE, which is relevant for the relative consumption response, is thus $(y + (1 + r)a - c)/c$.

[30]The group of mortgagors who adjust is smaller than half a percent, both in terms of the share of the group in the population and their consumption share, so that we do not report that group in Table 4. Depending on whether the homeowner has negative or positive financial assets, the interest rate is 1.5% or 3%, which would also correspond to the value of the MPC under a hypothetical benchmark of a classic permanent income model in which the discount rate equals the interest rate.

TABLE 4. Germany: Consumption responses of different groups of households to an unexpected fall of the interest rate.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative URE (mean)
All households, aggregate		0.0035	1.000	1.000	0.0035	0.16	12.60
Renters *pre-shock*		0.0017	0.530	0.483	0.0008	0.28	0.89
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-adjusting	owning-and-adjusting	0.0037	0.012	0.015	0.0001	0.03	5.99
owning-and-adjusting	renting	−0.0230	0.015	0.019	−0.0004	0.01	4.63
renting	renting	0.0027	0.503	0.448	0.0012	0.30	0.65
Outright owners *pre-shock*		0.0047	0.322	0.348	0.0016	0.02	38.67
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0049	0.318	0.340	0.0017	0.02	38.85
owning-and-adjusting	owning-and-adjusting	0.0031	0.003	0.005	0.0000	0.02	20.36
Mortgagors *pre-shock*		0.0061	0.147	0.169	0.0010	0.06	−2.33
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0063	0.146	0.169	0.0011	0.06	−2.30
MPC upper tercile		0.0026	0.330	0.244	0.0006	0.44	0.03
MPC middle tercile		0.0051	0.340	0.468	0.0024	0.05	1.25
MPC lowest tercile		0.0016	0.330	0.288	0.0005	0.01	36.86

Note: Relative consumption responses on impact after an unexpected fall of the real interest rate from 1.50% to 1.25%, thereafter expected to be reversed after 3 years, without pass-through to the rent-to-price ratio. Group membership is based on *pre-shock* variables, that is, properties prevailing at the *beginning of the period* when the shock hits. Thus, the incidence of renters and homeowners may differ slightly from the numbers reported for the calibration to end-of-period data. Subgroup membership is defined by the combination of two discrete choices: First, the (*post-shock*) discrete choice made given that the shock has hit. Second, the hypothetical (*without-shock*) discrete choice that would have been made in the absence of the shock. Discrete-choice subgroups are listed if their share in the population or their consumption share is at least half a percent. Marginal propensities to consume (MPCs) are assessed in the situation without shock. *Relative URE* refers to unhedged interest rate exposure relative to consumption. Rounding error may prevent the sum of shares or contributions of groups to equal the aggregate.

for the subgroup of those renters who have been triggered to become homeowners by the fall in the interest rate. They become owners after the shock but would have continued to be renters without the shock. This subgroup of renters accounts for only 2% of aggregate consumption but Table 4 shows that their strong negative consumption response is an order of magnitude larger, and thus reduces the positive aggregate consumption response by four basis points, which corresponds to 11% of the aggregate response. The last two columns of Table 4 further show that these renters who become owners have more resources, and thus a larger relative URE and a lower MPC than the average renter.

The strong consumption response of (non-adjusting) mortgagors, shown in Table 4, is similar to the empirical evidence of Cloyne, Ferreira, and Surico (2020), although their estimates are based on data for the U.K and the U.S.[31] A difference in Germany compared to these countries is that homeowners account for a much smaller share of aggregate consumption. Hence, the contribution of the response of homeowners to the aggregate consumption response is not as large as in other (euro-area) countries with larger homeownership rates.

Table 4 further shows that renters in Germany contribute only a quarter of the aggregate consumption response although they account for roughly half of aggregate consumption. Thus, the aggregate consumption response is smaller in Germany than in the other euro-area countries considered here.

Results for the other countries, France, Italy, Spain are reported in Appendix B.1. These results confirm that the type of housing tenure is an important dimension of heterogeneity for explaining aggregate consumption responses, and their cross-country differences. The results for the other countries also show that the specifically identified subgroups of non-adjusting (indebted) homeowners and those renters who are triggered by the interest rate shock to become homeowners play an important role for the aggregate consumption responses. For all countries, the consumption responses are largest in the middle tercile of the MPC distribution where intermediate MPCs are associated with intermediate relative UREs.

The importance of housing tenure for cross-country differences in aggregate consumption responses is revealed by a comparison of the results in Tables 8, 9, 10 in Appendix B.1. For all countries, it is the case that consumption responses differ by housing tenure groups. However, the consumption responses conditional on each housing tenure group are quantitatively similar across countries. Therefore, the vast differences in housing tenure are essential for explaining a large part of the cross-country differences in aggregate consumption responses. In Section 4.3, we will elaborate on this point for identifying the role of cross-country differences in household finances.

To which extent are the consumption responses that we have reported associated with different phases of the life cycle? Figures 4 and 5 illustrate the heterogeneity of the responses over the life cycle for Germany (illustrations for the other countries are qualitatively similar). The figures plot the life cycle profiles for selected cohorts, which are hit

[31] Their estimates of the responses are particularly significant at horizons beyond eight quarters, at which other effects may increasingly become important, apart from the direct effects we focus on.

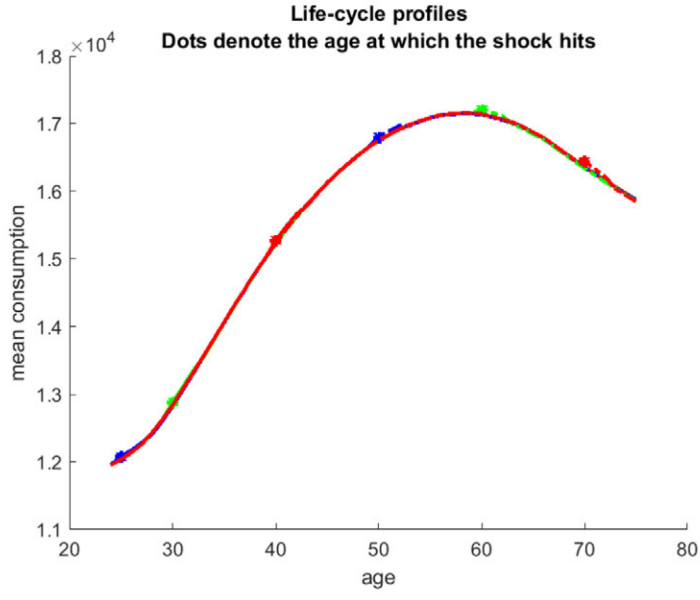


FIGURE 4. Consumption. Notes: Life-cycle profile for Germany. Population means based on model simulations. Dots denote the age at which the respective cohort is hit by the decrease of the interest rate.

