CESifo WORKING PAPERS

7088
2018

Original Version: May 2018
This Version: November 2021

# Differences in Euro-Area Household Finances and their Relevance for Monetary-Policy Transmission

*Thomas Hintermaier, Winfried Koeniger*

CESifo

## **Impressum:**

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp

An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 7088*

# Differences in Euro-Area Household Finances and their Relevance for Monetary-Policy Transmission

## Abstract

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 focuses on the four largest economies in the euro area: France, Germany, Italy, and Spain. Across these countries, we find that responses of consumption to changes in the real interest rate and in house prices differ substantially. Our analysis links the differences in the aggregate responses to the underlying heterogeneity in household characteristics such as age, housing tenure, and asset positions. We quantify how the size of the responses depends on household expectations about future financing conditions affected by forward guidance.

JEL-Codes: D140, D150, D310, E210, E430, G110.

Keywords: consumption, household portfolios, housing, monetary policy transmission, forward guidance.

*Thomas Hintermaier*
*University of Bonn*
*Adenauerallee 24-42*
*Germany – 53113 Bonn*
*thomas.hintermaier@uni-bonn.de*

*Winfried Koeniger*
*University of St. Gallen*
*Varnbuelstrasse 14*
*Switzerland – 9000 St. Gallen*
*winfried.koeniger@unisg.ch*

November 11, 2021
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 No. 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.

# 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 towards 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.

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. For a decrease that is expected to revert to its initial value after two years, the consumption response on impact is between 0.34% in Germany and 0.43% in Spain.[1] We quantify the extent to which the impact consumption responses depend on expectations of forward-looking households about the timing and duration of the interest rate change. We find that the cross-country heterogeneity in the impact consumption responses increases if forward guidance anchors expectations such that households expect interest rates to remain lower for longer.

We show that the quantitative size of the consumption response, as well as its degree of asymmetry for changes of the interest rate with opposite sign, depends on the pass-through of the interest rate to the rent-price ratio. We find that the asymmetries are caused by housing tenure transitions from renting to owning. This shows that a model with housing and a rental option is essential for inferring household consumption responses

[1] These numbers are in line with recent time series estimates for the euro area reported by Corsetti et al. (2021).

| | 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 rental rate (percent) | 53.3 | 41.1 | 32.2 | 18.8 |

Table 1: Household finances in the euro area
Notes: 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.

and the mechanisms driving them at the household level.

Regarding within-country differences explained by household characteristics such as age, we find that the household-level consumption responses to changes in the real interest rate are largest at ages above 45.[2] This age group contributes most to the aggregate consumption response. Across groups with different housing tenure, we find that the consumption response of homeowners to interest rate changes is larger than the response of renters, in particular if these homeowners are indebted.

The model delivers marginal propensities to consume out of liquid resources for different types of households. Homeowners have a larger marginal propensity to consume than renters. This implies a larger consumption response to interest rate changes (Auclert, 2019). Relying on the propensities to consume from our model, we find that differences in the cross-sectional composition of household portfolios at the time of the shock explain why the consumption response to changes in the interest rate in France, Italy and Spain is larger than in Germany. The reason is that the homeownership rate and the size of housing in the portfolio are both larger in these countries than in Germany.

The current low interest-rate environment has raised concerns that another house price correction may loom. The size of the consumption responses to changes in the house price have 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. Our model implies that a fall of the relative house price by 10 percent, on impact, implies an elasticity of consumption with respect to the house price between 0.11 for Germany and 0.17 for Spain. These elasticities are roughly of similar size as estimates

[2]For the U.S., where half of the young are homeowners with higher levels of leverage than in the euro area, Wong (2019) finds that the response is largest at young ages 25 – 34.

by Guren et al. (2021) for the U.S. They are a bit lower than the model-implied elasticity of 0.2 in Kaplan et al. (2020b) for the U.S. and the range of empirical estimates for the U.S. of 0.25 to 0.4 in Kaplan et al. (2020a), possibly associated with the lower leverage of most households in euro-area countries relative to the U.S.[3]

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 the solution of our model we allow for continuous portfolio choices to accurately capture the portfolio positions and a spread between the lending and borrowing rate, which are both important for computing the implied consumption responses.

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 include the observed means and age profiles for net worth, housing, and the housing rental rate for the four largest euro-area countries displayed in Table 1: 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 response 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 et al. (2017). The marginal propensity to consume determines the size of the consumption response to price changes, as shown by Auclert (2019) for changes in the interest rate and by Berger et al. (2018a) for changes in the house price.

Kaplan and Violante (2014) have shown that the marginal propensity to consume crucially depends on wealth composition, distinguishing liquid and illiquid assets. The marginal propensities to consume in our 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 and thus also influence the consumption responses to price shocks.

[3]Recent empirical evidence by Lennartz (2021) suggests that the lower leverage of Italian households may explain part of the smaller consumption response to house price changes in Italy compared to the U.S. Durable spending in the U.S. responds even more strongly to house price changes, with an elasticity of 0.6 to 0.8 for the U.S. reported in Mian et al. (2013).

Auclert (2019), Kaplan et al. (2018) and Wong (2019) have investigated the distributional and aggregate effects of unexpected changes in the interest rate on consumption for the U.S. Cloyne et al. (2020) compare the respective consumption responses in the U.S. and the U.K. Jappelli and Scognamiglio (2018) and Blomhoff Holm et al. (2021) provide evidence for Italy and Norway, respectively. We contribute to this literature by analyzing the dependence of these responses on the observed differences in household finances across the euro area.

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 et al. (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, that part of monetary policy transmission does not seem a quantitatively important source of cross-country heterogeneity in consumption responses.

Beraja et al. (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. This channel is also present in our analysis of the euro area. 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. We provide suggestive evidence that this cost would increase the cross-country differences in the consumption responses even further.[4]

Slacalek et al. (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

[4]Berger et al. (2018b) and Eichenbaum et al. (2018) show that the refinancing channel makes the effects of monetary policy path dependent in the U.S. as a result of refinancing fixed-rate mortgages. In our analysis, this channel seems less important for Germany and France where refinancing of mortgages is much more costly.

Figure 7, we find stronger direct effects of interest rate decreases on consumption in Germany and France than in Italy and Spain once we account for differences in household finances at the time of the shock (see Table 6). We also find that the stronger role of housing in portfolios of households in Italy and Spain increases the consumption response in these countries.

Our structural model allows us to analyze the mechanisms further. We find that home ownership plays an important role for the consumption response. The pass-through of interest rate changes to the rent-price ratio in the housing market and home ownership choices shapes the transmission of monetary policy to non-housing consumption, as we explain in subsection 4.1. The consumption of renters who plan to become owners in the future responds very differently to changes in the interest rate and this introduces an asymmetry in the consumption response to decreases relative to increases of the interest rate. We also uncover heterogeneous household decisions across countries resulting from differences in the economic environment. That is, using technical jargon to be more precise, we find that differences in the policy functions as well as differences in the state variables matter for the cross-country asymmetries of consumption responses.

The back-of-the envelope calculations by Slacalek et al. (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 Blomhoff Holm et al. (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 two years after the shock. Because the general equilibrium effect takes time, this suggests that the direct effect of interest rate changes, which we focus on in this paper, shapes the consumption response over shorter horizons after monetary policy shocks.

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 housing. The model is well suited to answer our question of interest, i.e., to which extent differences in housing across euro-area countries affect monetary policy transmission, given that home ownership is not a fixed trait but households typically purchase a home at a certain stage of the life cycle. An analysis of the underlying causes of the interest rate or house price fluctuations as well as of the consumption responses over time horizons longer than two years would require further modeling of equilibrium effects which we leave to future research.

Our analysis of the consumption responses for different timings of the interest rate changes relates to McKay et al. (2016). They show that the precautionary saving motive may reduce the response of consumption to future interest rate changes in economies with

uninsurable risk relative to a representative agent economy.[5] In accordance with these results, albeit in a life-cycle model with housing, we find that the impact consumption response is smaller (in absolute terms) if the change in the interest rate is announced to occur further in the future.

Concerning durable purchases and the timing of interest rate changes, McKay and Wieland (2021a) show that current changes in the user cost have a stronger effect on durable purchases relative to expected future changes of user cost.[6] This relates to the response of housing purchases after interest rate changes in our model, with the difference that agents can consume housing services by renting or owning housing units. We find that a decrease of the interest rate increases home purchases and this effect matters quantitatively, also for the consumption responses, if there is negligible pass-through to the rent-price ratio. With full pass-through instead, we find that home purchases are delayed after an interest rate decrease and this effect is quantitatively small. Greenwald and Guren (2021) and Landvoigt et al. (2015) show that the effect of changes in the user cost of homes on the homeownership rate and the rent-price ratio depends on the segmentation of the housing market. Our benchmark results for the consumption responses are based on the assumption of no pass-through to the rent-price ratio, given the empirical evidence for euro-area countries in Corsetti et al. (2021) and Koeniger et al. (2021).

The analysis of the consumption response to changes in relative house prices builds on work by Berger et al. (2018a), Guerrieri et al. (2020), Kaplan et al. (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 et al. (2013). Piazzesi and Schneider (2016) provide an excellent overview of the literature.

Recent empirical work by Calza et al. (2013) and Corsetti et al. (2021) reveals heterogeneity in the transmission of monetary policy to aggregate consumption and house prices across countries in the euro area. The heterogeneity is associated with differences in the housing market.[7] We build a structural model that allows us to inspect parts of the monetary-policy transmission mechanism in detail. We focus on how the differences in household finances within and across the considered four euro-area countries shape the transmission of changes in the real interest rate and the relative house price to consumption.

An important related literature has tried to uncover the determinants for the large

[5] Werning (2015) shows that, in a closed economy, the consumption responses are the same in both types of economies if individual income, borrowing constraints and assets are related to aggregate income in a proportional way.

[6] McKay and Wieland (2021b) also show that expansionary monetary policy may imply intertemporal shifts of durable purchases which reduce the effectiveness of monetary policy in the future.

[7] Calza et al. (2013) and Corsetti et al. (2021) 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.

observed differences in household finances. Guiso et al. (2003) document and analyze the differences in stock-market participation between the U.S. and European countries. Christelis et al. (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 in wealth 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 where higher homeownership rates imply lower wealth inequality. Kaas et al. (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. In our calibration of the model we find, as Kindermann and Kohls (2018) and Kaas et al. (2021), that differences in transaction costs and rental efficiency are important to match the differences in home ownership across the four analyzed euro-area countries.

# 2 The model

We use a life-cycle incomplete-markets model with household portfolio choice for our quantitative analysis. This section describes the features of all building blocks of the model. The specific choices of parameters used for the quantitative analysis – and, in particular, country-specific differences in the relevant parameters – are discussed in Section 3. In Appendix A we provide formal details of the recursive formulation and explain how we solve the model.

We implement a version of the life-cycle model which combines discrete choices and

continuous choices. For a realistic account of household decisions, we allow for discrete choices in owning versus renting a house and in adjusting versus not adjusting one's house size. Based on these discrete choices, the remaining choices of non-housing consumption, of financial assets, and of relevant housing quantities are continuous. The financial asset is the model counterpart for the residual wealth category *other wealth* in the data, given our portfolio choice problem with two assets.

## 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 $j = 1,\ldots,J$. Households maximize their expected discounted utility over the life cycle. They apply a discount factor $\beta$ on future period utilities. Expectations take into account survival probabilities, idiosyncratic risk in earnings, and aggregate risk in future returns on financial assets.[8]

The relevant consumption items for our analysis are non-housing 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 non-housing consumption and housing services:[9]

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

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

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

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 utility 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 $\Psi(\mathfrak{b})$ from bequeathing an amount of resources $\mathfrak{b}$, whose relation to the bequeather's asset positions is specified in the section on portfolio items below. The bequest utility function takes the form

$$\Psi(\mathfrak{b}) = \psi_0 \log\left(\psi_1 + \psi_2 \mathfrak{b}\right) .$$

[8]The calibration will abstract from aggregate risk but we consider probabilistic interest rate changes within our MIT-shocks experiments that follow later.

[9]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 of the model, as is explained in Appendix A.

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 Appendix B that $\psi_0 = 1/(1-\beta)$, $\psi_1$ equals average earnings of the offspring and $\psi_2 = r - g$ if the bequeather considers the consequences of the annual payment flows generated by the bequest on the marginal utility of the offspring for a long-run real interest rate $r$ and an annual income growth rate $g$. Determining the bequest parameters this way allows for an immediate economic interpretation and reduces the number of parameters in our 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,[10] we specify an **adjustment cost function** for which costs are proportional to the quantities sold or bought, with $p_t$ denoting the relative price of housing:

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

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

[10] 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 euro.

adjust the quantity of owned housing, such an adjustment will always result in a positive quantity $\hat{h}_{j+1}$. This is a consequence of the utility function specified above. Accordingly, when deciding to adjust to a new quantity of owned housing, such a decision will always entail triggering both the selling and the purchasing components of adjustment costs.

If the household chooses **not to adjust** the existing quantity of owned housing, such that $\hat{h}_{j+1} = \hat{h}_j$, no adjustment costs are incurred.

If the household chooses **to rent** this precludes owning (a positive quantity of) housing, meaning that $\hat{h}_{j+1} = 0$. Accordingly, when making such a choice, the household faces the adjustment cost component of the selling branch but is inactive on the purchasing branch, resulting in an adjustment cost of the form

$$\alpha_{pR}(\hat{h}_j) = \alpha_1 p_t \hat{h}_j.$$

A household starts with given initial levels of financial assets $a_1$ and of owned housing $\hat{h}_1$. Each period a household makes the discrete choices[11] of renting versus owning, and of adjustment versus non-adjustment, subject to the applicable versions of the budget constraint and the collateral constraint specified in the following.

If the household chooses to consume housing as an **owner adjusting** his housing stock, the **budget constraint** at age $j$ is

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

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 $r^- > r^+$.

If the household chooses to consume housing as an **owner not adjusting** his housing stock, such that $\hat{h}_{j+1} = \hat{h}_j$, the budget constraint becomes

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

If the household chooses to consume housing as a **renter**, the following budget constraint applies

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

[11] In the quantitative application we allow for the consideration of some degree of noise in decisions among discrete choices, as explained in the recursive formulation in Appendix A.

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 time variation of the rent-to-price ratio by considering it as the sum of a non-interest 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 $r_t^+$ 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*.[12]

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 $\mu$ represents the loan-to-value (LTV) ratio. The parameter $g_{y,j+1}$ denotes those pledgeable resources which are not related to asset holdings. For those households who choose to own and not to adjust their house size, meaning that $\hat{h}_{j+1} = \hat{h}_j$, this collateral constraint becomes $(1 + r_t)a_{j+1} \geq -\mu p_t \hat{h}_j - g_{y,j+1}$. For households who choose to be renters, and therefore get a housing position of $\hat{h}_{j+1} = 0$, this implies the borrowing constraint $(1 + r_t)a_{j+1} \geq -g_{y,j+1}$.

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

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

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

# 3 Calibration

Our approach is to calibrate the model to capture key dimensions of the observed heterogeneity in household finances, on which we have detailed data as illustrated in Table 1. We use the Household Finance and Consumption Survey (HFCS), a relatively recent

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

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.[13] Thus, we use a model, calibrated to match the household balance sheets, to infer the consumption responses across households with different characteristics. After aggregating the household-level consumption responses, we then compare the model-implied aggregated consumption responses, for example, to empirical estimates provided by the literature (Corsetti et al., 2021) for consumption responses to changes of the interest rate.

Our calibration includes a rich set of cross-country differences regarding crucial model features for France, Germany, Italy and Spain: the pension and tax systems, survival probabilities, labor-income profiles and labor-income risk, transaction costs for housing, rent-to-price ratios and some preference parameters, as shown in Table 2. We describe the essential cross-country differences in this section, and refer to Appendix C for details. Table 7 in that Appendix C documents all other parameters that are common across countries.

The aim of our calibration is to explain the differences in household finances by observable cross-country differences. The economic environment in a country influences household finances by affecting motives for asset accumulation and portfolio choice, for example, the motives for precautionary and retirement saving. Any remaining part, unexplained by the economic environment, is captured with the following preference parameters: the discount factor $\beta$, the weight of non-housing consumption in the consumption basket $\theta$, and the rental efficiency before and during retirement determined by the service-flow rates out of rental housing $\phi_R$ and $\phi_R^{ret}$. Such unobservable preference heterogeneity corresponds to a country fixed effect.[14] The bottom part of Table 2 shows that the preference heterogeneity required in the calibration is relatively small but for the rental efficiency parameters on which we comment further in the following.

We calibrate differences in the pay-as-you-go component of the pension systems using information on the adjustment factor for pre-retirement earnings (the valorisation 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).[15] We calculate pension benefits by computing the average income for the relevant pre-retirement earning years conditional on the last pre-retirement income draw. See Hintermaier and Koeniger (2011) for further details.

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

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

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

| | Germany | France | Italy | Spain |
|---|---|---|---|---|
| | *Non-interest component of rent-to-price ratio* | | | |
| $\underline{k}$ | 0.009 | 0.006 | 0.009 | 0.014 |
| | *Proportional transaction cost* | | | |
| $\alpha_2$ | 0.075 | 0.08 | 0.085 | 0.105 |
| | *Life-cycle income process* | | | |
| | *country-specific age profiles* | | | |
| | *country-specific pension and tax systems* | | | |
| | *std.dev. of innovation* | | | |
| $\sigma_{\text{innovation}}$ | 0.23 | 0.18 | 0.23 | 0.20 |
| | *Life expectancy* | | | |
| | *country-specific survival probabilities* | | | |
| | *Preferences* | | | |
| $\beta$ | 0.983 | 0.988 | 0.987 | 0.986 |
| $\theta$ | 0.82 | 0.80 | 0.80 | 0.84 |
| $\phi_R$ | 0.87 | 0.84 | 0.91 | 0.92 |
| $\phi_R^{ret}$ | 0.82 | 0.57 | 0.62 | 0.76 |

Table 2: Country-specific calibrated parameters

Notes: Details on our implementation of country-specific pension and tax systems, age-income profiles, and fees on real estate transactions are contained in Appendix C. For common parameters across countries see Table 7 in Appendix C.