by the unexpected decrease of the interest rate at different stages of their life cycles. The life cycle profiles show means and their responses in the simulated population, condi-

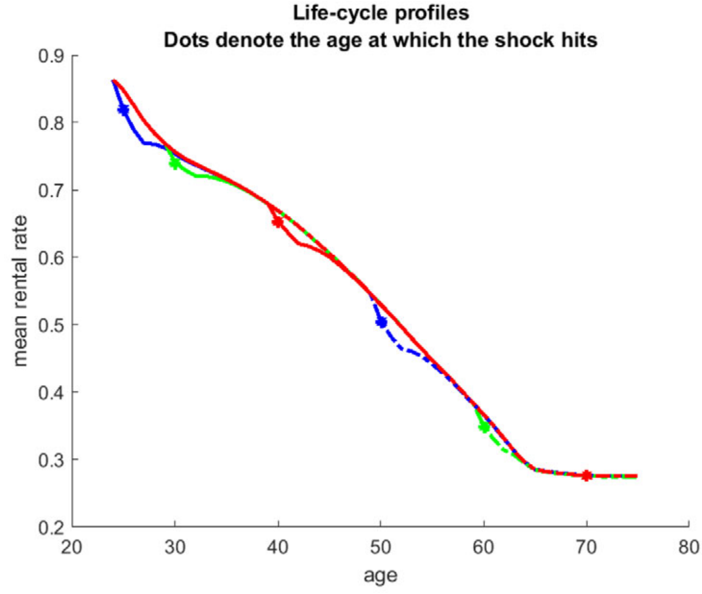


FIGURE 5. Housing renter share. Notes: See the notes for Figure 4.

tional on the relevant age of a cohort at the time of the shock. Note that such age-specific responses of the simulated cohorts of individual households form the basis of the aggregated consumption responses reported above, which also take into account the age composition.

Figure 4 exhibits the familiar hump shape of consumption over the life cycle. The figure also reveals that the degree of variation of consumption over the life-cycle, as captured by our model, is much larger than the changes triggered by the unexpected interest rate shocks.

Figure 5 shows stronger responses with respect to another margin of adjustment considered in our framework, namely changes in housing tenure from renting to owning, which are central for the previously discussed mechanisms underlying the consumption responses. Such changes in housing tenure are associated with portfolio shifts from liquid financial assets to less liquid housing.

Dynamics of the aggregate consumption response Beyond the previously discussed responses on impact, Figure 3 delivers further interesting insights for the dynamics of aggregate consumption. After year 3, when the interest rate increases back to its initial level, consumption falls below its initial level. As we will discuss below when analyzing the direction of the shock, an interest rate *in*crease has a stronger effect on consumption than an interest rate *de*crease. Such a fall of aggregate consumption below its initial level worsens the trade-off for stabilization using monetary policy: current increases of consumption after a reduction of the interest rate come at the cost of larger consumption reductions in the future, when the interest rate reverts to its initial level.

Asymmetries of consumption responses, depending on the direction of the shock We now identify sign-dependent asymmetries by analyzing consumption responses after a change in the interest rate in the opposite direction. The consumption response after an *increase* of the real interest rate by 25 bp (reversed after 3 years, without pass-through to the rent-price ratio, as in the benchmark) on impact is −0.39% for Germany, −0.43% for France, −0.41% for Italy, and −0.48% for Spain. Thus, the absolute size of the consumption response after an interest rate increase is 4 bp larger for Germany, 8 bp larger for France, 3 bp larger for Italy, and also 4 bp larger for Spain. These differences amount to relative changes of the absolute size of the response between 10% and 20% for these countries.

Inspecting the responses for each housing-tenure group reveals that the asymmetric responses to changes of interest rate with opposite sign, and the different extent of these asymmetric responses across countries, are caused by housing tenure transitions from renting to owning. In line with this explanation, the computations underlying the results reported above have also revealed that the consumption response of agents that do *not* change housing tenure after the shock is quantitatively symmetric after an interest rate increase or decrease.

Considering the case of an interest rate *decrease* and the implied housing tenure dynamics, we find that an interest rate decrease triggers additional housing tenure transitions from renting to owning on impact. The temporarily lower interest rate reduces the user cost of owning, while the rent-to-price ratio remains constant in the benchmark case without pass-through. Hence, renters at the margin of purchasing a home take advantage of the reduced user cost by transiting to ownership. Given this transition to home ownership and the adjustment costs, we find that these agents *lower* their expenditures for nonhousing consumption after an interest rate reduction.

Instead, when considering the case of an interest rate *increase* there is much less impact on the housing tenure transitions in the opposite direction, that is, from renting to owning. In this case, some renters at the margin of purchasing a home postpone their life-cycle decision of a home purchase until the temporarily higher interest rate falls back to its initial level.

We find that this asymmetry tends to be larger in Germany and France than in Italy and Spain because in the former countries fewer agents are homeowners in the early stages of their life cycle. This implies that interest rate changes meet a high potential of affecting the life-cycle timing of transitions to ownership between ages 35 and 55 visible in Figure 5. In the benchmark case considered above, a decrease in the interest rate affects housing tenure transitions significantly because there is no pass-through to the rent-price ratio, which amplifies the asymmetric responses of aggregate consumption. In the following, we analyze how the degree of pass-through shapes the responses to interest rate changes.

4.1.2 *The role of the pass-through of interest rates to the rent-price ratio* A comparison of results between the benchmark case without pass-through and the case with full pass-through shows that the responses of nonhousing consumption to changes in the interest rate are sensitive to assumptions about the transmission of monetary policy to the housing market. In the case of full pass-through, the relative consumption response to a 25 bp reduction of the interest rate is 0.5% for Germany, 0.52% for France, 0.45% for Italy, and 0.53% for Spain. These responses are larger than in the benchmark and the ordering of the sizes of the responses is at odds with the empirical evidence reported in Figure 6 of Corsetti, Duarte, and Mann (2022).

With full pass-through also the effects of monetary policy on rental expenditures and portfolio choices change substantially relative to the benchmark. Exploring the parameter space of our model in this direction has shown that the effect of the decrease in the real interest rate on household portfolios and the renter share is small in this case. As we will discuss in the following, these predictions implied by the case with full pass-through would be at odds with empirical evidence on monetary policy transmission to the housing market in the short to medium term.

Without pass-through to the rent-price ratio, as in our benchmark experiment, the model predicts a temporary increase of the home-ownership rate after an unexpected decrease of the interest rate that is in line with empirical evidence, which exists for some of the considered countries. For Germany, the model predicts a temporary increase of the homeownership rate by 1.5 pp due to renters who are triggered to become homeowners, which is in line with the empirical estimate for Germany in Koeniger, Lennartz, and Ramelet (2022). To put the size of the effect of the interest rate change on the home ownership rate into perspective, note that the standard deviation of a policy interest rate shock in the euro area is 7 bp in the 2000s so that the typical monetary policy shock is much smaller than 25 bp (Koeniger, Lennartz, and Ramelet (2022)). For Italy, the model predicts a temporary increase of the homeownership rate that is 1.4 pp, broadly in line with the smaller effect estimated for Italy in Koeniger, Lennartz, and Ramelet (2022).[32] Thus, the benchmark assumption of no pass-through gives rise to empirically plausible aggregate dynamics of home ownership and consumption across countries. Summing up, we find that our benchmark assumption of no pass-through to the rent-price ratio aligns the model predictions for the size and cross-country heterogeneity of the nonhousing consumption response better with the data.

4.1.3 *Discussion of the role of the debt contract for the consumption responses* The heterogeneity in the consumption responses across countries may be further shaped by the cross-country heterogeneity of the type of mortgage contracts. In Italy and Spain, for example, households have options to refinance mortgage loans at little cost or have mortgage contracts with adjustable interest rates. In France and Germany instead, most households have mortgage contracts with fixed rates and have to make penalty payments when they refinance their mortgage (European Central Bank (2009), Calza, Monacelli, and Stracca (2013), Ehrmann and Ziegelmeyer (2017), Jappelli and Scognamiglio (2018)).

The effect of mortgage-contract types and the cost of refinancing on the aggregate consumption response is ambiguous. As discussed in Wong (2019), fixed-rate mortgages, which can be refinanced at low cost, increase the consumption response of young, liquidity constrained homeowners after expansionary monetary policy shocks that lower interest rates. A higher incidence of adjustable-rate mortgages, however, increases the fraction of mortgagors whose consumption increases after an expansionary monetary policy shock. Furthermore, the option of refinancing fixed-rate mortgages introduces a path dependance of monetary policy (Berger et al. (2021), Eichenbaum, Rebelo, and Wong (2022)) because past monetary policy decisions determine for how many households, and to which extent, an expansionary monetary policy shock drives a wedge between the interest rate specified in their mortgage contract and the current market rate. Kinnerud (2022) shows that besides the refinancing channel also the adjustment of housing plays an important role for the aggregate consumption response to interest rate changes.

The quantitative results in Wong (2019) and Kinnerud (2022) for the U.S. suggest that the aggregate consumption response is larger if households have adjustable-rate rather than fixed-rate mortgages. Taken at face value, this would imply that the consumption responses for Germany and France would be relatively lower, and the cross-country heterogeneity thus larger, if we accounted for the higher incidence of fixed-rate mortgages in these countries relative to Italy and Spain. Further research is needed to check this conjecture, modeling the incidence of fixed-rate and adjustable-rate mortgage contracts explicitly to account for how the selection into different type of mortgage

[32] Empirically, Koeniger, Lennartz, and Ramelet (2022) find that the response to monetary policy shocks is heterogeneous within Italy where the transition from renting to owning is affected more in Northern regions that have been characterized as more financially developed in the literature (Guiso, Sapienza, and Zingales (2004)).

contracts shapes the consumption responses in euro area countries. Such an extension would be nontrivial mainly because it would add an additional endogenous state variable to the problem.[33]

4.2 *Consumption response to a fall in the house price*

The current environment has raised concerns about a house price correction because interest rates increased back to higher levels. We thus analyze the effect of a house price correction on consumption in this subsection and the heterogeneity of the effect across the considered euro-area countries with different homeownership rates.

The house-price change is implemented as an unanticipated fall of the house price by 10%. The consumption responses are intuitively larger in those countries in which home ownership rates are higher. Nonhousing consumption on impact falls by 1.16% in Spain, 1.14% in Italy, 0.93% in France and 0.83% in Germany. These responses imply elasticities of consumption to house price changes between 0.083 for Germany and 0.116 for Spain. The higher elasticities in Spain and Italy are in line with the higher homeownership rates, relative to Germany and France. The homeownership rates in Spain and Italy are closer to the homeownership rate in the U.S., and so are the elasticities of consumption in response to a house price change.[34]

Also for this scenario, our model allows us to investigate the heterogeneity of consumption responses across households. The experiment we consider abstracts from equilibrium feedback effects on renters from house-price changes so that the aggregate consumption response to the house price drop is driven by the consumption response of homeowners. The extensive margin of home ownership is thus particularly important for understanding the aggregate consumption response to house price changes.

Table 5 illustrates the heterogeneity of the consumption response within the group of homeowners for Germany where the last column displays the relative housing value exposure (ph/c) before the shock. Appendix B.2 contains the results for the other countries, which are similar in terms of the quantitative size of the responses of homeowners so that cross-country differences in the aggregate consumption responses to house price changes result from differences in home ownership, rather than from differences in the consumption responses of homeowners. Table 5 shows that the fall of the house price reduces consumption for both adjusting and non-adjusting homeowners. The largest negative response is by those adjusters whose adjustment has been triggered by the unexpected fall of the house price, that is, outright owners who would not have adjusted

[33] Papers which add such a third endogenous state variable have to reduce the grid size per endogenous state variable substantially, discretizing, for example, the number of house values to twenty points or less. The coarseness of such a grid may not be innocuous for the chosen portfolio positions of liquid and illiquid assets, and thus also the consumption response. Simplifying the analysis by reducing the heterogeneity of agents to three types, Corsetti, Duarte, and Mann (2022) find that the different incidence of fixed and adjustable-rate mortgages in the euro area plays a quantitatively modest role for consumption responses to monetary policy shocks. In a two-agent model of the currency union, Pica (2023) shows that the share of adjustable-rate mortgages interacts with the share of homeowners in shaping the consumption response.