We account for differences in labor-income taxes across countries by following Guvenen et al. (2014). Based on the information in the OECD tax database on tax exemptions and tax rates at different levels of labor earnings, we convert the labor earnings, including transfers that we observe in the HFCS survey, into earnings after taxes and transfers.

We compute the country-specific age profiles and standard deviations of earnings after transfers by regressing the logarithm of these earnings on a quartic age polynomial.[16] The assumption of an AR(1) process with an autocorrelation of 0.95 then implies the standard deviations of the innovations reported in Table 2 to match the variance of the residuals obtained from these regressions for each country.[17] The values 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 dataset, and with the variances of earnings based on national datasets reported by Fuchs-Schuendeln et al. (2010) or Pessoa (2021) for Germany, Jappelli and Pistaferri (2010) for Italy and Pijoan-Mas and Sanchez-Marcos (2010) for Spain.[18]

We capture country-specific transaction costs for housing and rent-price ratios which influence the portfolio choice between housing and liquid financial assets and the choice between home ownership and rental.[19] The costs also contain transaction taxes in the euro-area countries we consider and are typically borne by the purchaser. The taxes imply that the values displayed in Table 2 are considerably higher than in the U.S. where housing transaction costs due to fees for real-estate agents typically amount to 2.5% of the transacted value.

Those parameters in the model set to common values across countries are summarized in Table 7 in Appendix C. For all four euro-area countries considered, we calibrate the real interest rate as follows. We set the real lending rate to 0.5% and the borrowing rate to 2%, implying a spread of 1.5 percentage points. The long-run interest rate applied to generate expected income flows from bequests is set to 4%. This calibration of interest rates shall capture the low-interest rate environment after the financial crisis with a spread for mort-

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

[17] We use the Rouwenhourst method to approximate the Markov chain with seven income states.

[18] Recent evidence of the *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 of households 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.

[19] Kaas et al. (2021) emphasize the importance of transaction taxes to explain the lower home ownership rate in Germany compared to the U.S. Kindermann and Kohls (2018) find quantitatively sizable differences in the euro area for rental market efficiency. They quantify the wedge in the rental market between shelter provided by landlords and shelter received by renters that implies variation in rent-price ratios across countries.

gage loans broadly in line with evidence reported in ECB (2009), chart 21.[20] The higher long-run interest rate ensures that, for our specification of the bequest motive with the assumption of a common productivity growth rate of 1%, bequests remain sufficiently attractive to generate capital income for the offspring.

We assume stable expected relative house prices as a benchmark. The maximum value of the loan-to-value ratio $\mu$ is set 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 $\mu^{ret} = 0.3$ during retirement. This shall capture that mortgage contracts typically feature substantial amortization until retirement in the euro area countries we consider, as documented in ECB (2009), p. 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 $\mu^{ret}$ is not binding for most households whose optimal decisions imply substantial amortization even without the tighter maximum loan-to-value ratio during retirement.

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, and have survival probabilities that are calibrated using mortality tables from Eurostat.[21] These probabilities are available until age 85, which coincides with the terminal age in our model.

We simulate the model for 120,000 agents to compute model statistics. To obtain the initial 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. 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 calibrate the model by targeting the set of moments reported in Table 3 and Figures 1 and 2. These moments capture the extensive and intensive margins of household balance sheets in terms of housing tenure and the associated leverage.[22] Table 3 and Figures 1 and 2 show that the life-cycle model manages to match most of the targets well by ac-

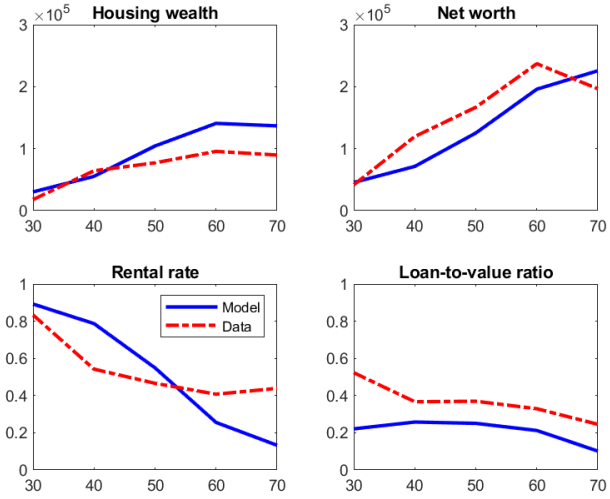
[20] Given that household debt is secured in our model, the calibrated spread is smaller than the 6 percentage points calibrated in Kaplan et al. (2018) who model net asset positions, thus consolidate housing assets and mortgage debt so that borrowing in their model should be interpreted as unsecured debt. Appendix D provides further details on the role of the interest spread in our model with housing.

[21] We use the mortality tables for the reference year 2009 which are available at https://ec.europa.eu/eurostat/web/main/data/database .

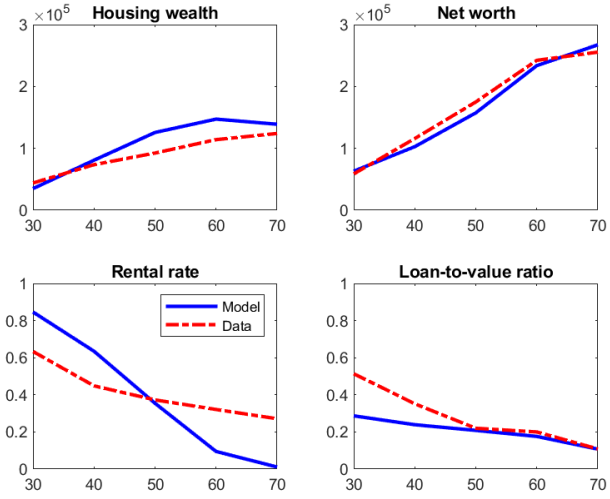
[22] We attach equal weight to the targets in the objective function to minimize the Euclidean distance from the targets in percentage points or percent, depending on the target.

| | Germany | | France | | Italy | | Spain | |
|---|---|---|---|---|---|---|---|---|
| | Data | Model | Data | Model | Data | Model | Data | Model |
| Net worth | 152,711 | 131,187 | 167,697 | 161,643 | 165,492 | 174,882 | 172,770 | 143,339 |
| of which: housing wealth | 69,474 | 93,462 | 88,922 | 105,881 | 105,278 | 125,991 | 93,708 | 102,273 |
| Rental rate (percent) | 53.3 | 53.0 | 41.1 | 39.7 | 32.2 | 29.4 | 18.8 | 19.2 |
| Fraction of homeowners with debt | 17.5 | 40.9 | 17.8 | 34.0 | 10.1 | 35.0 | 25.9 | 40.9 |
| LTV, conditional on debt | 36.1 | 20.9 | 36.5 | 20.9 | 28.9 | 20.2 | 39.5 | 30.5 |

Table 3: Averages by country in the data and model predictions

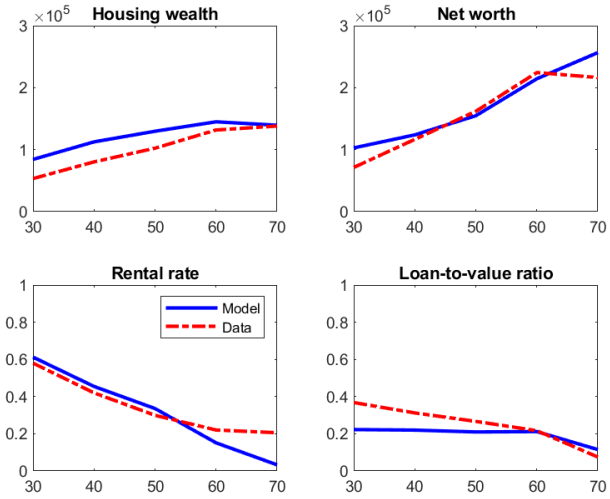



(a) Germany

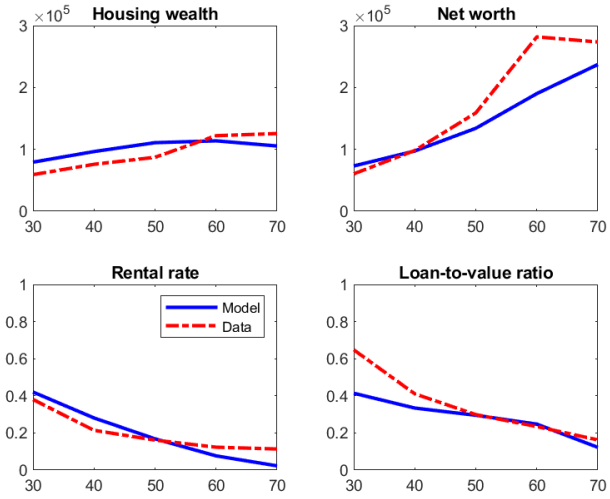



(b) France

Figure 1: Age profiles for Germany and France: data (dashed line) and model predictions (solid line)
Notes: Averages 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.




(a) Italy




(b) Spain

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

counting for key differences in the economic environment, that we have explained above, and by calibrating country-specific rent-price ratios as well as by allowing for some heterogeneity in preference parameters.[23] Although the parameters are jointly calibrated, some targets are tightly related to certain parameters. The discount factor $\beta$ allows to match average net worth and its age profile. The weight of non-housing consumption in the consumption basket $\theta$ together with the non-interest component of the rent-price ratio $\underline{k}$ and the parameters for the rental efficiency $\phi_R$ and $\phi_R^{ret}$ allow to match average housing wealth, the rental rate and their age profiles.[24] Within the set of parameters that match these targets well, we search for parameter combinations that align as much as possible the extensive and intensive margins of indebtedness associated with home ownership predicted by the model with the data.

Figures 1 and 2 reveal the trade-offs implied by our multi-dimensional objective function. The calibration matches the leverage of homeowners quite well. Once the extensive and intensive margin of leverage are disentangled, as in Figures 1 and 2 and Table 3, we observe that the predicted LTV ratios conditional on being a homeowner with debt (at the intensive margin) are lower than in the data, particularly at young ages. Instead, the incidence of homeowners with debt (at the extensive margin) is higher compared to the data, particularly for Italy (see Table 3). This is also related to the model predicting on average a larger share of housing wealth (of the main residence) in the portfolio than in the data, and lower rental rates during retirement. Our extensive search in 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 such as net worth. Further research may explore additional features to improve the model performance, which, however, may come at the cost of having to abandon a uniform modeling framework for the euro-area countries.

Overall the model fit is comparable with the life-cycle model by Kaas et al. (2021) calibrated to Germany. Our calibration implies a slightly higher adjustment incidence of housing of 3.1% in the synthetic model-generated data for Germans between ages $30-60$, given that we do not specify a minimum house size of $80,000$ euro as in Kaas et al. (2021)

[23] We calibrate the rent-price ratio because the existing data on rent-price ratios may be confounded by quality differences so that the quality-adjusted rent-price ratio is unobserved. The calibrated non-interest component of the rent-price ratio reported in Table 2 varies between 0.6 and 1.4 percent. These values have a plausible order of magnitude if one considers the rough approximation of the user cost for owned housing that equals the sum of the real interest rate and the depreciation rate, where the depreciation rate for housing is usually estimated to be small and within the ballpark of the values of the non-interest component in our calibration.

[24] It is noteworthy that the model requires a lower $\phi_R^{ret}$ than $\phi_R$ in the calibration. Without making rental less attractive during retirement, the model would predict more rental than empirically observed. We leave the question for further research in which way specific economic features might combine with cross-country cultural differences. The relevant combination may complement or partially substitute for the role played here by preferences in explaining why rental is seemingly less attractive during retirement.

and allow for continuous portfolio choices.[25] The incidence varies from 2.4% in Spain and 2.5% in Italy to 3.6% in France, in line with the empirical evidence on housing tenure transitions for Germany and Italy in Koeniger et al. (2021). Similarly to Kaas et al. (2021), we find that about half of the housing adjustments are accounted for by owners in Germany. This fraction increases to two thirds in Spain where more households are homeowners. In Appendix D 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.

Table 2 shows that the model also requires some differences in the preference parameters to match the country-specific data targets. In Appendix C.5, Table 9 shows that the country-specific model inputs in Table 2 and the differences in the initial asset distributions of young households are quantitatively important for explaining the cross-country differences in household finances. The differences in the age composition across countries observed in the HFCS instead contribute little.

# 4 Consumption responses

We use the calibrated model to analyze the response of non-housing 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 in the current low-interest rate environment if a housing bust occurred. We then illustrate the role of differences in household finances for the cross-country differences in the consumption responses.

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

We illustrate how the composition of household portfolios, the pass-through of interest rates to the rent-price ratio and expectations about the duration of an interest rate regime shape the consumption responses to interest rate changes. Standard models imply that a change of the interest rate has income and substitution effects for consumption. In our model, the strength of these effects for the aggregate consumption response depends on the portfolio of households, e.g. whether most households own a home and have a mortgage or whether most households rent and have some savings. As we are going to illustrate, there are further effects at work in our model. The consumption response depends

[25] We specify the minimum house size so that it is never binding in the simulations, consistent with the used first-order conditions in the solution algorithm. We solve the model on a grid of state variables of 480 points for housing and 335 points for the other asset in the portfolio. We allow for continuous portfolio choices. The future marginal utility consequences of any portfolio choice combination are obtained by interpolating on a grid, which is refined by a factor of 3 and 4, respectively, compared to the state grid.

on whether the portfolio is adjusted because of the change in the interest rate. We find that the incidence and size of portfolio adjustments depend on the pass-through of interest rates to the rent-price ratio in the housing market. We then illustrate that a further key determinant of the consumption response is the expectation of households about the duration of the interest rate change which can be influenced by the central bank's forward guidance.

The pass-through of interest rate changes to prices in the housing market and the pass-through of interest rate changes to housing tenure are two sides of the same coin. If changes of the interest rate do not pass through to the rent-price ratio, the cost of owning relative to renting changes so that housing tenure transitions are triggered. We show that the implied adjustment costs together with the change in the cost of consumed housing services for the affected subpopulation quantitatively change the aggregate consumption response. Because a fall in the interest rate triggers transitions from renting to owning whereas such transitions are postponed after a temporary increase of the interest rate, the response of non-housing consumption to monetary policy shocks is asymmetric. To the best of our knowledge, this quantitative finding has not received attention in the literature so far. The life cycle model with housing is well suited to analyze this effect because housing tenure transitions have systematic age patterns, where most transitions from renting to owning occur between ages 35 and 55. Our model thus allows us to analyze the specific drivers of the aggregate consumption response. Before doing so, we first discuss the main patterns of this response.

#### 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-price ratio. This assumption is supported by empirical evidence based on household-level data in Koeniger et al. (2021) who show that monetary shocks do not pass through to rents and house prices in Germany and Italy in the first two years after the shock. The aggregate evidence for euro-area countries by Corsetti et al. (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 policy shock. We discuss further below that the extent of the pass-through determines the size and asymmetry of the response of non-housing consumption to changes in the interest rate.

Figure 3 shows the response of non-housing consumption for a specific path of the interest rate chosen for illustrative purposes, where the real interest decreases by 25 basis points for two years and then increases back to its initial value. The duration of the

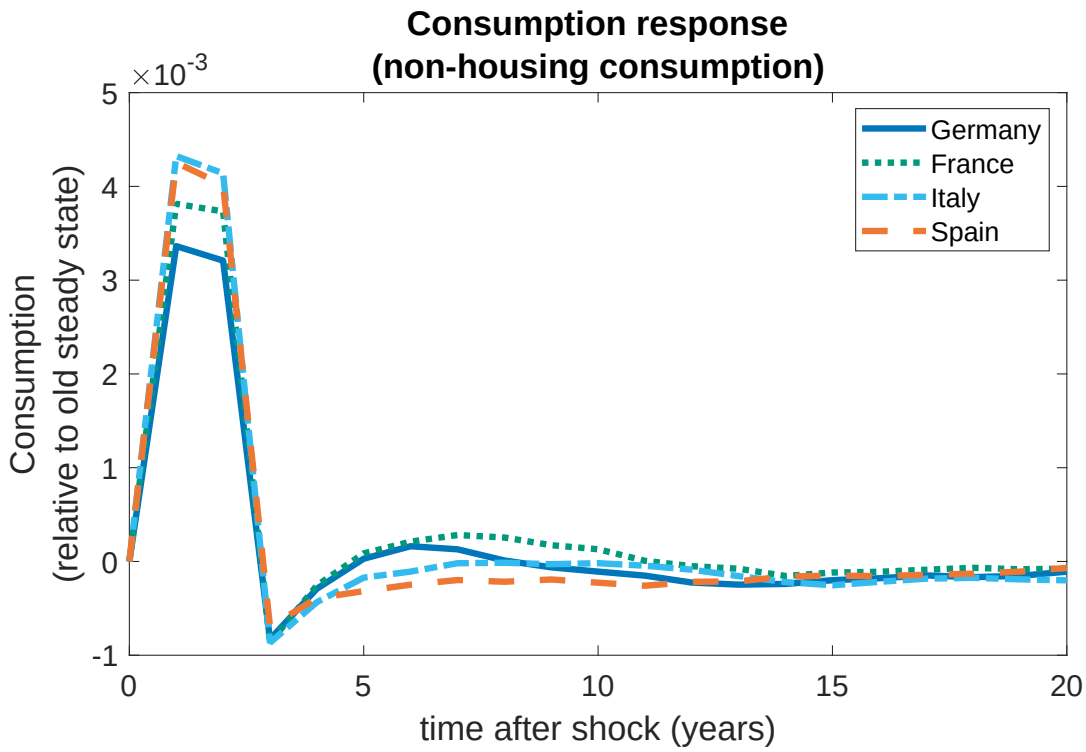



Figure 3: Unexpected fall of the real interest rate from 0.5% to 0.25% reversed after two years, without pass-through to the rent-to-price ratio

interest rate change is inspired by evidence of Corsetti et al. (2021) who report in their Figure 4 that the effect of monetary policy shocks on interest rates lasts for approximately two years. In the experiments we assume that households expect, 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 two years. We 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] In order to analyze the role of expectations about the persistence of the change, below we also report results for different time durations of the interest rate decrease.