[34] The model-implied elasticities for Italy and Spain are in the range of estimates for the U.S. reported in Guren et al. (2021) and are somewhat below 0.2, the model-based estimate for the U.S. in Kaplan, Mitman, and Violante (2020b).

TABLE 5. Germany: Consumption responses of different groups of households to an unexpected fall of the house price.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative HVE (mean)
All households, aggregate		−0.0083	1.000	1.000	−0.0083	0.16	5.29
Outright owners *pre-shock*		−0.0157	0.322	0.348	−0.0055	0.02	11.67
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0147	0.314	0.334	−0.0049	0.02	11.79
owning-and-adjusting	owning-and-not-adj.	−0.0647	0.005	0.008	−0.0005	0.01	6.98
Mortgagors *pre-shock*		−0.0168	0.147	0.169	−0.0028	0.06	10.39
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0171	0.145	0.167	−0.0029	0.05	10.34

Note: Relative consumption responses on impact after an unexpected fall of the house price by 10%. Group membership is based on *pre-shock* variables, that is, properties prevailing at the *beginning of the period* when the shock hits. Thus, the incidence of homeowners may differ slightly from the numbers reported for the calibration to end-of-period data. Subgroup membership is defined by the combination of two discrete choices: First, the (*post-shock*) discrete choice made given that the shock has hit. Second, the hypothetical (*without-shock*) discrete choice that would have been made in the absence of the shock. Discrete-choice subgroups are listed if their share in the population or their consumption share is at least half a percent. Marginal propensities to consume (MPCs) are assessed in the situation without shock. *Relative HVE* refers to housing value exposure relative to consumption.

without the shock. These adjusters only account for 0.5–1.1% of the population and for 0.8–1.6% of aggregate consumption, depending on the country. Their three to five times larger negative response compared to the other homeowners thus does not affect the aggregate consumption response much.

Our findings show that the consumption response to house price changes is largest in Spain and Italy where housing is quantitatively more important for household portfolios relative to France and Germany. This result aligns with the rule of thumb proposed by Berger et al. (2018). The rule of thumb is based on the consumption response in a frictionless model, which nests the preferences in our model and shares the specification of the collateral constraint. In this case, the consumption response to house price changes is determined by the endowment effect, while the substitution, income and collateral-constraint effects cancel.

Challenges for monetary policy implied by asymmetric effects of a housing bust Our results on the consumption responses to changes of real interest rates and relative house prices illustrate policy challenges for a central bank, which faces regionally asymmetric consumption responses after a housing bust and sets a common policy interest rate within the currency area.

Consider a central bank that tries to mitigate the consumption slump after a housing bust with accommodative monetary policy. According to the numbers presented above, the consumption response on impact after a fall in house prices by 10% differs by 33 bp across the considered euro-area countries. The consumption response is larger in Italy and Spain than in Germany and France because the homeownership rate is higher in Italy and Spain and the size of housing in household portfolios is larger. Quantitatively, we find that the cross-country asymmetry of the consumption response in a housing bust is only partially compensated by the stronger response of consumption to a decrease in the real interest rate in Spain and Italy compared with Germany and France, illustrated in Figure 3. The consumption response after a 25 bp decrease of the *real* interest rate is 9 bp larger in Spain than in Germany and France. Our results indicate that this heterogeneity may make it particularly challenging to stabilize consumption after housing busts in countries with high homeownership rates, such as Italy and Spain. This would require large decreases in the interest rate which, however, would trigger a consumption boom in Germany and France. These challenges may intensify if housing busts are heterogeneous across countries. In the Great Recession and subsequent sovereign debt crisis house prices fell by more than 10% in Italy and Spain and by less in France and Germany.[35]

4.3 *The role of differences in household finances*

We now try to uncover the role of differences in the composition of household balance sheets for the cross-country differences in aggregate consumption responses. Our results have shown that distinguishing housing-tenure groups captures essential parts of the heterogeneity that is underlying the aggregate consumption response. We compute

[35]See the deflated house-price index (the series called *tipsho*) for 2006 to 2016 available at Eurostat.

Table 6. Consumption responses on impact and differences in the incidence of housing-tenure groups.

	Germany	France	Italy	Spain
Responses to decrease of the ***real interest rate*** *from* 1.5% *to* 1.25%				
Benchmark responses	0.0035	0.0035	0.0038	0.0044
Responses with German incidence of housing-tenure groups	0.0035	0.0028	0.0027	0.0032
Responses to decrease of the ***house price*** *by 10%*				
Benchmark responses	−0.0083	−0.0093	−0.0114	−0.0116
Responses with German incidence of housing-tenure groups	−0.0083	−0.0072	−0.0082	−0.0080

Note: The responses with the German incidence of housing-tenure groups are constructed by using the German incidence of groups for the calculation of counterfactual consumption shares, which are then combined with the country-specific consumption responses per group. The groups used are the *pre-shock* housing-tenure groups defined above: renters, outright owners, mortgagors.

counterfactual consumption responses for France, Italy, and Spain. These counterfactual responses are constructed by assigning to these other countries the German incidence of the *pre-shock* housing-tenure groups featured above, namely of renters, outright owners, and mortgagors. This allows us to gauge the extent to which accounting for differences at the extensive margin, which are easier to measure than differences at the intensive margin, would allow policymakers to assess the scope of cross-country differences in the consumption responses, abstracting from heterogeneity within housing-tenure groups.

As shown in the top panel of Table 6, the consumption responses to a fall in the real interest rate for France, Italy, and Spain decrease when counterfactually imposing the German incidence of housing-tenure groups. Cross-country asymmetries between Spain and Germany in the consumption responses are reduced if we assign the German incidence. The difference in the incidence of renters between Spain and Germany leads to differences between the actual consumption share and the counterfactual consumption share of Spanish renters, whose consumption response to changes in the real interest rate is much smaller than for outright owners and mortgagors.