Figure 3 shows that a fall in the real interest rate by 25 basis points (bp), that is reversed after two years, increases non-housing consumption on impact between 34 bp in Germany, 38 bp in France and 43 bp in Italy and Spain. 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 one year in the euro area, as in recent evidence reported in Figures 4 and 6 of Corsetti et al. (2021), based on high-frequency identification of monetary policy shocks. The consumption responses

[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.

generated by our model are well within the confidence interval of estimates reported in Corsetti et al. (2021). 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 et al. (2021) 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 et al. (2021), Figure 6, we find that the consumption response is largest in Spain and smallest in Germany. The larger quantitative differences in the responses across countries in Corsetti et al. (2021) suggest that there are additional channels 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. For instance, some households may increase their housing stock after the fall of the interest rate and *reduce* their non-housing consumption. Other households may simply react by increasing non-housing consumption.

Table 4 illustrates some of the heterogeneity in the consumption responses on impact after the fall of the interest rate for Germany, focusing on observable group characteristics at the time of the shock that have received interest in empirical analyses of consumption responses for the U.S. or U.K. by Cloyne et al. (2020) or Wong (2019), for example. The results for the other euro-area countries considered are qualitatively similar in many respects, as presented in the corresponding tables in Appendix E.2. Those aspects that differ significantly across countries are highlighted in the following along with the discussion of results for Germany.

Table 4 shows that consumers above age 45 or in the top half of the net-worth distribution contribute most to the positive aggregate consumption response after a decrease in the interest rate.[27] The consumption response up to the 75-th percentile of the net-worth distribution in Table 4 is determined by the incidence of renters, who have lower consumption responses (in particular those becoming homeowners). In Germany, where renting is more common, the consumption responses thus increase between the third and fourth quartile of the net-worth distribution. Tables 10 to 12 in Appendix E.2 show that in

[27] Note that the contribution to the aggregate consumption response by households in the top percentiles of the net-worth distribution is smaller than in an economy with complete markets. As pointed out by Kaplan et al. (2018), p. 701, high liquid wealth households do not react much to an interest-rate cut due to uninsurable income shocks and possibly binding liquidity constraints in the future.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = 0.0034 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | 0.0031 | 0.16 | 0.18 | 0.0005 |
| Ages 35 – 44 | 0.0020 | 0.20 | 0.23 | 0.0004 |
| Ages 45 – 54 | 0.0028 | 0.25 | 0.26 | 0.0007 |
| Ages 55 – 64 | 0.0044 | 0.19 | 0.18 | 0.0008 |
| Ages 65 – 74 | 0.0054 | 0.18 | 0.14 | 0.0008 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | 0.0028 | 0.25 | 0.18 | 0.0005 |
| Percentiles 25 – 50 | 0.0027 | 0.25 | 0.23 | 0.0006 |
| Percentiles 50 – 75 | 0.0019 | 0.25 | 0.24 | 0.0005 |
| Percentiles 75 – 90 | 0.0052 | 0.15 | 0.18 | 0.0009 |
| Percentiles 90 – 95 | 0.0054 | 0.05 | 0.07 | 0.0004 |
| Percentiles 95 – 99 | 0.0048 | 0.04 | 0.07 | 0.0003 |
| Percentiles 99 – 99.9 | 0.0045 | 0.009 | 0.022 | 0.0001 |
| Percentiles 99.9 – 100 | 0.0029 | 0.001 | 0.006 | 0.0000 |
| *Composition of impact response across housing-tenure types* | | | | |
| *Homeowners* | 0.0056 | 0.47 | 0.53 | 0.0030 |
| ... with positive assets | 0.0051 | 0.28 | 0.34 | 0.0018 |
| ... with non-positive assets | 0.0065 | 0.19 | 0.19 | 0.0012 |
| *Renters* | 0.0008 | 0.53 | 0.47 | 0.0004 |
| ... with positive assets | 0.0006 | 0.35 | 0.35 | 0.0002 |
| ... with non-positive assets | 0.0015 | 0.18 | 0.12 | 0.0002 |

Table 4: Germany: heterogeneity of the (non-housing) consumption response across households. Notes: response on impact after an unexpected fall of the real interest rate from 0.5% to 0.25% reversed after two years, without pass-through to the rent-to-price ratio. In the middle panel of the table, group membership is based on *state* variables prior to the shock that determine the position in the net-worth distribution. In the bottom panel of the table, group membership is determined by *chosen* asset positions at the time of the shock that are associated with the housing tenure choice.

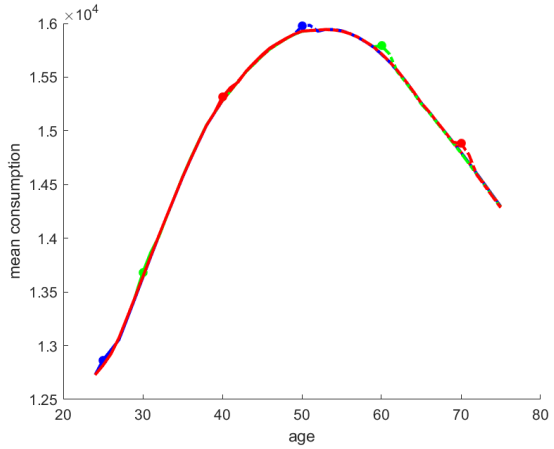



Figure 4: Consumption

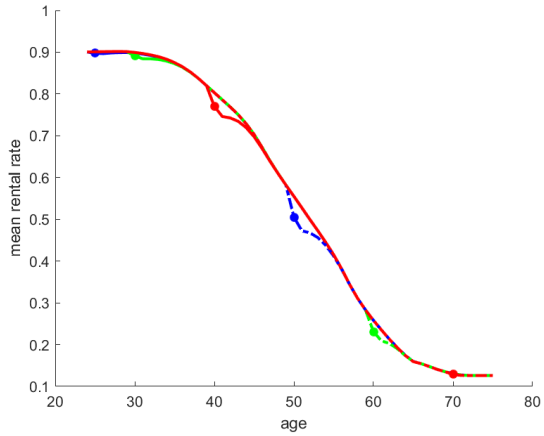



Figure 5: Housing rental rate

Notes: Life-cycle profiles 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.

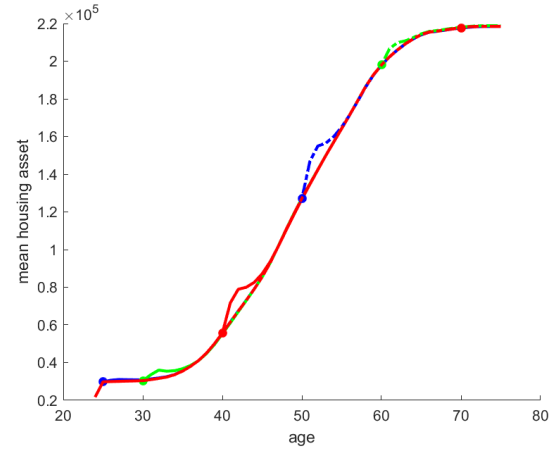



Figure 6: Housing wealth

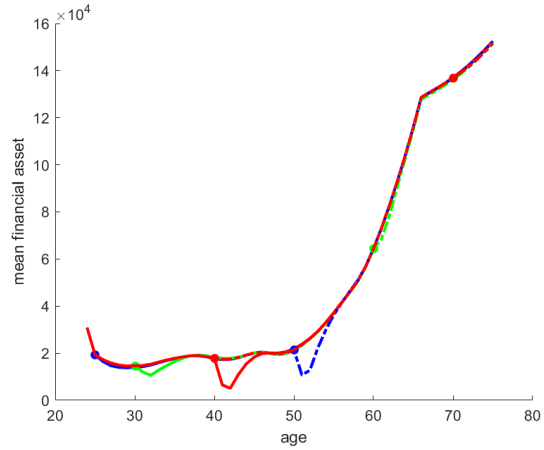



Figure 7: Financial assets

Notes: Life-cycle profiles 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.

France and Italy this occurs between the second and third quartile, and in Spain between the first and second quartile.

Age matters for the consumption response not only because young agents have a longer horizon but also because their asset positions vary with age. For example, the income effect on consumption after a fall in the real interest rate is positive for a borrower and negative for a saver, and younger agents borrow more on average. Indeed, the bottom panel of the table shows in the first column that the consumption response of homeowners is higher and particularly so if they are indebted.

The strong consumption response of indebted homeowners is similar to the empirical evidence of Cloyne et al. (2020) for the U.K and the U.S. A difference in Germany compared to these countries is that indebted homeowners account for a much smaller share

of aggregate consumption, as reported in the third column of Table 4. Hence, the contribution of the response of indebted homeowners to the aggregate consumption response is not as large as in other (euro-area) countries with larger homeownership rates. Column 4 in the table shows that indebted homeowners account for an aggregate increase in consumption of 0.12%, compared to the aggregate response of 0.34%. Appendix E.2 shows that, among the considered euro-area countries, the contribution of indebted homeowners to the aggregate consumption response is largest in Spain. Indebted homeowners in Spain account for 33% of the population, for 30% of consumption and thus they account for an approximately twice as large consumption increase after the fall of the interest rate compared to indebted homeowners in Germany.

The bottom panel of Table 4 further shows that renters contribute little to the aggregate consumption response, in Germany where the incidence of renting is largest and, as shown in Appendix E.2, also in the other considered euro-area countries. The consumption response of indebted renters is larger than the consumption response of renters with positive assets but their population share and consumption share is smaller.

Figures 4 to 7 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 by the unexpected decrease of the interest rate at different stages of the life cycle. The figures show that the consumption response is larger for agents that are older at the time of the shock. A larger proportion of these households are homeowners.

Instead of pronounced consumption responses, younger age groups show stronger responses with respect to another margin of adjustment considered in our framework, namely changes in housing tenure from renting to owning. Significant household portfolio adjustments occur for ages between 35 and 55.

**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. The consumption response is largest on impact and then decreases because the real rate is expected to switch back to its initial level. As the interest rate remains below its initial level for a longer time, the additional consumption and the shift towards housing wealth reduce other wealth (the financial assets in our model). The lower interest rate also reduces capital income for consumers with financial assets. For both reasons, the increase of consumption becomes smaller.[28] After year 2, when the interest rate increases back to its initial level, consump-

[28]The drop of financial assets is illustrated in the life-cycle patterns of Figure 7 above. The drop in financial assets also occurs because of changes in housing tenure from renting to owning, which mostly happen on impact after the initial decrease of the real interest rate.

tion falls below its initial level for the following reasons. Firstly, aggregate consumption decreases as the portfolio shifts back towards financial assets, in line with the life-cycle patterns illustrated in Figures 6 and 7. Secondly, as we will show 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. The fall of aggregate consumption below its initial level worsens the trade-off for stabilization using monetary policy: current increases of consumption after an expansionary reduction of the interest rate come at the cost of larger consumption reductions in the future once the interest rates reverts to its initial level.

As visible in Figure 3, it takes time for non-housing consumption to return to its initial level after the interest rate has done so. We thus find that there is a persistent slump in non-housing consumption when a period with a low real interest rate comes to an end.

**Asymmetries of consumption responses, depending on the direction of the shock**

Figure 13 in Appendix E.1.1 shows the consumption response after a change of the real interest rate of *opposite sign*. The consumption response after an *increase* of the real interest rate by 25 bp (reversed after two years, without pass-through to the rent-price ratio as in the benchmark) on impact is 9 bp larger for Germany in absolute terms than the consumption response to the interest-rate *de*crease illustrated in Figure 3, implying an increase of the absolute size of the response by 26%. The absolute size of the response increases even more by 11 bp for France whereas the increase is smaller for Italy (8 bp) and Spain (5 bp).

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. 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, whereas the rent-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 non-housing consumption after an interest rate reduction.

We find 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. Instead, there are much less housing tenure transitions from renting to owning after an interest rate increase. In this case, some renters at the margin of purchasing a home postpone their home purchase until the temporarily higher interest rate falls back to its initial level. The asymmetry of the consumption response is thus caused by renters becoming

owners after a decrease in the interest rate which dampens the positive consumption response.

As a rule of thumb, we find that the size of this asymmetry in the aggregate consumption response can be approximately determined by relying on the fraction of the agents changing from renting to owning, in the following way: The difference in the consumption response for this group resulting from their change of housing tenure needs to be multiplied by their share in the population.

We find that this asymmetry is 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 the high potential of transitions to ownership between ages 35 and 55 visible in Figure 5.[29]

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—according to the previously mentioned rule of thumb—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

Figure 14 in Appendix E.1.2 shows the consumption responses if we assume that there is full pass-through from the interest rate to the rent-price ratio. The responses then are larger than in the benchmark and the response is largest in France and smallest in Spain, which is at odds with the empirical evidence reported in Figure 6 of Corsetti et al. (2021).

Our comparison of results between the benchmark case and the case with full pass-through shows that the responses of non-housing consumption to changes in the interest rate are sensitive to assumptions about the transmission of monetary policy to the housing market. 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 non-housing consumption response better with the data.

With full pass-through also the effects of monetary policy on rental expenditures and portfolio choices change substantially relative to the benchmark. Results that are not reported for brevity show that the effect of the decrease in the real interest rate on household portfolios and the rental rate 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

[29] In this discussion we focus on owner occupiers. The agents selling the real estate to them may be investors for whom such a transaction amounts to a portfolio reshuffle within asset categories consolidated in other wealth in our model. Hence, the quantitative modifications to the aggregate consumption responses reported in the paper would likely be small if we considered these sellers explicitly.

medium term.

Without pass-through to the rent-price ratio, as in our benchmark experiment, the model predicts a temporary increase of the homeownership 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 3 pp, which is in the ballpark of the empirical estimate for Germany of 2 pp in Koeniger et al. (2021) considering that the empirical estimate considers a 25 bp decrease of the *nominal* interest rate and changes of the nominal rate pass through to the real interest rate less than fully. 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 et al., 2021). For Italy, the model predicts a temporary increase of the homeownership rate that is 0.5 pp smaller than in Germany, broadly in line with the smaller effect estimated for Italy in Koeniger et al. (2021).[30]

### 4.1.3 The duration of the interest rate regime affected by forward guidance

We explore for the benchmark case without pass-through to the rent-price ratio how forward guidance modifies the consumption responses by anchoring expectations of households about interest rates. In the first experiment, forward guidance affects the (expected) persistence of an interest rate change. In the experiment we consider, it implies that agents expect the interest rate to remain lower for longer. In the second experiment, forward guidance anchors expectations for an interest *in*crease at different time horizons in the future. This experiment seems particularly relevant for the current monetary policy discussion about the timing for exiting an interest rate regime with a low policy interest rate. In both experiments, we focus on the consumption response on impact which is independent of additional assumptions on the further realized path of interest rates after the initial change.[31]

#### Anchoring expectations on interest rates that remain lower for longer

The first experiment illustrates that forward guidance may increase the consumption response on impact by anchoring expectations of households on interest rates that stay lower for longer. Figure 8 shows that the consumption response is stronger, as one would expect, the more persistent the decrease in the interest rate is expected to be. The effect of

[30] Empirically, Koeniger et al. (2021) 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 et al., 2004).

[31] The probabilistic nature of interest rate changes makes the problem stationary across cohorts which simplifies the analysis compared with considering deterministic interest rate paths.

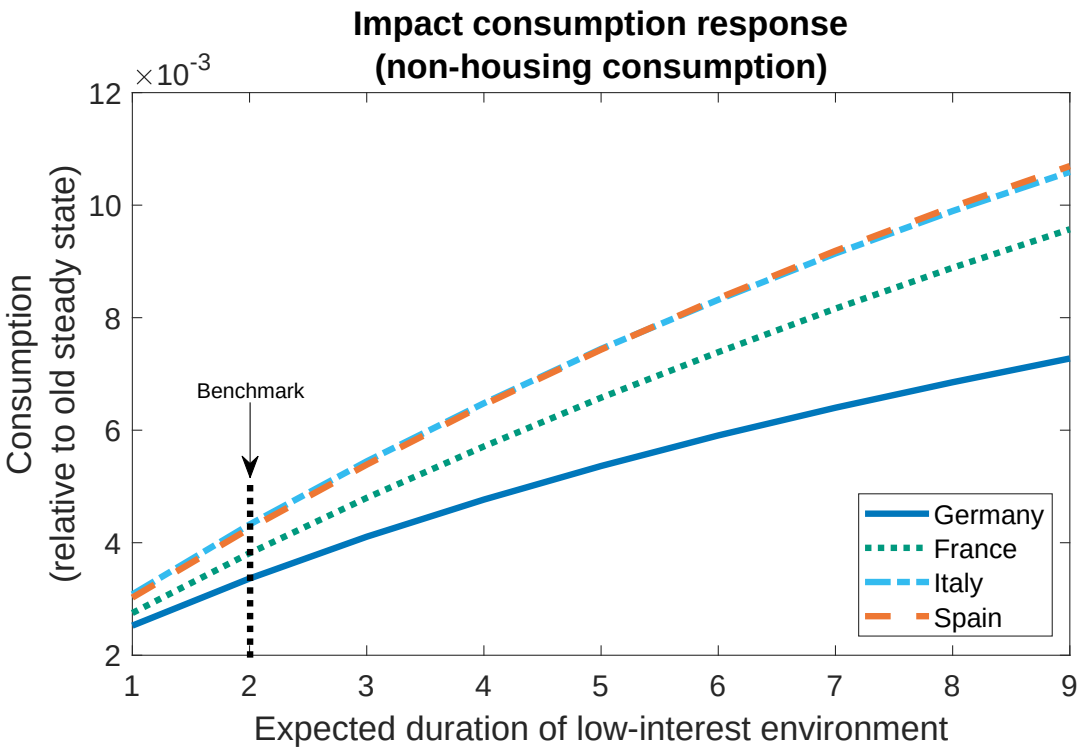



Figure 8: Impact consumption response as a function of the expected duration of the regime of low-interest rate environment (interest rate decrease of 25 bp)

more persistent interest rate changes on consumption is positive but the marginal effect of such a longer expected duration is diminishing. Figure 8 shows that the consumption response on impact is concave in the years that the interest change is expected to last. For Germany, for example, reverting the shock after two years instead of one year increases the impact consumption response by 9 bp (thus increasing the impact consumption response by 36%), whereas an additional year after 8 years only increases the consumption response by about half that amount (4 bp).[32] The cumulative consumption response, of course, trivially becomes larger if the decrease in the interest rate lasts for a longer time span.

Figure 8 further shows that the cross-country differences in the consumption response (on impact) become larger if the decrease of the interest rate is expected to be more persistent. The results show that a decrease of the interest rate, which is expected to last for two years as in the benchmark, implies that the consumption responses differ across the

[32]Results, not reported for brevity, show that the effect of more persistent interest rate changes on home purchases is positive but the marginal effect of such a longer expected duration is diminishing. This is closely related to the insight by McKay and Wieland (2021a) that current decreases in the user cost have a stronger effect on durable purchases (housing in our model) than future decreases. The difference in our model with housing and a rental option is that this depends on the pass-through of the interest rate change to the rent-price ratio. Home purchases and the transition from renting to owning increase after a decrease in the interest rate if the relative cost of owning decreases, as in the empirically plausible benchmark case without pass-through.

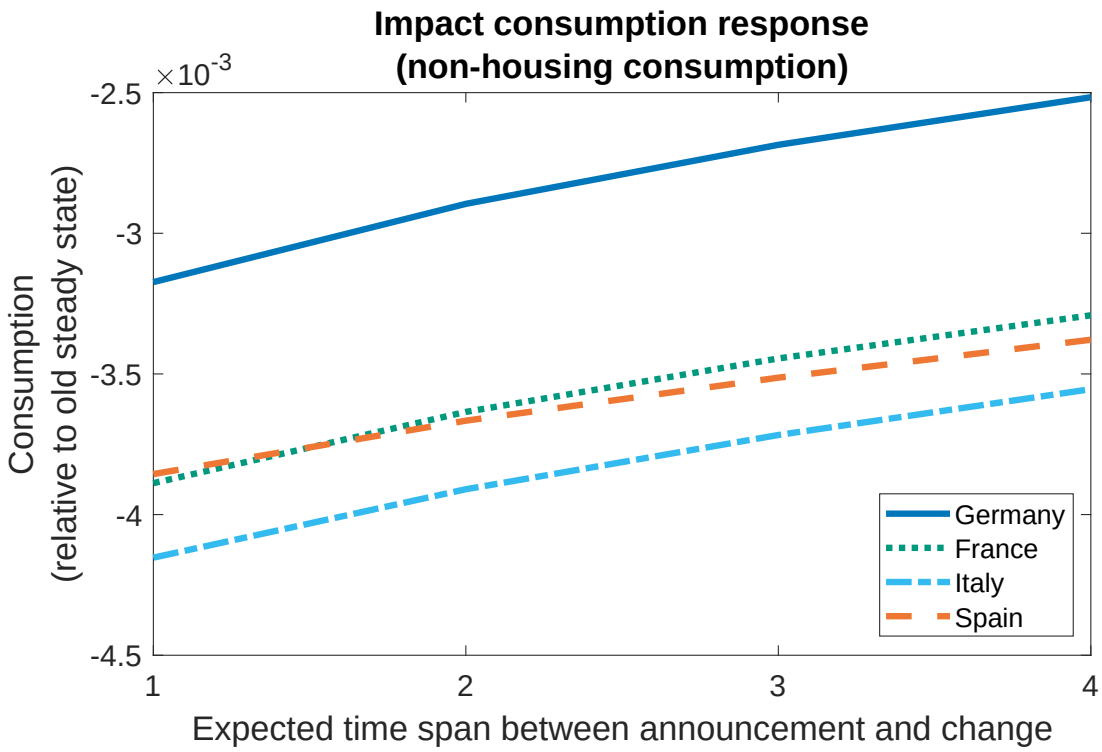



Figure 9: Impact consumption response as a function of the expected time span in years between the announcement and the increase of the interest rate by 25 bp.
Note: The change of the interest rate is expected to last for two years, as in the benchmark.

considered countries by as much as 9.6 bp. This extent of cross-country heterogeneity reduces to 5.5 bp if we assume that the regime with the lower interest rate is expected to last for only one year.

**Anchoring expectations about the timing of a future interest rate increase**

The second experiment illustrates that the effect of an announced interest rate increase implies a smaller consumption slump on impact if the announced increase is expected to take place further in the future.[33] Figure 9 shows that the consumption response on impact decreases by about 10% if the interest rate is announced to increase in the expected time span of two years rather than of one year. This confirms results of McKay et al. (2016) for models with precautionary savings and borrowing constraints, albeit in a life-cycle setting with housing in this paper.

Figure 9 illustrates once more the substantial cross-country heterogeneity in the consumption responses, which is thus a robust finding in our analysis. Note that the size of the consumption responses in Figure 9 for the second experiment is also affected by the uncertainty about whether the interest increase will indeed take place in the future.

[33] If we consider a decrease of the interest rate, the results are qualitatively similar but smaller (in absolute terms) because of the asymmetry discussed previously.

Thus, the difference between the impact response in this experiment and the response in the experiment with a *current* increase of interest rate in Figure 13, Appendix E.1.1 depends both on the timing of the interest rate increase and the uncertainty about the future increase. As is intuitive, the size of the impact consumption response is smaller in Figure 9 than in Figure 13. Overall, the findings for the second experiment highlight the policy trade-off for a central bank to mitigate the drop in consumption, by announcing the increase of the interest rate well ahead of the actual implementation, at the cost of shifting the drop in consumption from the future to the present.

#### 4.1.4 Discussion

How robust is the heterogeneity in the consumption responses across countries if we restrict the pass-through of changes in the policy rate to the interest rate of mortgage loans? We use our results on the disaggregated consumption responses of households with different portfolios to check the relevance of the assumption that borrowing households benefit from a decline in the interest rate. This assumption is natural for Italy and Spain where households have options to refinance mortgage loans at little cost or many mortgage contracts have variable 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 (see ECB (2009), Calza et al. (2013) and Jappelli and Scognamiglio (2018)).

The quantitative importance of these differences in mortgage finance across countries for the reported consumption responses is not obvious. The higher incidence of fixed-rate mortgages together with the higher cost of refinancing may dampen the response of (non-housing) consumption in France and Germany relative to Italy and Spain and thus may further increase the cross-country heterogeneity in consumption responses to changes in the real interest rate. As a rough check of this conjecture, we compute the aggregate consumption response under the assumption that the consumption response of borrowing homeowners is zero in Germany and France because of fixed-rate mortgage contracts and large penalty payments for refinancing. This adjustment likely provides an upper bound for the reduction of the consumption response in these countries because we do not only eliminate the income effect but also the substitution effect of the reduction of the interest rate, which both increase consumption in the group of borrowers, and any further effects, possibly due to precautionary savings and the occasionally binding collateral constraint.

The bottom panel of Table 4 shows that the consumption response of homeowners with debt accounts for 12 basis points of the aggregate response in Germany. Abstracting from the consumption response of indebted homeowners hence reduces the consumption response on impact from 0.34% to 0.22% in Germany and, analogously based on the results

reported in Table 10 of Appendix E.2, from 0.37% to 0.24% in France, thus increasing the difference to the consumption responses in Italy and Spain.[34]

We find substantial heterogeneity in the direct effect of changes in the interest rate on consumption across the four euro-area countries. It would be interesting in further research to nest the analysis of the consumption responses in a framework which allows for general equilibrium effects through the labor market or fiscal policy, as emphasized by Kaplan et al. (2018). Results by Blomhoff Holm et al. (2021), based on detailed administrative household-level data in Norway, show that the direct effect of interest rate changes on consumption dominates the indirect general equilibrium effect over a horizon of two years after the shock. This suggests that the general equilibrium effect takes time and that the direct effect of interest rate changes shapes the consumption response over shorter horizons after monetary policy shocks, which are the main focus in our paper. National peculiarities in labor market institutions and in the conduct of fiscal policy across euro-area countries suggest that the general equilibrium effects and their timing may well be additional sources of cross-country heterogeneity in the transmission of real-interest rate changes to consumption.

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

The current environment of persistently low interest rates has raised concerns about a looming house price correction once interest rates increase 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.

Figure 10 shows the non-housing consumption responses after a drop in house prices. We illustrate the responses for a scenario, in which house prices drop by 10% and this drop is reversed in two steps within four years. The house-price changes are implemented as a sequence of MIT shocks, i.e., unanticipated and supposedly permanent changes. The responses are intuitively larger in those countries in which home ownership rates are higher. Non-housing consumption on impact falls by 1.70% in Spain, 1.51% in Italy, 1.13% in France and 1.15% in Germany.[35] These responses imply elasticities of consumption to house price changes between 0.11 for Germany and France and $0.15-0.17$ for Italy

[34] In further research it would be desirable to check the robustness of this result if we modeled fixed-rate and variable-rate mortgage contracts explicitly to account for changes in consumer behavior. This extension is non-trivial because it would require additional state variables in the problem. Simplifying the analysis by reducing the heterogeneity of agents to three types, Corsetti et al. (2021) 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.

[35] The overshooting of consumption after the relative price for housing has returned to its initial level results from accumulation of cheaper housing during the period with a lower relative price which allows agents to afford more non-housing consumption.

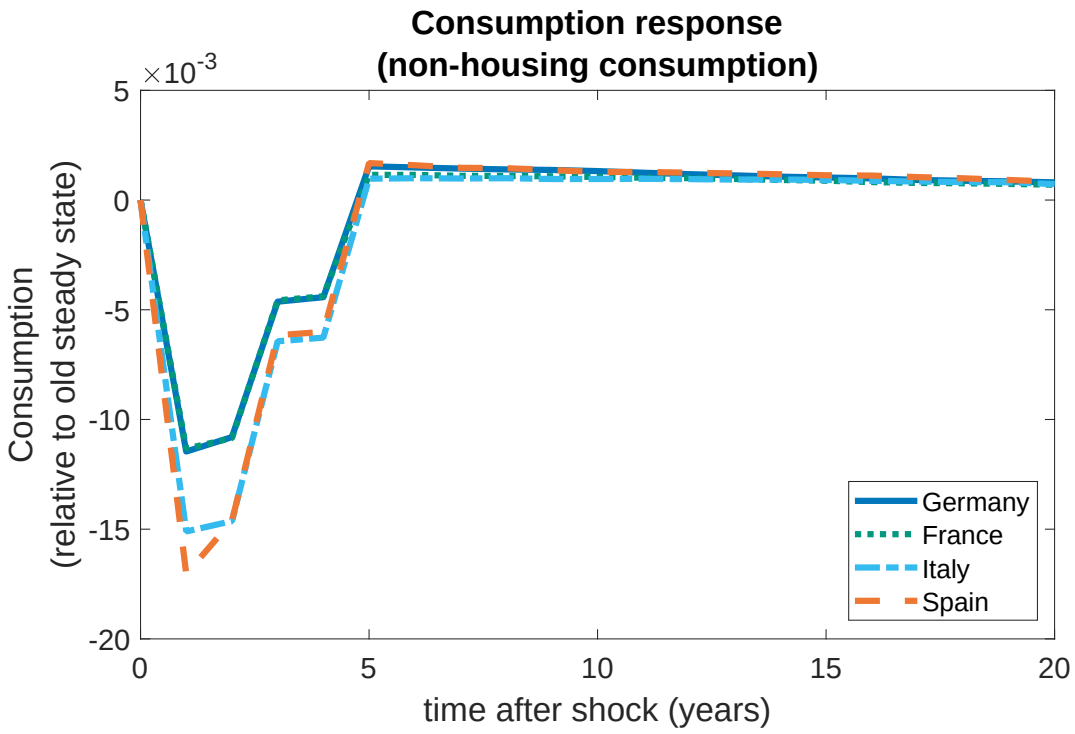



Figure 10: Unexpected fall of the relative house price by 10%, reversed in two steps within 4 years

and Spain. The higher homeownership rates in Italy and Spain, relative to Germany and France, are more similar to the homeownership rate in the U.S., and so are the elasticities of consumption in response to a house price change.[36]

Figure 15 in Appendix E.3.1 shows that the magnitude (in absolute terms) of the consumption response to house price changes does not depend much on the sign of the price change. This is in line with the moderate leverage on average in the considered euro-area countries so that the incidence of collateral constraints does not matter much quantitatively for the aggregate consumption responses. After a 10% house-price increase, consumption increases by 1.08% and 1.05% respectively in Germany and France, by 1.38% in Italy and 1.47% in Spain.

Our model allows us to investigate the heterogeneity of consumption responses across households. We find that changes in house prices affect consumers quite differently depending on their age and portfolio positions. Table 5 illustrates the heterogeneity for

[36]The model-implied elasticities for Italy and Spain are of similar size as the upper end of the range of estimates for the U.S. reported in Guren et al. (2021) and are a bit below 0.2, the model-based estimate for the U.S. in Kaplan et al. (2020b). Recent empirical evidence by Lennartz (2021) exploits household-level variation in house prices and consumption and suggests that the average elasticity of consumption with respect to house price changes across Italian households is lower than in the U.S. because Italian households are less leveraged. The point estimates in Lennartz (2021) imply an elasticity of 0.05−0.1 for the time period 1987 – 2016 and are thus somewhat lower than the predictions of our model which is calibrated to match statistics observed in the HFCS towards the end of that sample period.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = −0.0115 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | -0.0031 | 0.16 | 0.18 | -0.0006 |
| Ages 35 – 44 | -0.0054 | 0.20 | 0.23 | -0.0012 |
| Ages 45 – 54 | -0.0114 | 0.25 | 0.26 | -0.0030 |
| Ages 55 – 64 | -0.0180 | 0.19 | 0.18 | -0.0032 |
| Ages 65 – 74 | -0.0219 | 0.18 | 0.14 | -0.0031 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | 0.0000 | 0.25 | 0.18 | 0.0000 |
| Percentiles 25 – 50 | -0.0007 | 0.25 | 0.23 | -0.0002 |
| Percentiles 50 – 75 | -0.0130 | 0.25 | 0.24 | -0.0031 |
| Percentiles 75 – 90 | -0.0218 | 0.15 | 0.18 | -0.0039 |
| Percentiles 90 – 95 | -0.0245 | 0.05 | 0.07 | -0.0018 |
| Percentiles 95 – 99 | -0.0255 | 0.04 | 0.07 | -0.0018 |
| Percentiles 99 – 99.9 | -0.0258 | 0.009 | 0.022 | -0.0006 |
| Percentiles 99.9 – 100 | -0.0306 | 0.001 | 0.006 | -0.0002 |
| *Composition of impact response across financial positions of homeowners* | | | | |
| *Homeowners* | -0.0216 | 0.47 | 0.53 | -0.0115 |
| ... with positive assets | -0.0238 | 0.28 | 0.34 | -0.0082 |
| ... with non-positive assets | -0.0176 | 0.19 | 0.19 | -0.0033 |

Table 5: Germany: heterogeneity of the (non-housing) consumption response across households. Notes: response on impact after an unexpected fall of the relative house price by 10%. In the middle panel of the table, group membership is based on *state* variables prior to the shock that determine the position in the net-worth distribution. In the bottom panel of the table, group membership is determined by *chosen* asset positions at the time of the shock that are associated with the housing tenure choice.

Germany. Appendix E.4 contains the results for the other countries and we will refer to the main differences in the findings across countries below.

Table 5 shows that non-housing consumption of older households decreases relatively more after a drop in house prices because more of these households own housing, and conditional on ownership their housing stock is larger. Agents with ages between 45 and 64 account for 44% of aggregate consumption and the consumption responses of this age group contribute more than half of the aggregate consumption response. In Appendix E.4 we show that this pattern is similar for France while for Italy and Spain households aged 35 – 44 contribute more to the aggregate consumption response because of the relatively higher homeownership rate in this age group.

Table 5 further shows that, for Germany, the consumption response increases across percentiles in the top half of the net-worth distribution. Because housing wealth and its ownership is concentrated among wealthier households, the top half of the distribution also accounts for most of the aggregate consumption response. Appendix E.4 shows that this is quantitatively less so in Italy and Spain where housing wealth is less concentrated.

The bottom panel of Table 5 shows that homeowners with debt or zero other wealth in Germany have a smaller consumption response than homeowners with positive financial assets because they own smaller homes which more than offsets their larger marginal propensity to consume for their response to the fall in the house price. They account for less of the aggregate consumption response because their share of aggregate consumption is smaller. Appendix E.4 shows that this pattern is similar for France and Italy and quantitatively less so in Spain where homeowners with debt or zero other wealth account for a third of aggregate consumption. Note that the consumption response of homeowners to house price changes equals the aggregate consumption response because the experiment we consider abstracts from equilibrium feedback effects on renters from house-price changes.[37] The extensive margin of home ownership is thus particularly important to understand the aggregate consumption response to house price changes.

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. (2018a). 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. Another effect identified by Guerrieri et al. (2020) is that the

[37] If the price drop caused the rent-price ratio to increase instead, the negative consumption responses would be amplified (in absolute terms). For an analysis of such a scenario with constant rents after the house-price drop, see the working paper version (Hintermaier and Koeniger, 2019).

consumption slump after a house price drop may be persistent because housing also provides self insurance against shocks.