The bottom panel of Table 6 shows that, accounting for cross-country differences in the incidence of housing-tenure groups, the aggregate consumption response after a fall in the house price becomes less asymmetric across Germany, Italy, and Spain. The counterfactual consumption responses of Italy and Spain decrease slightly below the response for Germany. The counterfactual consumption response of France also decreases so that the absolute value of the difference to the German response remains approximately unchanged. In line with the endowment effect, which is captured by the rule of thumb for the consumption response to changes in house prices in Berger et al. (2018), the decrease of the consumption response is stronger in countries, which differ more from Germany in terms of the incidence of homeowners, and thus the size of housing in the portfolio. Given that the homeownership rate is lowest in Germany among the considered countries, accounting for cross-country differences in housing tenure groups strongly reduces the consumption responses for France, Italy, and Spain.

The findings in Table 6 show that using housing-tenure groups as a proxy to account for pre-existing cross-country differences tend to reduce the cross-country differences of consumption responses compared to the benchmark.

5. Conclusion

We have applied a life-cycle incomplete-markets model with owned and rented housing and collateralized debt to capture key dimensions of heterogeneity in household finances in the four largest euro-area countries: France, Germany, Italy, and Spain. The aggregate consumption responses generated by the model have revealed sizable differences in the transmission from changes in the real interest rate and house prices to consumption across these countries, which differ in their pension and tax systems, income risk, and fees on real estate transactions.

Through the lens of our model, the cross-country differences in the consumption responses are strongly associated with the different incidence of home ownership across countries. Within countries, the consumption responses tend to be largest for homeowners who do not adjust illiquid housing wealth, particularly if they are indebted. Our quantitative analysis with discrete choices for housing tenure respects the principle that housing tenure dynamics are as endogenous as consumption behavior itself. Understanding housing tenure dynamics after shocks is thus an integral part of understanding consumption dynamics. Based on this principle, we find that the specific transitions in housing tenure triggered by interest rate changes make the absolute size of the consumption response dependent on the direction of the interest rate change, thus giving rise to a sign-dependent asymmetry of the consumption response.

From a conceptual point of view, the structural life-cycle model we employ features discrete decisions for home ownership and adjustment of owned housing, a borrowing spread and continuous portfolio choices. An appropriately designed solution method allows us to avoid restrictions of house sizes to positions on a coarse, discrete grid that is often used in the existing literature. The continuous choice of house size we allow for captures portfolio positions accurately, which is important for computing the implied consumption responses.

We have illustrated the limits for what uniform monetary policy in the euro area can achieve in the presence of asymmetric consumption responses across countries to both housing busts and interest rate changes. Our results suggest that country-specific fiscal policy through national taxes or within-country transfers may be a useful complementary policy instrument, for mitigating not only the asymmetric effects of monetary policy across countries but also the distributional effects across consumers at different stages of their life cycle and with different household portfolios.

Appendix A: Calibration of cross-country differences

In this Appendix, we provide further details on the calibration of the labor earnings process, the implementation of the pension and tax system, minimum income benefits, and transaction taxes. We also show how the differences in the calibration across countries contribute to explaining cross-country differences in the statistics on net worth, housing wealth and the renter share.

TABLE 7. Country-specific parameters for the pay-as-you-go pensions.

		Germany	France	Italy	Spain
Pension parameters					
Earnings years		35	25	35	15
Valorization rate (in percent)		1	0	1	0
Benefit growth rate (in percent)		0	0	0	0
Net replacement rate (in percent)	0.5	53.4	78.4	81.8	82.0
at the following multiples of	0.75	56.6	64.9	78.2	83.9
mean income	1	58.0	63.1	77.9	84.5
	1.5	59.2	58.0	78.1	85.2
	2	44.4	55.4	79.3	72.4

Note: Source: Authors' compilation based on the country studies, Table I.2 on pages 28–30 and the net replacement rate reported on page 35 in OECD (2007).

A.1 *Pensions*

Table 7 displays the country-specific pension parameters that we use as inputs when we calibrate the pay-as-you-go component of the pension systems based on the information available in OECD (2007). The first row shows the number of *earning years* used for the computation of the pension benefits. For Germany and Italy, we use 35 years to approximate the lifetime average earnings in our model. In France and Spain, pension benefits are computed based on a smaller number of highest earning years or final years before retirement, respectively. Since labor earnings grow over the life cycle in our model and reach their peak not long before retirement, the final 25 years in France are on average also the years with the highest earnings.

The *valorization rate* in the second row shows how pre-retirement earnings are adjusted when pensions are computed at the time of retirement. In Germany and Italy, earnings are adjusted at the growth rate of (real) earnings, which we set to 1% annually. In France and Spain, pre-retirement earnings are inflation indexed but are not adjusted for real earnings growth so that the valorization rate is 0% in real terms.

The *benefit growth rate* in the third row of Table 7 captures how pension benefits are adjusted during retirement. In practice, benefits have been adjusted for inflation so that we set the growth rate of (real) benefits to zero. For Germany and Italy, this calibration of (real) benefit growth deserves further discussion. In Germany, the pension benefit adjustment formula (*Rentenanpassungsformel*) seems to imply a more complicated adjustment of pension benefits than just an inflation indexation. Deflating the *de facto* nominal benefit growth after 2000, documented at https://www.deutsche-rentenversicherung.de, shows however that the nominal benefit growth in Germany just has compensated retirees for inflation. This has been the time period in which households, surveyed in the HFCS, have made their savings decisions based on their expectations about the pay-as-you-go pension system. We thus set the (real) benefit growth rate to zero, which implies indexation to inflation and no changes of benefits in real terms. We do the same for Italy, albeit high pensions in Italy were not fully inflation indexed, so that they decreased in real terms. We abstract from modeling this detail because it seemed only a transitory measure to decrease the liability resulting from the pension system in real terms.

The bottom of Table 7 displays the *net replacement rate* for different multiples of mean earnings. We apply these net replacement rates according to how past earnings of agents (based on the relevant earnings years for each country) compare to the mean of past earnings when we compute the pension benefits.