**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 which tries to mitigate the consumption slump after a housing bust with accommodative monetary policy. As discussed before when presenting Figure 10, the consumption response on impact after a fall in relative house prices by 10% differs by 55 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 Italy and Spain than in Germany and 5 bp larger than in France. In a low-interest-rate environment, such as the current one, the policy space is limited for reducing the real rate much further. Our results indicate that such policy limitations may make it particularly challenging to stabilize consumption after housing busts in countries with high homeownership rates, such as Italy and Spain. These challenges may intensify if housing busts are heterogeneous across countries. In the Great Recession and subsequent sovereign debt crisis house prices fell more than 10 % in Italy and Spain and less in France and Germany.[38]

## 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 heterogeneous consumption responses in more detail. In Table 6 we disentangle the effects on consumption responses resulting from observed country-specific household balance sheets (state variables in the model) and country-specific financial decision making of households (policy functions affected by the model environment). We compare the consumption response (on impact), presented in subsections 4.1 and 4.2,

[38]See the deflated house-price index for 2006 to 2016 available at Eurostat. For a further discussion of results with asymmetric house-price shocks see the working paper version, subsection 4.3 (Hintermaier and Koeniger, 2019).

with the consumption response that would obtain if, at the time of the shock, households in France, Italy and Spain had the *same* distribution of household finances as in Germany, conditional on age.[39]

Table 6 shows that the responses to a fall in the real interest rate (top panel) and the house price (bottom panel) would become smaller in absolute value if households in France, Italy and Spain had the German distribution of household finances. This is intuitive given that there are less homeowners in Germany and homeowners have higher consumption responses.

When considering the consumption responses for a given distribution of household finances at the time of the shock, cross-country asymmetries in the consumption responses to a fall in the real interest rate for France, Italy and Germany are reduced, as shown in the top panel of Table 6. The consumption response for Spain decreases most if we assign the German distribution of household balance sheets because the difference between the incidence of renters is largest between Germany and Spain and the consumption response of renters to changes in the real interest rate is much smaller than for homeowners. The smaller consumption response in Spain than in Germany, for a given distribution of household finances, illustrates that differences in household balance sheets may offset some of the heterogeneity across these two countries which would otherwise result just from differences in the financial decision making.

The bottom panel of Table 6 shows that neutralizing any effects from differences in household finances makes the consumption response to a fall in the relative house price less asymmetric across Germany, Italy and Spain. The consumption responses for France, Italy and Spain decrease below the response for Germany. 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. (2018a), the decrease of the consumption response is stronger in countries which differ more from Germany in terms of the size of housing in the portfolio. Given that the homeownership rate is lowest in Germany among the considered countries, the cross-country differences in home ownership imply that the consumption response decreases most for Spain, and more for Italy than for France, if households in these countries are assigned the German household finances at the time of the shock.

The findings in Table 6 show that pre-existing differences in household financial posi-

[39] We obtain the aggregate response of consumption attributable to the interest rate or house price change by applying the differences-in-differences technique. Given that we impose the German steady-state distribution of household finances on France, Italy and Spain, these economies converge back to their respective steady state, causing dynamic changes in consumption even without any price changes. To account for this additional effect, we construct a control group of consumers in France, Italy and Spain that start with the German distribution of household finances and that are *not* exposed to a change of the interest rate or the house price. We construct a treatment group of consumers in France, Italy and Spain that start with the German distribution of household finances and that are exposed to the price changes. We report the difference of the impact response between the treatment and control group.

| Responses to decrease of the **real interest rate** from 0.5% to 0.25% | | | | |
|---|---|---|---|---|
| | Germany | France | Italy | Spain |
| Benchmark responses | 0.0034 | 0.0038 | 0.0043 | 0.0043 |
| Responses with German distribution of household finances | 0.0034 | 0.0033 | 0.0030 | 0.0019 |
| Responses to decrease of the **house price** by 10% | | | | |
| | Germany | France | Italy | Spain |
| Benchmark responses | -0.0115 | -0.0113 | -0.0151 | -0.0170 |
| Responses with German distribution of household finances | -0.0115 | -0.0071 | -0.0086 | -0.0084 |

Table 6: Consumption responses on impact and differences in household finances
Notes: The responses with the German distribution of household finances contain the part of the response attributable to the change of the interest rate or house price. See footnote 39.

tions can explain why consumption responses to changes in the real interest rate or relative house prices are larger in Italy and Spain than in France and Germany. Our results also show that the pre-existing differences in household portfolios are not the entire story. Heterogeneous household decisions after a shock explain the other part of cross-country differences. That is, not only differences in the state variables matter for the different consumption responses but also differences in the policy functions. These policy functions for the consumption and portfolio decisions are determined by the country-specific environment, augmenting the importance of household finances in shaping the transmission of price shocks to consumption across euro-area countries.

# 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. Within countries, we have identified which population groups in terms of ages, housing tenure and asset positions quantitatively contribute most to the aggregate consumption response.

We have shown that pre-existing differences in household financial positions can explain why consumption responses to changes in the real interest rate or relative house prices are larger in Italy and Spain than in France and Germany. Because some of the effects are explained by differences in household financial decisions, that depend on the country-specific environment, our findings underline the importance of a structural approach of modeling financial decisions of heterogeneous households when analyzing the transmission mechanism of monetary policy.

From a conceptual point of view, the structural life-cycle model we employ features discrete decisions on home ownership and adjustment of owned housing, a borrowing spread and continuous portfolio choices. With an appropriately designed solution method, this allows us to avoid restrictions on the utility value of housing to positions on a coarse, discrete grid as in much of the literature. Instead we capture the portfolio positions accurately, which is important for computing the implied consumption responses.

The analysis of the consumption responses has revealed that the model predicts empirically plausible cross-country differences in the impact responses of consumption and housing tenure to interest rate changes if, in line with empirical evidence, there is no immediate pass-through of the interest rate to the rent-price ratio in the housing market. We find that the transitions in housing tenure after interest rate changes then give rise to asymmetries in the consumption response to interest rate changes of opposite sign.

Besides discovering these interactions between consumption responses and the transmission of monetary policy to the housing market, we have used our calibrated model to perform policy-relevant experiments. We have illustrated the quantitative effect on the consumption responses if interest rates are expected to stay lower for longer. We have pointed out a policy trade-off. If regimes with low interest rates are brought to an end, the resulting consumption slump may be smaller and sooner or larger and later. We have illustrated challenges for monetary policy resulting from asymmetric effects of housing busts in an environment with low interest rates.

The heterogeneity of consumption responses across and within countries, which we find in our analysis, illustrates the limits for what uniform monetary policy in the euro area can achieve. Our results suggest that country-specific fiscal policy through national taxes or within-country transfers may be useful complementary policy instruments if policy makers want to mitigate not only the asymmetric effects of monetary policy across countries but also the distributional effects across consumers with different ages, housing tenure and asset positions that we find for each of the analyzed euro-area countries.

# A Recursive solution

This appendix relies on the description of the model presented in Section 2 and explains its solution based on the recursive formulation.

First we **normalize** the household problem such that the price level $p_t$ does not enter as a separate state variable. We define *price-transformed variables* in the following way.

$$\bar{s}_j = p_t \hat{s}_j,$$

$$h_{j+1} = p_t \hat{h}_{j+1},$$

$$f_j = p_t \hat{f}_j.$$

The normalization uses the assumption of a constant price-growth factor

$$\Pi = \frac{p_t}{p_{t-1}}.$$

## Normalizing the utility function

In terms of price-transformed units, $\bar{s}_j = p_t \hat{s}_j$, the utility function is expressed as

$$u(c_j, \hat{s}_j) = \theta \log c_j + (1-\theta) \log\left(\frac{1}{p_t} p_t \hat{s}_j\right) = \theta \log c_j + (1-\theta) \log\left(\bar{s}_j\right) - (1-\theta) \log p_t.$$

Therefore, utility is equivalently described by

$$U(c_j, \bar{s}_j) = \theta \log c_j + (1-\theta) \log\left(\bar{s}_j\right)$$

Resources relevant for bequests contain the term $p_{t+1}\hat{h}_{j+1}$, which can be expressed as $\Pi h_{j+1}$. Given the separability in discounted expected life-cycle utility, the normalization extends to the forward-looking objective of the household.

In the following we are going to show that, for any possible discrete choice $d_j$, also the constraint sets can equivalently be expressed in terms of price-transformed variables.

## Normalizing the constraints for each discrete choice

### Ownership choice, not adjusting

*If the household chooses to* consume housing as an **owner, not adjusting** the housing stock, we code this as $d_j = 0$. We first make precise what non-adjustment means in terms of valued units. Non-adjustment of housing is naturally defined in terms of having the same

*physical* (i.e., utility generating) quantity in two consecutive periods, meaning that

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

Multiplying by $p_t$ and using the definition of $\Pi$,

$$p_t \hat{h}_{j+1} = p_t \hat{h}_j = p_t \frac{1}{p_{t-1}} p_{t-1} \hat{h}_j = \Pi p_{t-1} \hat{h}_j \ .$$

In terms of price-transformed units, **physical non-adjustment** therefore implies that

$$h_{j+1} = \Pi h_j \ .$$

Ownership of housing implies that rented physical housing units $\hat{f}_j = 0$ and hence $p_t \hat{f}_j = 0$. Therefore

$$f_j = 0 \ .$$

For the physical service flow in the non-adjustment case we have $\hat{s}_j = \phi \hat{h}_j$, implying $p_t \hat{s}_j = \phi p_t \hat{h}_j$, and therefore

$$\bar{s}_j = \phi \Pi h_j \ .$$

The budget constraint is

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

and the collateral constraint $(1 + r_t) a_{j+1} \geq -\mu p_t \hat{h}_j - g_{y,j+1}$ can be expressed as

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

**Ownership choice, adjusting**

*If the household chooses to* consume housing as an **owner, adjusting** the housing stock, coded as $d_j = 1$, $\hat{f}_j = 0$ implies

$$f_j = 0 \ .$$

The physical service flow $\hat{s}_j = \phi \hat{h}_{j+1}$ implies $p_t \hat{s}_j = \phi p_t \hat{h}_{j+1}$, and therefore

$$\bar{s}_j = \phi h_{j+1}.$$

The adjustment cost function can be written as

$$\begin{aligned}\alpha_p(\hat{h}_j, \hat{h}_{j+1}) &= \alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1} \\ &= \alpha_1 \frac{p_t}{p_{t-1}} h_j + \alpha_2 h_{j+1} \\ &= \alpha_1 \Pi h_j + \alpha_2 h_{j+1} \ .\end{aligned}$$

Denoting

$$\alpha(h_j, h_{j+1}) = \alpha_1 \Pi h_j + \alpha_2 h_{j+1} \ ,$$

the budget constraint

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

becomes

$$c_j + a_{j+1} + h_{j+1} + \alpha(h_j, h_{j+1}) = y_j(s_j) + (1 + r_{t-1}) a_j + p_t \frac{p_{t-1}}{p_{t-1}} \hat{h}_j \ ,$$

which, using the price growth factor, can be written as

$$c_j + a_{j+1} + h_{j+1} + \alpha(h_j, h_{j+1}) = y_j(s_j) + (1 + r_{t-1}) a_j + \Pi h_j \ .$$

The collateral constraint $(1 + r_t) a_{j+1} \geq -\mu p_t \hat{h}_{j+1} - g_{y,j+1}$ can be expressed as

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

**Rental choice**

*If the household chooses to* consume housing as a **renter**, coded as $d_j = 2$, the choice of non-ownership of housing $\hat{h}_{j+1} = 0$ implies $p_t \hat{h}_{j+1} = 0$, and therefore

$$h_{j+1} = 0 \ .$$

The physical service flow $\hat{s}_j = \phi_R \hat{f}_j$ implies $p_t \hat{s}_j = \phi_R p_t \hat{f}_j$, and therefore

$$\bar{s}_j = \phi_R f_j \ .$$

The adjustment cost function can be expressed as

$$\begin{aligned}\alpha_{pR}(\hat{h}_j) &= \alpha_1 p_t \hat{h}_j \\ &= \alpha_1 \frac{p_t}{p_{t-1}} h_j \\ &= \alpha_1 \Pi h_j \ .\end{aligned}$$

Denoting

$$\alpha_R(h_j) = \alpha_1 \Pi h_j \ ,$$

and using the rent-to-price ratio $k_t$ to express the rental price $q_t = k_t p_t$, the budget constraint

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

becomes

$$c_j + a_{j+1} + k_t p_t \hat{f}_j + \alpha_R(h_j) = y_j(s_j) + (1 + r_{t-1}) a_j + p_t \frac{p_{t-1}}{p_{t-1}} \hat{h}_j \ ,$$

which, using $f_j = p_t \hat{f}_j$ and the price growth factor, can be written as

$$c_j + a_{j+1} + k_t f_j + \alpha_R(h_j) = y_j(s_j) + (1 + r_{t-1}) a_j + \Pi h_j \ .$$

The collateral constraint is

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

## The recursive formulation

Uncertainty in the dynamic optimization problem is captured by a Markov process, with discrete states $s \in S$, and transition probabilities denoted by $\pi_{s,s'}$, such that for all $s$ we have that $\sum_{s' \in S} \pi_{s,s'} = 1$. We denote the realization of the Markov state at age $j$ by $s_j$. 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.

We first define an auxiliary state variable, which turns out to be convenient for the solution, and rewrite all constraints using that variable. The auxiliary state variable $x_j$, which may be interpreted as liquidable wealth, is defined as

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

For the two cases (not adjusting and adjusting) of ownership choice, the budget con-

straint is expressed in terms of the auxiliary variable as follows:

$$c_j + a_{j+1} + h_{j+1} + \mathbf{1}_{d_j=1}\ \alpha(h_j, h_{j+1}) = y_j\left(s_j\right) + (1 + r_{t-1})a_j + \Pi h_j,$$

where $\mathbf{1}_{d_j=1}$ denotes an indicator function which takes the value of 1 if an adjustment is made and zero otherwise.

In the case of **non-adjustment** of housing, where the discrete choice variable is $d_j = 0$, and $h_{j+1} = \Pi h_j$, we have

$$c_j = y_j\left(s_j\right) + x_j - (1 - \alpha_1)\Pi h_j - a_{j+1}.$$

In the case of **adjustment** of housing, where the discrete choice variable is $d_j = 1$, we have

$$c_j = y_j\left(s_j\right) + x_j - a_{j+1} - h_{j+1} - \alpha_2 h_{j+1}.$$

In both cases, adjustment and non-adjustment, the next-period asset positions need to satisfy the collateral constraint

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

which, in terms of our auxiliary variable can be expressed as derived in the following. For the next age, the definition of the auxiliary state variable can be solved for the financial asset

$$(1 + r_t)\, a_{j+1} = x_{j+1} - (1 - \alpha_1)\,\Pi h_{j+1}\ .$$

Substituting for $(1 + r_t)\, a_{j+1}$ in the collateral constraint, we obtain

$$x_{j+1} \geq [(1 - \alpha_1)\,\Pi - \mu]\, h_{j+1} - g_{y,j+1}\ .$$

For the case of **rental choice**, where the discrete choice is $d_j = 2$, and $h_{j+1} = 0$, the budget constraint

$$c_j + a_{j+1} + k_t f_j + \alpha_R(h_j) = y_j\left(s_j\right) + (1 + r_{t-1})a_j + \Pi h_j$$

is expressed in terms of the auxiliary variable as follows

$$c_j + k_t f_j = y_j\left(s_j\right) + x_j - a_{j+1}\ ,$$

and the collateral constraint is

$$x_{j+1} \geq -g_{y,j+1}\ .$$

In the recursive problem we denote

$$W_j(x_j, h_j, s_j) = \max_{d_j, c_j, f_j, a_{j+1}, h_{j+1}} \{U(c_j, \bar{s}_j) + \left(1 - \iota_j\right) \beta \underset{s_{j+1}|s_j}{E} W_{j+1}(x_{j+1}, h_{j+1}, s_{j+1}) + \iota_j \Psi\left(x_{j+1}\right)\},$$

where the expectation operator $\underset{s'|s}{E} f(\cdot, s') = \sum_{s' \in S} \pi_{s,s'} f(\cdot, s')$.[40] The probability of death in period $j$ is denoted by $\iota_j$. We consider a warm-glow bequest motive, represented by utility from bequeathing, as captured by the function $\Psi\left(x_{j+1}\right)$, whose argument is therefore to be interpreted as liquidable wealth after death. The bequest utility function is parameterized as follows:

$$\Psi(x_{j+1}) = \psi_0 \log\left(\psi_1 + x_{j+1}\right).$$

Given that $\psi_1 > g_{y,j+1}$ for all $j$ in our calibration, the bequest utility function is well defined for borrowers in the feasible borrowing set of our model.

Henceforth we denote by $\beta_j$ the product of the survival probability in age $j$ and the discount factor $\beta$, that is

$$\beta_j \equiv \left(1 - \iota_j\right) \beta.$$

By the same token, we define

$$\Psi_j\left(x_{j+1}\right) \equiv \iota_j \Psi\left(x_{j+1}\right).$$

Conditional on the discrete choice,

$$w_j(x_j, h_j, s_j | d_j) = \max_{c_j, f_j, a_{j+1}, h_{j+1}} \left\{ U(c_j, \bar{s}_j) + \beta_j \underset{s_{j+1}|s_j}{E} W_{j+1}(x_{j+1}, h_{j+1}, s_{j+1}) + \Psi_j\left(x_{j+1}\right) \right\}.$$

So far, there is uncertainty about death, earnings, and future interest rates in the model. We handle the discrete-choice options in the recursive problem according to the approach suggested by Iskhakov et al. (2017). More specifically, we consider the addition of a random component to the valuation of discrete-choice options, and assume that this component is distributed according to an extreme-value (type I) distribution so that, keeping for simplicity the same notation for functions $W_j(\cdot)$ and $w_j(\cdot)$,

$$W_j(x_j, h_j, s_j, \eta_j) = \max_{d_j \in D_j} \{w_j(x_j, h_j, s_j | d_j) + \eta_{d_j}\},$$

where $\eta_{d_j}$ denotes the realization of the random component specific to a discrete choice $d_j$, and the vector $\eta_j$ contains the collection of all realizations at age $j$ for the set of all available discrete choices $D_j$. This randomness is considered for the discrete-choice-specific value functions so that

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

$$w_j(x_j,h_j,s_j|d_j) = \max_{c_j,f_j,a_{j+1},h_{j+1}} \left\{ U(c_j,\bar{s}_j) + \beta_j \underset{s_{j+1}|s_j}{E} \left[ \underset{\eta_{j+1}}{E} W_{j+1}(x_{j+1},h_{j+1},s_{j+1},\eta_{j+1}) \right] + \Psi_j\left(x_{j+1}\right) \right\}$$
$$= \max_{c_j,f_j,a_{j+1},h_{j+1}} \left\{ U(c_j,\bar{s}_j) + \beta_j \underset{s_{j+1}|s_j}{E} \lambda(\mathbf{w}_{j+1}(x_{j+1},h_{j+1},s_{j+1}|d_{j+1}),D_{j+1};\sigma) + \Psi_j\left(x_{j+1}\right) \right\}$$

with[41]

$$\lambda\left(\left(\mathbf{x}|d_{j+1}\right),D_{j+1};\sigma\right) = \sigma \log\left[\Sigma_{d_{j+1}\in D_{j+1}} \exp \frac{\left(x|d_{j+1}\right)}{\sigma}\right].$$

**Ownership choice, not adjusting**

In the case of non-adjustment, where $h_{j+1} = \Pi h_j$, using the budget constraint for this case, we have

$$w_j(x_j,h_j,s_j|d_j=0) = \max_{a_{j+1}} \{ U(y_j\left(s_j\right) + x_j - (1-\alpha_1)\Pi h_j - a_{j+1}, \phi \Pi h_j)$$
$$+ \beta_j \underset{s_{j+1}|s_j}{E} \lambda(\mathbf{w}_{j+1}(x_{j+1},\Pi h_j,s_{j+1}|d_{j+1}),D_{j+1};\sigma) + \Psi_j\left(x_{j+1}\right)\},$$

subject to the collateral constraint

$$x_{j+1} \geq [(1-\alpha_1)\Pi - \mu]\Pi h_j - g_{y,j+1}.$$

**Ownership choice, adjusting**

Inserting the budget constraint and the adjustment cost function, the recursive problem in the case of adjustment is

$$w_j(x_j,h_j,s_j|d_j=1) = \max_{a_{j+1},h_{j+1}} \{ U(y_j\left(s_j\right) + x_j - a_{j+1} - h_{j+1} - \alpha_2 h_{j+1}, \phi h_{j+1})$$
$$+ \beta_j \underset{s_{j+1}|s_j}{E} \lambda(\mathbf{w}_{j+1}(x_{j+1},h_{j+1},s_{j+1}|d_{j+1}),D_{j+1};\sigma) + \Psi_j\left(x_{j+1}\right)\}.$$

The next-period asset positions need to satisfy the collateral constraint

$$x_{j+1} \geq [(1-\alpha_1)\Pi - \mu]h_{j+1} - g_{y,j+1}.$$

Note that in this discrete-choice-specific problem any dependence on $h_j$ is captured by its

[41] The notation with a boldface variable $\mathbf{x}$ in the expression $\left(\mathbf{x}|d_{j+1}\right),D_{j+1}$ is shorthand for denoting the corresponding collection of discrete-choice-specific variables by $\left\{\left(x|d_{j+1}\right): d_{j+1} \in D_{j+1}\right\}$.

contribution to $x_j$. Apart from this contribution, the problem conditional on choosing to adjust is independent of $h_j$, which is convenient for the numerical solution.

**Rental choice**

Using the budget constraint for the case of renting, considering the service flow obtained as $\bar{s}_j = \phi_R f_j$, and taking into account non-homeownership for the next-period state, $h_{j+1} = 0$, we have

$$w_j(x_j, h_j, s_j | d_j = 2) = \max_{f_j, a_{j+1}} [U(y_j\left(s_j\right) + x_j - a_{j+1} - k_t f_j, \phi_R f_j) + \beta_j \underset{s_{j+1}|s_j}{E} \lambda(\mathbf{w}_{j+1}(x_{j+1}, 0, s_{j+1}|d_{j+1}), D_{j+1}; \sigma) + \Psi_j\left(x_{j+1}\right)] .$$

The collateral constraint in this case is

$$x_{j+1} \geq -g_{y,j+1} .$$

Note that also for this discrete-choice-specific problem any dependence on $h_j$ is captured by its contribution to $x_j$. Separate from this contribution, the problem conditional on choosing to rent is independent of $h_j$, which conveniently simplifies the numerical solution.

We implement the solution of the maximization operations present in the recursive formulation by exploiting the implied first-order and envelope conditions. This lets us take advantage of the method for solving portfolio choice problems suggested by Hintermaier and Koeniger (2010), identifying candidates for optimal portfolio choice combinations in a first step, and then using them to determine optimal policy functions for all continuous decision variables.

# B Bequest parameters

Consider a bequest $\mathfrak{b}$ that generates a perpetuity with annual payment flow $r\mathfrak{b}$, where $r$ is the real interest rate. The bequeather considers the utility consequences of the bequest taking into account the average earnings of the offspring $\bar{y}$. The disposable income consists of the annual payment flow $r\mathfrak{b}$ and the offspring's earnings $\bar{y}$, and the per-period utility is $u(\bar{y} + r\mathfrak{b})$.

If the bequeather considers the discounted sum of these future period utilities for the

offspring, the utility generated by the bequest equals

$$u(\bar{y}+r\mathfrak{b})+\beta u(\bar{y}+r\mathfrak{b})+\beta^2 u(\bar{y}+r\mathfrak{b})+\beta^3 u(\bar{y}+r\mathfrak{b})...=\frac{1}{1-\beta}u(\bar{y}+r\mathfrak{b})$$

where the bequeather and the offspring discount with the same factor $\beta$. For a logarithmic per-period utility function, the bequest motive is then captured by the function

$$\Psi(\mathfrak{b})=\frac{1}{1-\beta}\log(\bar{y}+r\mathfrak{b}). \tag{B.1}$$

Note that bequests are a luxury simply because the bequeather considers the utility consequences of the bequest taking into account the average earnings of the offspring.

We now refine the function for the bequest motive by allowing for aggregate income growth after death which increases earnings of the offspring relative to the bequeather. Suppose that the bequests shall generate annual coupon payments $z$ which grow at the same rate $g$ as average earnings. The size of $z$, which can be financed with a bequeathed amount $\mathfrak{b}$, is

$$z=\mathfrak{b}(r-g).$$

because

$$\begin{aligned}
& & (1+r)\mathfrak{b} &= z+\frac{1+g}{1+r}z+\left(\frac{1+g}{1+r}\right)^2 z+\left(\frac{1+g}{1+r}\right)^3 z+\dots, \\
\iff & & (1+r)\mathfrak{b} &= \frac{1}{1-\frac{1+g}{1+r}}z=\frac{1+r}{r-g}z, \\
\iff & & \mathfrak{b} &= \frac{1}{r-g}z.
\end{aligned}$$

Note that without growth ($g=0$), $z=rb$ as in (B.1).

Now consider the sum of discounted utilities, with both the coupon $z$ and average earnings $\bar{y}$ growing at rate $g<r$. Then,

$$
\begin{aligned}
\Psi(\mathfrak{b}) &= \log(\bar{y}+z) + \beta\log((1+g)(\bar{y}+z)) + \beta^2\log\left((1+g)^2(\bar{y}+z)\right) + ... \\
&= \log(\bar{y}+z) + \beta\log(\bar{y}+z) + \beta\log(1+g) + \beta^2\log(\bar{y}+z) + \beta^2 2\log(1+g) + ... \\
&= \frac{1}{1-\beta}\log(\bar{y}+z) + \log(1+g)\sum_{\tau=1}^{\infty}\beta^\tau\tau \\
&= \frac{1}{1-\beta}\log(\bar{y}+z) + \bar{R}_c \ ,
\end{aligned}
$$

with

$$
\bar{R}_c \equiv \log(1+g)\frac{\beta}{(1-\beta)^2} \ .
$$

The bequest motive of a bequeather who anticipates future growth is thus

$$
\Psi(\mathfrak{b}) = \frac{1}{1-\beta}\log(\bar{y}+(r-g)\mathfrak{b}) + \bar{R}_c \ . \tag{B.2}
$$

Note that the constant $\bar{R}_c$ is independent of choices and state variables in the decision problem of the bequeather so that we can abstract from it.

The marginal utility of bequests is

$$
\Psi'(\mathfrak{b}) = \frac{1}{1-\beta}\frac{r-g}{\bar{y}+(r-g)\mathfrak{b}} \ .
$$

In the quantitative application of the model, we set $\bar{y}$ to average earnings at the beginning of the life cycle. The bequest function could be further refined by choosing lower values to capture the extent to which the bequeather cares about the income risk which the offspring faces.

# C Calibration

Table 7 shows the parameters that are common across countries in the calibration. For this set of parameters we keep the values close to values typically calibrated in the existing quantitative literature. We briefly explain the values for those parameters that have not been discussed already in the main text in Section 3.

We set the proportional adjustment cost for sellers $\alpha_1$ 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 displayed in Table 2 in Section 3, we calibrate a higher country-specific cost for the purchaser $\alpha_2$ because in the considered euro-area countries buyers typically pay the transaction taxes. These taxes differ across countries.

| | |
|---|---|
| | *Adjustment costs* |
| $\alpha_1$ | 0.025 |
| | *Loan-to-value ratio before and after retirement* |
| $\mu$ | 0.8 |
| $\mu^{ret}$ | 0.3 |
| | *Pledgeable share of income* |
| $\xi$ | 0.6 |
| | *Autocorrelation of income shocks* |
| $\rho$ | 0.95 |
| | *Real interest rate* |
| lending rate $r^+$ | 0.005 |
| borrowing rate $r^-$ | 0.02 |
| long-run rate $r$ applied to bequests | 0.04 |
| | *Aggregate income growth rate* |
| $g$ | 0.01 |
| | *Price growth factor* |
| $\Pi$ | 1.0 |
| | *Scale parameter of taste shock for discrete choice* |
| $\sigma$ | 0.01 |

Table 7: Common parameters across countries
Note: Country-specific parameters are contained in Table 2.

We allow agents to borrow up to a fraction $\xi = 0.6$ of the smallest possible labor earnings draw. Given that the fraction $\mu = 0.8$ of the housing value can be collateralized during working life, this plausibly implies that housing has a much larger collateral value than labor earnings.

In our benchmark we assume that housing has a stable value ($\Pi = 1$) and labor income is risky. We estimate differences in labor income risk across countries based on the same HFCS data that we use to compute the data targets in our calibration (see the different standard deviations of the innovations reported in Table 2). Given that the cross-sectional nature of the HFCS data does not allow direct estimation of the persistence of the income shocks, we set the autocorrelation of the shocks to $\rho = 0.95$ for all countries. This value is within the range of values for the persistence of income shocks typically assumed in quantitative analyses.

The scale parameter of taste shocks for the discrete choice, $\sigma$, 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 given discrete grids for the endogenous states.

| | Germany | France | Italy | Spain |
|---|---|---|---|---|
| *Pension parameters* | | | | |
| Earnings years | 35 | 25 | 35 | 15 |
| Valorisation rate (in percent) | 1 | 0 | 1 | 0 |
| Benefit growth rate (in percent) | 0 | 0 | 0 | 0 |
| Net replacement rate (in percent) | | | | |
| at following multiples of mean income | | | | |
| 0.5 | 53.4 | 78.4 | 81.8 | 82.0 |
| 0.75 | 56.6 | 64.9 | 78.2 | 83.9 |
| 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 |

Table 8: Country-specific parameters for the pay-as-you-go pensions
Source: Authors' compilation based on the country studies, Table I.2 on pp. 28-30 and the net replacement rate reported on p. 35 in OECD (2007).

## C.1 Pensions

Table 8 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 *valorisation 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 valorisation rate is 0% in real terms.

The *benefit growth rate* in the third row of Table 8 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 since 2000 however, documented at https://www.deutsche-

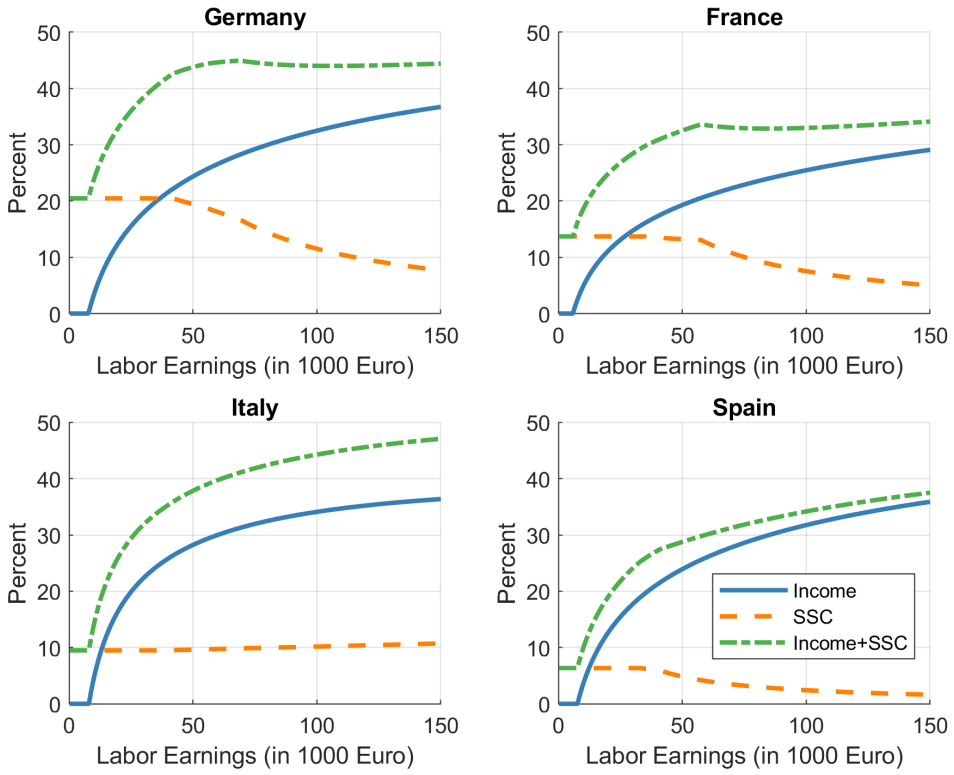



Figure 11: Country-specific schedules for average income taxes and social security contributions
Source: Authors' computation based on the OECD Tax Database, Tables i1, i5 ad i7.

rentenversicherung.de, shows 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 are not fully inflation indexed currently so that they decrease in real terms. We abstract from modeling this detail because this seems only a transitory measure to decrease the liability resulting from the pension system in real terms.

The bottom of Table 8 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.

## C.2 Taxation of labor income

In order to convert gross labor earnings including transfers into net labor earnings, we follow Guvenen et al. (2014). Based on the OECD Tax Database 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 non-linear 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 euro (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, i.e. 2009 for Germany and France and 2010 for Italy and Spain. Figure 11 illustrates the schedules used in our calibration.

## C.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 reported in Table 2, that is implied by the assumption of an AR(1)-process with persistence $\rho = 0.95$. Figure 12 displays the estimated quartic polynomials for the age income profiles together with income averages for five-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 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.

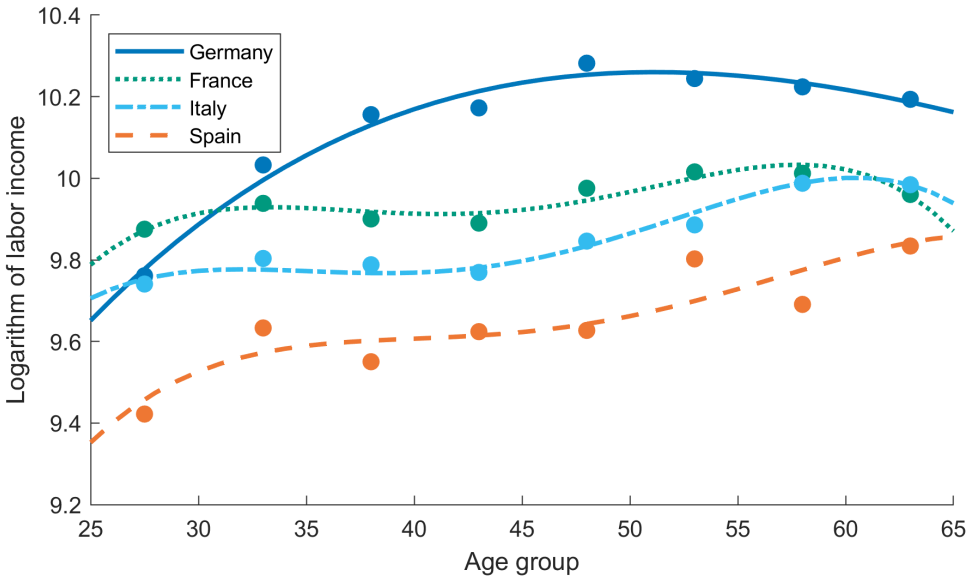



Figure 12: Country-specific age profiles of equivalized earnings
Source: Authors' computation based on the based on the first wave of the HFCS.

## C.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 contains some useful first information in English language on differences in transaction taxes and fees across countries.

| | Age composition | Initial distribution of net worth and housing | Pensions/Tax/ Income profile and process | Transaction cost | Rent-price ratio | Preference parameters |
|---|---|---|---|---|---|---|
| *Statistics predicted* | *Change relative to total difference between model prediction and German benchmark* | | | | | |
| *France* | | | | | | |
| Housing wealth | -0.04 | -0.21 | -0.59 | -0.12 | -1.08 | 3.04 |
| Net worth | -0.05 | -0.24 | -1.03 | -0.02 | -0.17 | 2.51 |
| Rental rate | -0.05 | 0.08 | 0.14 | -0.01 | -0.84 | 1.68 |
| *Italy* | | | | | | |
| Housing wealth | 0.13 | 0.64 | -0.55 | -0.12 | 0.07 | 0.83 |
| Net worth | 0.15 | 0.58 | -1.04 | -0.03 | 0.02 | 1.32 |
| Rental rate | 0.13 | 0.41 | -0.17 | -0.04 | 0.08 | 0.59 |
| *Spain* | | | | | | |
| Housing wealth | 0.12 | 0.72 | -1.79 | -1.33 | 2.35 | 0.93 |
| Net worth | -0.09 | 0.49 | -3.05 | -0.30 | 0.67 | 3.28 |
| Rental rate | 0.02 | 0.15 | -0.03 | -0.10 | 0.59 | 0.37 |

Table 9: Decomposition of effects of country-specific model inputs
Notes: The changes are implemented incrementally across columns moving from left to right in the table. The changes reported in each row sum to one, i.e., to the full relative change between the considered country and the benchmark country Germany. See further description in the main text.