A.2 *Taxation of labor income*

In order to convert gross labor earnings including transfers into net labor earnings, we follow Guvenen, Kuruscu, and Ozkan (2014). Based on the OECD Tax Database (OECD (2016)) that reports average tax rates and social security contributions at various multiples of mean labor earnings as well as tax exemptions and tax credits, we fit parametric approximations for the schedules of taxes and social security contributions for each country. Specifically, we use the information on the average tax rates and social security contributions in Table i5 of the OECD Tax Database, the information on the top marginal tax rate, the earnings threshold above which it applies, the mean labor earnings in Table i7, and the information on tax exemptions in Table i1. We estimate the parameters of the nonlinear tax schedule under the restriction that taxes are paid only above an earnings threshold that is obtained from information on tax exemptions and tax credits. In the approximation of social security contributions, we capture that contributions are roughly a constant fraction of income below a maximum earnings threshold in France, Germany, and Spain and become an ever decreasing fraction of income above that threshold. For Italy, we assume no maximum earnings threshold for social security contributions because such a threshold has been introduced only for labor market entrants after 1996 and this threshold is very high at 100,000 euros (see https://www.ssa.gov/policy/docs/progdesc/ssptw/2016-2017/europe/italy.html for a documentation in English language). For the estimation, we match the year in the OECD Tax Database with the respective year for which households are asked about their income in the first wave of the HFCS, that is, 2009 for Germany and France and 2010 for Italy and Spain. Figure 6 illustrates the schedules used in our calibration.

A.3 *Estimation of the age income profile and calibration of income risk*

We regress the logarithm of labor earnings in adult equivalents, including transfers, on a quartic age polynomial for the ages 25 to 65 that correspond to working life in our model. The variance of the residual is used to compute the standard deviation of the innovation that is implied by the assumption of an AR(1)-process with persistence $\rho = 0.95$. The standard deviation of the innovation is 0.23 for Germany, 0.18 for France, 0.23 for Italy, and 0.24 for Spain. Figure 7 displays the estimated quartic polynomials for the age income profiles together with income averages for 5-year age groups. The figure shows that the smooth polynomials approximate the income averages of the age groups well. The flatter part of the profiles at ages between 35 and 45 in France, Italy,

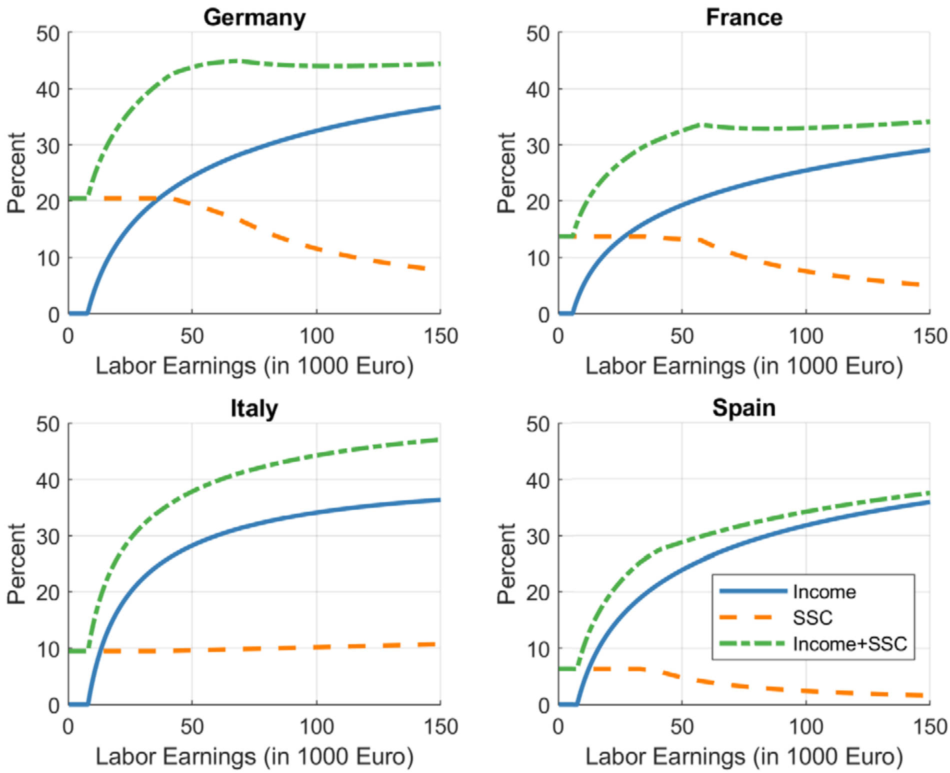


FIGURE 6. Country-specific schedules for average income taxes and social security contributions. Source: Authors' computation based on the OECD Tax Database, Tables i1, i5 ad i7.

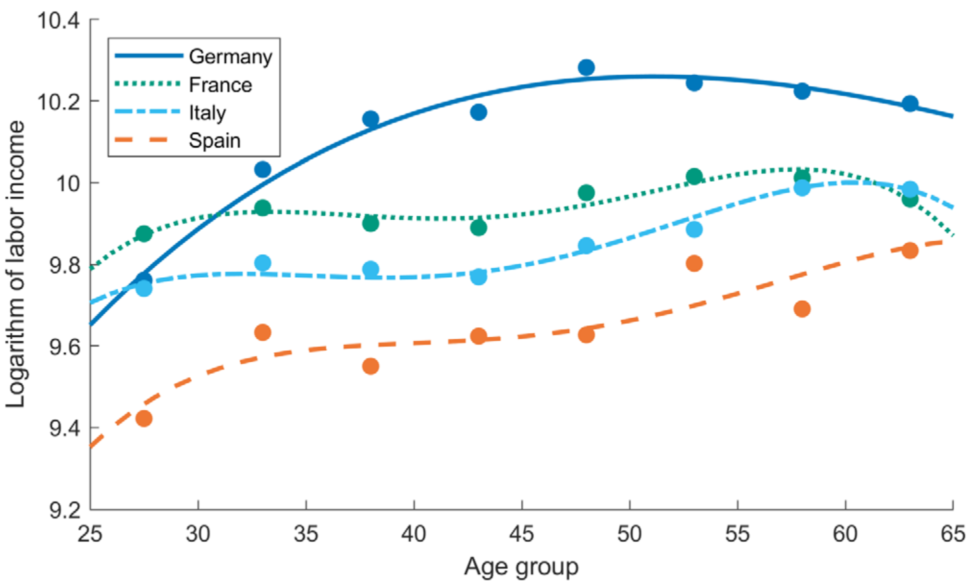


FIGURE 7. Country-specific age profiles of equivalized earnings. Source: Authors' computation based on the first wave of the HFCS.

and Spain is related to stronger increases in household size relative to income growth given that we plot labor income in adult equivalents. We convert the age profile into a life-cycle profile, assuming a growth rate of real income of 1% to account for cohort effects.