## C.5 Decomposition of the effects of country-specific model inputs

We decompose how differences in model inputs across countries influence key model predictions reported in Table 3. Table 9 displays the decomposition for France, Italy and Spain relative to Germany, for the three key model predictions on housing wealth, net worth and the housing rental rate. Each column displays the change in the target statistics, resulting from the additional implemented change of the model input mentioned in the header of the respective column, *relative to* the total difference in the model prediction for the considered country compared with the German benchmark. Thus, the sum across the columns of Table 9 equals one.[42]

The changes are implemented incrementally and, as is well known, the sequence matters for the precise quantitative contribution that is attributed to each change of model input for the respective predicted statistic. The main point of these tables is thus to provide an indication for the order of magnitude with which a certain country-specific model input affects the model predictions. We comment on the results at the end of Section 3 of the main text.

[42]The decomposition for the model predictions on the fraction of homeowners with debt or the LTV ratio is less insightful because, for some of the countries, there is not much of a difference in the model prediction for these statistics relative to the German benchmark.

## C.6 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 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, non-mortgage 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 dataset 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, i.e., this variable shows for which households housing wealth is positive. The *rental rate* 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.

# D The role of the interest spread in the life-cycle model with housing

It is instructive to comment on the role of the interest spread in our model. It is well known, at least since Kaplan and Violante (2014), that agents can have high marginal propensities to consume because of an interest spread, even if the borrowing constraint is not binding. If shocks are not large enough to make adjustment of the illiquid asset optimal, non-adjusting agents with illiquid wealth and an intertemporal marginal rate of substitution between the interest factor implied by the borrowing and lending rate behave as (wealthy) hand-to-mouth consumers. Analogously, agents without illiquid wealth behave as hand-to-mouth consumers if the spread makes it optimal for them not to change their position of zero liquid wealth after a shock.

It is important to emphasize that the consolidation of balance sheets, required for consistency of the data and our model, implies a different interpretation of the spread and the corresponding incidence of households with zero *other wealth*, which is liquid in our model. Kaplan et al. (2018) and Kaplan et al. (2014) consolidate housing wealth and mortgage liabilities to home equity as part of their illiquid wealth position so that negative liquid wealth has the interpretation of unsecured debt. The standard portfolio choice model, in which the house (not home equity) is a consumption good, an asset and serves as collateral, requires a different consolidation in a two-asset portfolio choice setting.[43] Other wealth besides housing wealth then is the consolidated position of all other assets and liabilities. A negative value of this position then typically implies secured mortgage debt for homeowners.

Not only does the different consolidation call for a calibration of a smaller spread, as noted in footnote 20 in the main text, also the interpretation and the economic implications of the incidence of zero other wealth for homeowners are different. Such homeowners have either amortized their mortgage or hold gross positions of other assets of the same value as the mortgage so that their net worth equals their housing wealth. Homeowners with such portfolio positions tend to be older, i.e., at later stages in their life cycle, and richer and thus can more easily afford to pay adjustment costs to avoid the illiquidity and higher volatility of the marginal utility of consumption implied by the interest spread.

Let us elaborate on the interaction between adjustment costs and the interest spread in our setting compared with the literature. A key difference relative to models with an asset consolidation as in Kaplan et al. (2018) is that, in our model, the *housing asset* is

[43] Extending the dimensionality of the portfolio choice problem by allowing for a third continuous endogenous state variable has proven prohibitively costly computationally so far. Such an extension would allow to distinguish features, such as liquidity, of assets and liabilities consolidated in the *other wealth* position.

illiquid but *home equity* is not. Households in our model can adjust their debt position and thus home equity without cost by changing their position in other wealth to finance consumption. Because of the spread, an adjustment of the position in other wealth may not be optimal if other wealth is zero. Net worth then contains no liquid resources so that households in these circumstances bear more consumption risk because adjusting the housing asset is costly. Home equity in our model thus becomes illiquid as in Kaplan et al. (2018) only when the interest spread implies that it is optimal to hold zero other wealth because the intertemporal marginal rate of substitution of consumption is between the interest factor implied by the borrowing and lending rate.

Agents can avoid this situation *ex ante* by adjusting the housing asset to prevent other wealth from being zero. The costs in terms of marginal utility for paying the adjustment costs can be smoothed intertemporally. This behavior of homeowners is analogous to standard quantitative models with occasionally binding constraints in which agents take precautions to avoid that these constraints bind and thus distort their intertemporal consumption profile. The finding that the incidence of the constraints is low *ex post* does not imply that the constraints do not matter *ex ante*. In particular, the low incidence of zero holdings of other wealth for homeowners does not imply that the interest spread is not important quantitatively for consumption responses and accumulation behavior.[44]

We find that the incidence of agents with zero other wealth is small for homeowners. Only 0.5% of the synthetic model-generated sample are homeowners with zero other wealth. The incidence of zero other wealth is higher for renters. 2% of the sample are renters with zero other wealth in France, 2.6% in Italy, 3.8% in Spain and 5% in Germany.[45] The heterogeneity across countries is determined by two main forces: the incidence of renters in the population which is higher in Germany and France than in Italy and Spain; and the extent of household borrowing which is somewhat higher in Spain and Germany compared with France and Italy.

Note that, for renters, the position of other wealth in terms of our model corresponds to net worth given that renters have no housing asset. Homeowners in the considered

[44]Kaplan et al. (2014) illustrate how the higher return of the illiquid asset makes it optimal *ex ante* to choose portfolios that imply wealthy hand-to-mouth behavior *ex post* of agents who hold zero liquid assets due to the interest spread. Agents are willing to bear more consumption risk because of the higher return to illiquid home equity. Our findings illustrate that the interest spread may imply less illiquidity *ex post* if only the housing asset is costly to adjust but not the associated mortgage liability. Intuitively, the utility cost conditional on being illiquid *ex post* changes as well as the gain of avoiding such illiquidity *ex ante*. In future research, we plan to investigate further the economic implications of different modeling assumptions for the illiquidity of home equity, which are related to the consolidation of assets in portfolio choice models. Such a detailed comparison is not essential for the research question in this paper, which requires a consolidation of the balance sheet that distinguishes housing and the associated mortgage liabilities.

[45]When computing these statistics based on the simulated data, we consider other wealth to be zero if it lies within the interval $[-500; 500]$ in terms of euro in adult equivalents. We also choose a fine grid of the auxiliary state variable $x$, defined in Appendix A, implying differences between gridpoints of at most $1,000$ for values of $x$ up to $200,000$.

countries typically have positive net worth because the relatively conservative maximum LTV ratios, particularly relative to Anglo-Saxon countries, imply positive home equity. Thus, we can benchmark the incidence of renters with non-positive net worth to the fraction of households with non-positive net worth in the HFCS. As reported by Kaplan et al. (2014), Table 2, the fraction is between 5−8% for the considered countries in the first wave of the HFCS. Our model predicts 6% for France, 8% for Italy, 9% for Spain and 21% for Germany. By and large the model predictions correspond to the incidence of poor hand-to-mouth households reported between 4 – 12% for the considered countries in Slacalek et al. (2020), Figure 1.

For Germany, our model predicts an incidence that is 9 percentage points higher than reported in Slacalek et al. (2020) but this has to be put into perspective because (i) many German renters in the data only hold small positive amounts of net worth and (ii) renters can borrow at most four digit euro amounts in our model, to guarantee solvency in the presence of idiosyncratic income risk. Hence, the difference between the model prediction and the data in terms of net worth and thus the marginal propensities to consume is smaller for German households than the difference in the reported incidences above suggest. The difference implies that the quantitative finding of smaller consumption responses of households to changes of the interest rate or house prices in Germany, relative to the other euro area countries, may be understated.

# E Further results on the consumption responses

## E.1 Consumption response to changes in the real interest rate

### E.1.1 Asymmetry of the response

Figure 13 shows that the absolute size of the consumption response to an increase of the interest rate is quantitatively larger than the response to a decrease of the interest rate. See Figure 3 and the discussion in the main text.

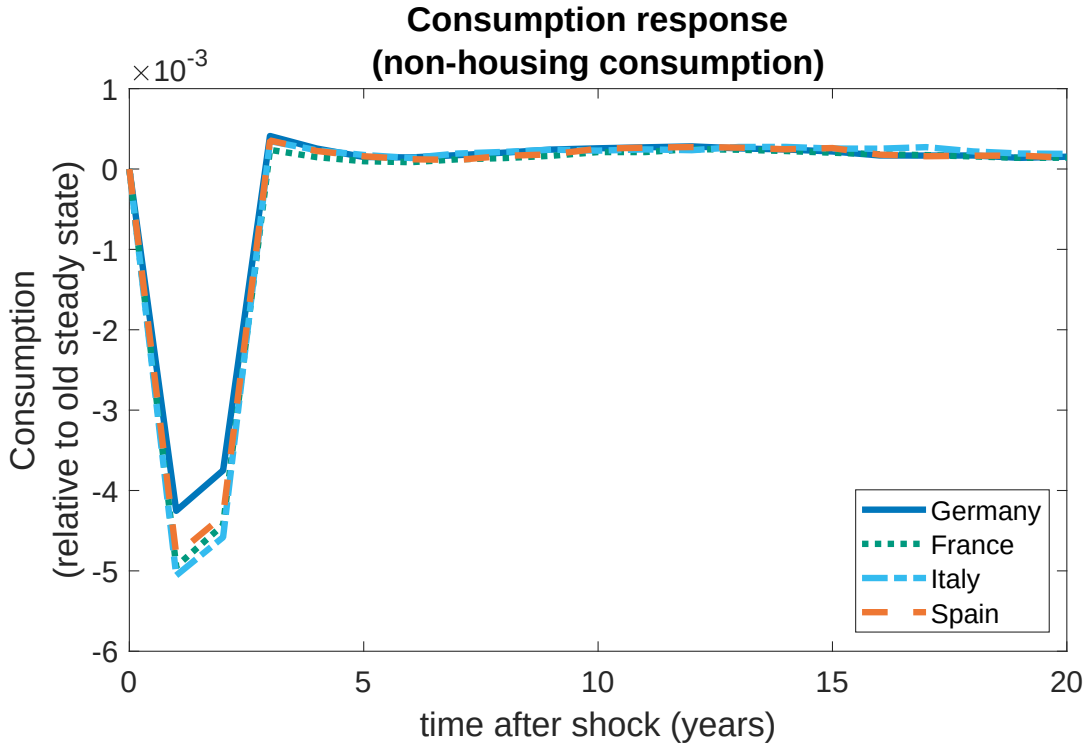



Figure 13: Unexpected increase of the real interest rate from 0.5% to 0.75% reversed after two years, without pass-through to the rent-to-price ratio

### E.1.2 Full pass-through to the rent-price ratio

Figure 14 shows that, with a full pass-through to the rent-price ratio, the responses of non-housing consumption are larger than in the benchmark. The response is largest in France and smallest in Spain, which is at odds with empirical evidence. See the discussion in the main text.

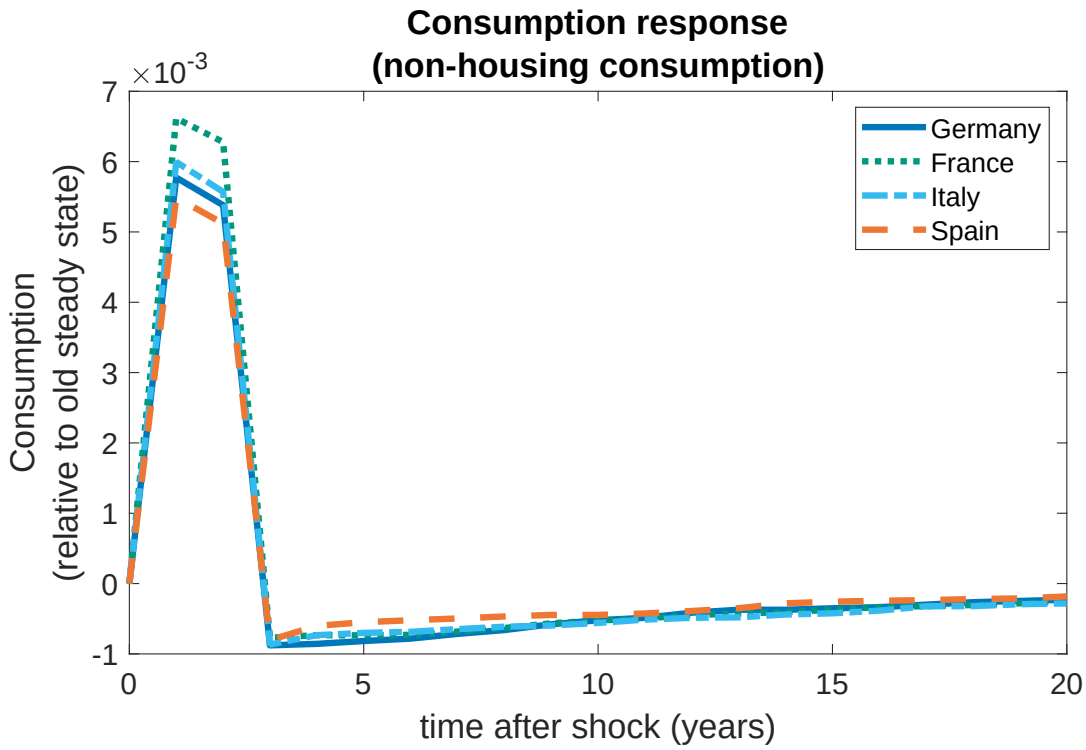



Figure 14: Unexpected fall of the real interest rate from 0.5% to 0.25% reversed after 2 years, with full pass-through to the rent-to-price ratio

## E.2 Results for France, Italy and Spain on the heterogeneity of the consumption response after a fall in the interest rate

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = 0.0038 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | 0.0036 | 0.16 | 0.19 | 0.0007 |
| Ages 35 – 44 | 0.0021 | 0.22 | 0.24 | 0.0005 |
| Ages 45 – 54 | 0.0036 | 0.22 | 0.22 | 0.0008 |
| Ages 55 – 64 | 0.0053 | 0.23 | 0.21 | 0.0011 |
| Ages 65 – 74 | 0.0055 | 0.16 | 0.12 | 0.0007 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | 0.0053 | 0.25 | 0.22 | 0.0012 |
| Percentiles 25 – 50 | -0.0008 | 0.25 | 0.23 | -0.0002 |
| Percentiles 50 – 75 | 0.0047 | 0.25 | 0.25 | 0.0012 |
| Percentiles 75 – 90 | 0.0058 | 0.15 | 0.16 | 0.0010 |
| Percentiles 90 – 95 | 0.0054 | 0.05 | 0.06 | 0.0003 |
| Percentiles 95 – 99 | 0.0050 | 0.04 | 0.06 | 0.0003 |
| Percentiles 99 – 99.9 | 0.0046 | 0.009 | 0.016 | 0.0001 |
| Percentiles 99.9 – 100 | 0.0052 | 0.001 | 0.003 | 0.0000 |
| *Composition of impact response across housing-tenure types* | | | | |
| *Homeowners* | 0.0060 | 0.60 | 0.62 | 0.0037 |
| ... with positive assets | 0.0056 | 0.40 | 0.42 | 0.0023 |
| ... with debt | 0.0068 | 0.20 | 0.20 | 0.0013 |
| *Renters* | 0.0004 | 0.40 | 0.38 | 0.0001 |
| ... with positive assets | 0.0001 | 0.35 | 0.35 | 0.0000 |
| ... with non-positive assets | 0.0029 | 0.05 | 0.03 | 0.0001 |

Table 10: France: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 4.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = 0.0043 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | 0.0029 | 0.09 | 0.11 | 0.0003 |
| Ages 35 – 44 | 0.0037 | 0.23 | 0.25 | 0.0009 |
| Ages 45 – 54 | 0.0041 | 0.25 | 0.26 | 0.0011 |
| Ages 55 – 64 | 0.0051 | 0.21 | 0.20 | 0.0010 |
| Ages 65 – 74 | 0.0054 | 0.20 | 0.17 | 0.0009 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | 0.0038 | 0.25 | 0.18 | 0.0007 |
| Percentiles 25 – 50 | 0.0017 | 0.25 | 0.22 | 0.0004 |
| Percentiles 50 – 75 | 0.0056 | 0.25 | 0.26 | 0.0015 |
| Percentiles 75 – 90 | 0.0055 | 0.15 | 0.18 | 0.0010 |
| Percentiles 90 – 95 | 0.0054 | 0.05 | 0.07 | 0.0004 |
| Percentiles 95 – 99 | 0.0050 | 0.04 | 0.06 | 0.0003 |
| Percentiles 99 – 99.9 | 0.0044 | 0.009 | 0.018 | 0.0001 |
| Percentiles 99.9 – 100 | 0.0044 | 0.001 | 0.004 | 0.0000 |
| *Composition of impact response across housing-tenure types* | | | | |
| *Homeowners* | 0.0057 | 0.71 | 0.76 | 0.0043 |
| ... with positive assets | 0.0052 | 0.46 | 0.53 | 0.0028 |
| ... with debt | 0.0068 | 0.25 | 0.23 | 0.0016 |
| *Renters* | -0.0001 | 0.29 | 0.24 | -0.0000 |
| ... with positive assets | -0.0006 | 0.23 | 0.21 | -0.0001 |
| ... with non-positive assets | 0.0031 | 0.06 | 0.03 | 0.0001 |

Table 11: Italy: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 4.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = 0.0043 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | 0.0028 | 0.12 | 0.13 | 0.0004 |
| Ages 35 – 44 | 0.0035 | 0.26 | 0.28 | 0.0010 |
| Ages 45 – 54 | 0.0045 | 0.25 | 0.26 | 0.0012 |
| Ages 55 – 64 | 0.0053 | 0.19 | 0.19 | 0.0010 |
| Ages 65 – 74 | 0.0052 | 0.17 | 0.14 | 0.0007 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | -0.0013 | 0.25 | 0.17 | -0.0002 |
| Percentiles 25 – 50 | 0.0061 | 0.25 | 0.22 | 0.0013 |
| Percentiles 50 – 75 | 0.0051 | 0.25 | 0.27 | 0.0014 |
| Percentiles 75 – 90 | 0.0053 | 0.15 | 0.18 | 0.0010 |
| Percentiles 90 – 95 | 0.0052 | 0.05 | 0.07 | 0.0004 |
| Percentiles 95 – 99 | 0.0048 | 0.04 | 0.06 | 0.0003 |
| Percentiles 99 – 99.9 | 0.0041 | 0.009 | 0.019 | 0.0001 |
| Percentiles 99.9 – 100 | 0.0034 | 0.001 | 0.004 | 0.0000 |
| *Composition of impact response across housing-tenure types* | | | | |
| *Homeowners* | 0.0055 | 0.81 | 0.87 | 0.0048 |
| ... with positive assets | 0.0048 | 0.48 | 0.57 | 0.0027 |
| ... with debt | 0.0069 | 0.33 | 0.30 | 0.0021 |
| *Renters* | -0.0041 | 0.19 | 0.13 | -0.0005 |
| ... with positive assets | -0.0066 | 0.12 | 0.09 | -0.0006 |
| ... with non-positive assets | 0.0023 | 0.07 | 0.04 | 0.0001 |

Table 12: Spain: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 4.