We restrict labor earnings after taxes and transfers to equal at least the minimum income benefit. We use information from the OECD Social and Welfare Statistics for the year corresponding to the income information for each country in the first wave of the HFCS.[36] The minimum annual income benefit for a single without children, corresponding to an adult equivalent, is 4308 euro in Germany (2009), 5608 euro in France (2009), 0 in Italy, and 4507 euro in Spain (2010). These benefits do not include housing benefits that can only be spent for housing purposes.

A.4 *Transaction taxes*

For Germany, we add the 5% transaction tax (*Grunderwerbsteuer*) to fees of 2.5% for real-estate agents. Although the transaction tax varies between 3.5% and 6.5% across regions, we cannot exploit this variation because we do not have precise enough information about the region of the households in the HFCS. We thus choose the median value across regions.

In France, transaction taxes (*frais de mutation*) consist of a municipal and departmental tax and usually amount to 5.5% of the value of property. We thus set the proportional transaction cost for the purchaser to 8%, including fees for real-estate agents.

In Italy, the buyer has to pay a registration tax (*imposta di registro*) of at least 3% for purchase of the main residence or alternatively VAT, depending on the seller. Furthermore, the purchaser has to pay a cadastral tax of 1% and land registry taxes of 2% (*imposte ipotecarie e catastali*). We thus set the transaction cost, including real-estate agent fees, to 8.5%.

In Spain, home buyers typically have to pay 7–8% of value added tax and a documentation fee of 0.5% (*impuesto sobre actos jurídicos documentados*). Hence, we set transaction costs in Spain to 10.5%, including real-estate agent fees.

The website https://www.angloinfo.com, accessed in October 2017, contains information in English language on differences in transaction taxes and fees across countries.

A.5 *Variable definitions*

We provide information on how we construct variables of interest based on the HFCS. For information on the survey, its methodology and descriptive statistics we refer to Eurosystem Household Finance and Consumption Network (2013a) and Eurosystem Household Finance and Consumption Network (2013b).

We interpret the asset data in the survey as end-of-period information at the time when the survey is carried out because the questions in the survey refer to income

[36] See https://data.oecd.org/, accessed in July 2022.

in the previous year and agents have made their consumption and portfolio choices conditional on this income. We construct all variables for as many observations as possible. While information on net worth, home ownership, the value of the main residence with the corresponding mortgages, nonmortgage debt, and gross income is available (if applicable) for more than 62,000 households in the euro area in the first wave of the HFCS, for example, information on mortgage payments per month (if applicable) is less complete, for example, and available for around 55,000 households.

When computing the statistics in the tables, we use the sampling weights provided in the HFCS to account for the oversampling of wealthy households, we account for the survey structure with five implicates per household (to capture the variance introduced by the imputation of values for some observations) and we use the replicate weights provided by the HFCS to account for sampling error. The variables are defined as follows (variable names in the HFCS data set are in brackets).

Labor income (incl. transfers) is total gross household income from employment (di1100) and self-employment (di1200), income from pensions (di1500), and from social transfers except pensions (di1600).

Net worth is the consolidated net wealth position of a household (dn3001).

Housing wealth is defined as the value of the household's main residence (da1110).

Other wealth or financial assets contain financial assets, other real estate, and durables, net of outstanding debt. It is defined as the difference between net worth and housing wealth.

Home ownership is defined as the ownership of the household's main residence, that is, this variable shows for which households housing wealth is positive. The *renter share* is defined as $1-$ *homeownership rate*.

We convert variables that are reported in euro for households into adult equivalents by giving a weight of 1 to the first adult, 0.34 to each additional adult, and 0.3 to each additional child. See also the last column in Fernández-Villaverde and Krueger (2007), Table 1. When combining data across HFCS waves, we use the inflation adjustment factors reported in the HFCS methodological report.

Appendix B: Further results on the consumption responses

B.1 *Results for France, Italy, and Spain on the heterogeneity of the consumption response after a fall in the interest rate*

Table 8. France: Consumption responses of different groups of households to an unexpected fall of the interest rate.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative URE (mean)
All households, aggregate		0.0035	1.000	1.000	0.0035	0.10	15.54
Renters *pre-shock*		0.0006	0.400	0.410	0.0002	0.22	1.69
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-adjusting	owning-and-adjusting	0.0039	0.012	0.012	0.0000	0.02	9.23
owning-and-adjusting	renting	−0.0281	0.020	0.022	−0.0006	0.00	6.67
renting	renting	0.0021	0.367	0.377	0.0008	0.24	1.16
Outright owners *pre-shock*		0.0047	0.393	0.364	0.0017	0.01	40.18
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0051	0.388	0.357	0.0018	0.01	40.48
Mortgagors *pre-shock*		0.0068	0.208	0.225	0.0015	0.04	−4.41
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0070	0.207	0.224	0.0016	0.04	−4.39
MPC upper tercile		0.0038	0.330	0.346	0.0013	0.28	−0.15
MPC middle tercile		0.0053	0.340	0.416	0.0022	0.02	3.63
MPC lowest tercile		−0.0002	0.330	0.239	−0.0000	0.00	43.49

Note: Relative consumption responses on impact after an unexpected fall of the real interest rate from 1.50% to 1.25%, thereafter expected to be reversed after 3 years, without pass-through to the rent-to-price ratio. Group membership is based on *pre-shock* variables, that is, properties prevailing at the *beginning of the period* when the shock hits. Thus, the incidence of renters and homeowners may differ slightly from the numbers reported for the calibration to end-of-period data. Subgroup membership is defined by the combination of two discrete choices: First, the (*post-shock*) discrete choice made given that the shock has hit. Second, the hypothetical (*without-shock*) discrete choice that would have been made in the absence of the shock. Discrete-choice subgroups are listed if their share in the population or their consumption share is at least half a percent. Marginal propensities to consume (MPCs) are assessed in the situation without shock. *Relative URE* refers to unhedged interest rate exposure relative to consumption. Rounding error may prevent the sum of shares or contributions of groups to equal the aggregate.

Table 9. Italy: Consumption responses of different groups of households to an unexpected fall of the interest rate.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative URE (mean)
All households, aggregate		0.0038	1.000	1.000	0.0038	0.15	5.57
Renters *pre-shock*		0.0000	0.321	0.291	0.0000	0.41	1.29
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-adjusting	owning-and-adjusting	0.0036	0.009	0.007	0.0000	0.03	6.66
owning-and-adjusting	renting	−0.0243	0.014	0.012	−0.0003	0.01	5.21
renting	renting	0.0010	0.298	0.271	0.0003	0.44	0.95
Outright owners *pre-shock*		0.0050	0.499	0.554	0.0028	0.02	11.35
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0053	0.491	0.544	0.0029	0.02	11.41
owning-and-adjusting	owning-and-adjusting	0.0033	0.005	0.006	0.0000	0.02	7.98
Mortgagors *pre-shock*		0.0064	0.180	0.155	0.0010	0.04	−2.84
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0066	0.180	0.154	0.0010	0.04	−2.81
MPC upper tercile		0.0026	0.330	0.315	0.0008	0.42	−0.16
MPC middle tercile		0.0055	0.340	0.372	0.0021	0.02	4.78
MPC lowest tercile		0.0028	0.330	0.313	0.0009	0.01	12.10

Note: See the notes of Table 8.

Table 10. Spain: Consumption responses of different groups of households to an unexpected fall of the interest rate.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative URE (mean)
All households, aggregate		0.0044	1.000	1.000	0.0044	0.05	6.75
Renters *pre-shock*		0.0003	0.243	0.175	0.0001	0.15	2.05
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-adjusting	owning-and-adjusting	0.0037	0.012	0.012	0.0000	0.02	7.08
owning-and-adjusting	renting	−0.0202	0.018	0.017	−0.0003	0.01	5.62
renting	renting	0.0024	0.212	0.147	0.0003	0.17	1.45
Outright owners *pre-shock*		0.0049	0.555	0.652	0.0032	0.02	12.23
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0052	0.546	0.640	0.0033	0.02	12.29
owning-and-adjusting	owning-and-adjusting	0.0037	0.005	0.007	0.0000	0.02	8.85
Mortgagors *pre-shock*		0.0067	0.202	0.173	0.0012	0.04	−2.65
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	0.0068	0.202	0.173	0.0012	0.04	−2.63
MPC upper tercile		0.0057	0.330	0.255	0.0015	0.14	−0.87
MPC middle tercile		0.0050	0.340	0.422	0.0021	0.02	8.64
MPC lowest tercile		0.0026	0.330	0.323	0.0008	0.01	12.42

Note: See the notes of Table 8.

B.2 *Results for France, Italy, and Spain on the heterogeneity of the consumption response after a house price drop*

TABLE 11. France: Consumption responses of different groups of households to an unexpected fall of the house price.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative HVE (mean)
All households, aggregate		−0.0093	1.000	1.000	−0.0093	0.10	10.35
Outright owners *pre-shock*		−0.0166	0.393	0.364	−0.0061	0.01	17.81
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0148	0.382	0.349	−0.0052	0.01	18.00
owning-and-adjusting	owning-and-not-adj.	−0.0807	0.008	0.010	−0.0008	0.01	11.13
Mortgagors *pre-shock*		−0.0144	0.207	0.225	−0.0032	0.04	16.17
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0154	0.204	0.222	−0.0034	0.04	16.14

Note: Relative consumption responses on impact after an unexpected fall of the house price by 10%. Group membership is based on *pre-shock* variables, that is, properties prevailing at the *beginning of the period* when the shock hits. Thus, the incidence of homeowners may differ slightly from the numbers reported for the calibration to end-of-period data. Subgroup membership is defined by the combination of two discrete choices: First, the (*post-shock*) discrete choice made given that the shock has hit. Second, the hypothetical (*without-shock*) discrete choice that would have been made in the absence of the shock. Discrete-choice subgroups are listed if their share in the population or their consumption share is at least half a percent. Marginal propensities to consume (MPCs) are assessed in the situation without shock. *Relative HVE* refers to housing value exposure relative to consumption.

Table 12. Italy: Consumption responses of different groups of households to an unexpected fall of the house price.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative HVE (mean)
All households, aggregate		−0.0114	1.000	1.000	−0.0114	0.15	8.64
Outright owners *pre-shock*		−0.0155	0.499	0.554	−0.0086	0.02	12.63
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0145	0.484	0.535	−0.0078	0.02	12.77
owning-and-adjusting	owning-and-not-adj.	−0.0571	0.010	0.013	−0.0007	0.01	8.18
owning-and-adjusting	owning-and-adjusting	−0.0134	0.005	0.006	−0.0001	0.02	7.56
Mortgagors *pre-shock*		−0.0182	0.180	0.155	−0.0028	0.04	12.95
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0174	0.178	0.152	−0.0027	0.04	12.90

Note: See the notes of Table 11.

Table 13. Spain: Consumption responses of different groups of households to an unexpected fall of the house price.

Group		Relative consump. response of group	Share of group	Consump. share of group	Contrib. of group to aggr. response	MPC (mean)	Relative HVE (mean)
All households, aggregate		−0.0116	1.000	1.000	−0.0116	0.05	8.51
Outright owners *pre-shock*		−0.0143	0.555	0.652	−0.0093	0.02	10.99
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0135	0.539	0.628	−0.0085	0.02	11.12
owning-and-adjusting	owning-and-not-adj.	−0.0460	0.011	0.016	−0.0007	0.01	6.66
owning-and-adjusting	owning-and-adjusting	−0.0110	0.005	0.007	−0.0001	0.02	6.14
Mortgagors *pre-shock*		−0.0135	0.202	0.173	−0.0023	0.04	11.95
subgroup (discrete choices)							
post-shock	*without-shock*						
owning-and-not-adj.	owning-and-not-adj.	−0.0145	0.200	0.172	−0.0025	0.04	11.91

Note: See the notes of Table 11.

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Co-editor Morten Ravn handled this manuscript.

Manuscript received 13 January, 2022; final version accepted 11 July, 2024; available online 18 July, 2024.

The replication package for this paper is available at https://doi.org/10.5281/zenodo.11397064. The authors were granted an exemption to publish their data because either access to the data is restricted or the authors do not have the right to republish them. Therefore, the replication package only includes the codes but not the data. However, the authors provided the Journal with (or assisted the Journal to obtain) temporary access to the data. The Journal checked the restricted data and the provided codes for their ability to reproduce the results in the paper and approved online appendices.