## E.3 Consumption response to changes in the relative house price

### E.3.1 Asymmetry of the response?

Compared to Figure 10 for the consumption response to a drop in house prices, Figure 15 shows that an increase in the relative house price has quantitatively smaller effects. The asymmetry of the effects is rather small as discussed in the main text.

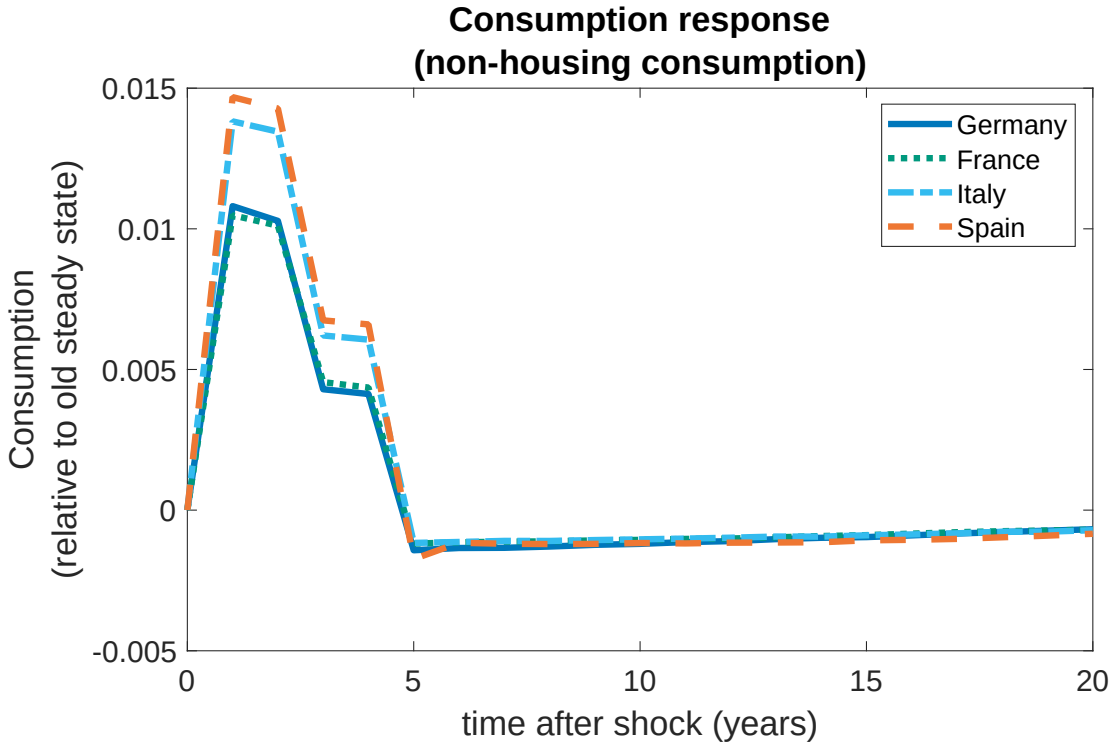



Figure 15: Unexpected increase of the relative house price by 10%, reversed in two steps within 4 years

## E.4 Results for France, Italy and Spain on the heterogeneity of the consumption response after a house price drop

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = −0.0113 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | -0.0030 | 0.16 | 0.19 | -0.0006 |
| Ages 35 – 44 | -0.0075 | 0.22 | 0.24 | -0.0018 |
| Ages 45 – 54 | -0.0129 | 0.22 | 0.22 | -0.0028 |
| Ages 55 – 64 | -0.0167 | 0.23 | 0.21 | -0.0035 |
| Ages 65 – 74 | -0.0192 | 0.16 | 0.12 | -0.0024 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | -0.0001 | 0.25 | 0.22 | -0.0000 |
| Percentiles 25 – 50 | -0.0050 | 0.25 | 0.23 | -0.0011 |
| Percentiles 50 – 75 | -0.0164 | 0.25 | 0.25 | -0.0041 |
| Percentiles 75 – 90 | -0.0198 | 0.15 | 0.16 | -0.0033 |
| Percentiles 90 – 95 | -0.0200 | 0.05 | 0.06 | -0.0012 |
| Percentiles 95 – 99 | -0.0202 | 0.04 | 0.06 | -0.0011 |
| Percentiles 99 – 99.9 | -0.0223 | 0.009 | 0.016 | -0.0004 |
| Percentiles 99.9 – 100 | -0.0278 | 0.001 | 0.003 | -0.0001 |
| *Composition of impact response across financial positions of homeowners* | | | | |
| *Homeowners* | -0.0184 | 0.60 | 0.62 | -0.0113 |
| ... with positive assets | -0.0201 | 0.40 | 0.42 | -0.0084 |
| ... with non-positive assets | -0.0148 | 0.20 | 0.20 | -0.0029 |

Table 13: France: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 5.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = −0.0151 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | -0.0090 | 0.09 | 0.11 | -0.0009 |
| Ages 35 – 44 | -0.0127 | 0.23 | 0.25 | -0.0032 |
| Ages 45 – 54 | -0.0151 | 0.25 | 0.26 | -0.0039 |
| Ages 55 – 64 | -0.0175 | 0.21 | 0.20 | -0.0035 |
| Ages 65 – 74 | -0.0192 | 0.20 | 0.17 | -0.0032 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | -0.0004 | 0.25 | 0.18 | -0.0001 |
| Percentiles 25 – 50 | -0.0127 | 0.25 | 0.22 | -0.0028 |
| Percentiles 50 – 75 | -0.0194 | 0.25 | 0.26 | -0.0051 |
| Percentiles 75 – 90 | -0.0214 | 0.15 | 0.18 | -0.0039 |
| Percentiles 90 – 95 | -0.0212 | 0.05 | 0.07 | -0.0015 |
| Percentiles 95 – 99 | -0.0216 | 0.04 | 0.06 | -0.0013 |
| Percentiles 99 – 99.9 | -0.0214 | 0.009 | 0.018 | -0.0004 |
| Percentiles 99.9 – 100 | -0.0291 | 0.001 | 0.004 | -0.0001 |
| *Composition of impact response across financial positions of homeowners* | | | | |
| *Homeowners* | -0.0198 | 0.71 | 0.76 | -0.0151 |
| ... with positive assets | -0.0214 | 0.46 | 0.53 | -0.0113 |
| ... with non-positive assets | -0.0163 | 0.25 | 0.23 | -0.0038 |

Table 14: Italy: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 5.

| Group | Consumption response of group | Share of group | Consumption share of group | Contribution of group to aggregate consumption response |
|---|---|---|---|---|
| *Aggregate response on impact* = −0.0170 | | | | |
| *Composition of impact response across age groups* | | | | |
| Ages 25 – 34 | -0.0156 | 0.12 | 0.13 | -0.0020 |
| Ages 35 – 44 | -0.0178 | 0.26 | 0.28 | -0.0050 |
| Ages 45 – 54 | -0.0179 | 0.25 | 0.26 | -0.0046 |
| Ages 55 – 64 | -0.0162 | 0.19 | 0.19 | -0.0030 |
| Ages 65 – 74 | -0.0164 | 0.17 | 0.14 | -0.0023 |
| *Composition of impact response across net-worth distribution* | | | | |
| Percentiles 0 – 25 | -0.0127 | 0.25 | 0.17 | -0.0021 |
| Percentiles 25 – 50 | -0.0186 | 0.25 | 0.22 | -0.0041 |
| Percentiles 50 – 75 | -0.0177 | 0.25 | 0.27 | -0.0047 |
| Percentiles 75 – 90 | -0.0173 | 0.15 | 0.18 | -0.0032 |
| Percentiles 90 – 95 | -0.0179 | 0.05 | 0.07 | -0.0013 |
| Percentiles 95 – 99 | -0.0180 | 0.04 | 0.06 | -0.0012 |
| Percentiles 99 – 99.9 | -0.0190 | 0.009 | 0.019 | -0.0004 |
| Percentiles 99.9 – 100 | -0.0210 | 0.001 | 0.004 | -0.0001 |
| *Composition of impact response across financial positions of homeowners* | | | | |
| *Homeowners* | -0.0196 | 0.81 | 0.87 | -0.0170 |
| ... with positive assets | -0.0185 | 0.48 | 0.57 | -0.0105 |
| ... with non-positive assets | -0.0216 | 0.33 | 0.30 | -0.0065 |

Table 15: Spain: heterogeneity of the (non-housing) consumption response across households. Notes: see notes of Table 5.

# References


Adam, K. and Tzamourani, P. (2016). Distributional Consequences of Asset Price Inflation in the Euro Area. *European Economic Review*, 89(C):172–192.

Adam, K. and Zhu, J. (2016). Price-Level Changes and the Redistribution of Nominal Wealth across the Euro Area. *Journal of the European Economic Association*, 14(4):871–906.

Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R., and Ragusa, G. (2019). Measuring Euro Area Monetary Policy. *Journal of Monetary Economics*, 108(C):162–179.

Arrondel, L., Bartiloro, L., Fessler, P., Lindner, P., Mathä, T. Y., Rampazzi, C., Savignac, F., Schmidt, T., Schürz, M., and Vermeulen, P. (2016). How Do Households Allocate Their Assets? Stylized Facts from the Eurosystem Household Finance and Consumption Survey. *International Journal of Central Banking*, 12(2):129–220.

Auclert, A. (2019). Monetary Policy and the Redistribution Channel. *American Economic Review*, 109(6):2333–2367.

Beraja, M., Fuster, A., Hurst, E., and Vavra, J. (2018). Regional Heterogeneity and the Refinancing Channel of Monetary Policy. *Quarterly Journal of Economics*, 133:109–183.

Berger, D., Guerrieri, V., Lorenzoni, G., and Vavra, J. (2018a). House Prices and Consumer Spending. *Review of Economic Studies*, 85:1502–1542.

Berger, D. W., Milbradt, K., Tourre, F., and Vavra, J. (2018b). Mortgage Prepayment and Path-Dependent Effects of Monetary Policy. *NBER Working Paper No. 25157*.

Blomhoff Holm, M., Paul, P., and Tischbirek, A. (2021). The Transmission of Monetary Policy under the Microscope. *Journal of Political Economy*.

Bover, O., Casado, J. M., Costa, S., Caju, P. D., McCarthy, Y., Sierminska, E., Tzamourani, P., Villanueva, E., and Zavadil, T. (2016). The Distribution of Debt across Euro-Area Countries: The Role of Individual Characteristics, Institutions, and Credit Conditions. *International Journal of Central Banking*, 12(2):71–128.

Calza, A., Monacelli, T., and Stracca, L. (2013). Housing Finance and Monetary Policy. *Journal of the European Economic Association*, 11:101–122.

Carroll, C., Slacalek, J., Tokuoka, K., and White, M. N. (2017). The distribution of wealth and the marginal propensity to consume. *Quantitative Economics*, 8(3):977–1020.

Christelis, D., Georgarakos, D., and Haliassos, M. (2013). Differences in Portfolios across Countries: Economic Environment versus Household Characteristics. *The Review of Economics and Statistics*, 95(1):220–236.

Cloyne, J., Ferreira, C., and Surico, P. (2020). Monetary Policy when Households have Debt: New Evidence on the Transmission Mechanism. *Review of Economic Studies*, 87(1):102–129.

Corsetti, G., Duarte, J. B., and Mann, S. (2018). One Money, Many Markets: A Factor Model Approach to Monetary Policy in the Euro Area with High-Frequency Identication. Working paper, Mimeograph.

Corsetti, G., Duarte, J. B., and Mann, S. (2021). One Money, Many Markets: Monetary Transmission and Housing Financing in the Euro Area. *Journal of the European Economic Association*.

Diaz, A. and Luengo-Prado, M. J. (2008). On the User Cost and Homeownership. *Review of Economic Dynamics*, 11(3):584–613.

Doepke, M. and Schneider, M. (2006). Inflation and the Redistribution of Nominal Wealth. *Journal of Political Economy*, 114(6):1069–1097.

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

Eichenbaum, M., Rebelo, S., and Wong, A. (2018). State Dependent Effects of Monetary Policy: the Refinancing Channel. *NBER Working Paper No. 25152*.

Eurosystem Household Finance and Consumption Network (2013a). The Eurosystem Household Finance and Consumption Survey - Methodological Report. Statistics Paper Series 1, European Central Bank.

Eurosystem Household Finance and Consumption Network (2013b). The Eurosystem Household Finance and Consumption Survey - Results from the First Wave. Statistics Paper Series 2, European Central Bank.

Fernández-Villaverde, J. and Krueger, D. (2007). Consumption over the Life Cycle: Facts from Consumer Expenditure Survey Data. *The Review of Economics and Statistics*, 89(3):552–565.

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

Greenwald, D. L. and Guren, A. (2021). Do Credit Conditions Move House Prices? Manuscript, Boston University.

Guerrieri, V., Lorenzoni, G., and Prato, M. (2020). Slow Household Deleveraging. *Journal of the European Economic Association*, 18(6):2755–2775.

Guiso, L., Haliassos, M., and Jappelli, T. (2003). Household Stockholding in Europe: Where Do We Stand and Where Do We Go? *Economic Policy*, 18(36):123–170.

Guiso, L., Sapienza, P., and Zingales, L. (2004). Does Local Financial Development Matter? *Quarterly Journal of Economics*, 119(3):929–969.

Guren, A. M., McKay, A., Nakamura, E., and Steinsson, J. (2021). Housing Wealth Effects: the Long View. *Review of Economic Studies*, 88(2):669–707.

Guvenen, F., Kuruscu, B., and Ozkan, S. (2014). Taxation of Human Capital and Wage Inequality: A Cross-Country Analysis. *Review of Economic Studies*, 81(2):818–850.

Hintermaier, T. and Koeniger, W. (2010). The Method of Endogenous Gridpoints with Occasionally Binding Constraints among Endogenous Variables. *Journal of Economic Dynamics and Control*, 34(10):2074–2088.

Hintermaier, T. and Koeniger, W. (2011). On the Evolution of the US Consumer Wealth Distribution. *Review of Economic Dynamics*, 14(2):317–338.

Hintermaier, T. and Koeniger, W. (2019). Differences in Euro-Area Household Finances and their Relevance for Monetary-Policy Transmission. IZA Discussion Papers No. 12743, IZA.

Iskhakov, F., Jørgensen, T. H., Rust, J., and Schjerning, B. (2017). The Endogenous Grid Method for Discrete-Continuous Dynamic Choice Models with (or without) Taste Shocks. *Quantitative Economics*, 8(2):317–365.

Jappelli, T. and Pistaferri, L. (2010). Does Consumption Inequality Track Income Inequality in Italy? *Review of Economic Dynamics*, 13(1):133–153.

Jappelli, T. and Scognamiglio, A. (2018). Monetary Policy, Mortgages and Consumption: Evidence from Italy. *Economic Policy*, 33:183–224.

Kaas, L., Korchakov, G., Preugschat, E., and Siassi, N. (2021). Low Homeownership in Germany: a Quantitative Exploration. *Journal of the European Economic Association*.

Kaplan, G., Mitman, K., and Violante, G. L. (2020a). Non-Durable Consumption and Housing Net Worth in the Great Recession: Evidence from Easily Accessible Data. *Journal of Public Economics*, 189(C).

Kaplan, G., Mitman, K., and Violante, G. L. (2020b). The Housing Boom and Bust: Model Meets Evidence. *Journal of Political Economy*, 128:3285–3345.

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

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

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

Kindermann, F. and Kohls, S. (2018). Rental Markets and Wealth Inequality in the Euro-Area. Working paper, Mimeograph.

Koeniger, W., Lennartz, B., and Ramelet, M.-A. (2021). On the Transmission of Monetary Policy to the Housing Market. SNB Working Paper No. 06/2021, SNB.

Landvoigt, T., Piazzesi, M., and Schneider, M. (2015). The Housing Market(s) of San Diego. *American Economic Review*, 105(4):1371–1407.

Lennartz, B. (2021). The Consumption Effects of House Price Changes: Evidence from Italy. Manuscript, University of St.Gallen.

McKay, A., Nakamura, E., and Steinsson, J. (2016). The Power of Forward Guidance Revisited. *American Economic Review*, 106(10):3133–3158.

McKay, A. and Wieland, J. F. (2021a). Forward Guidance and Durable Goods Demand. *American Economic Review: Insights*.

McKay, A. and Wieland, J. F. (2021b). Lumpy Durable Consumption Demand and the Limited Ammunition of Monetary Policy. *Econometrica*, 89(6):2717–2749.

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

Mian, A. and Sufi, A. (2011). House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis. *American Economic Review*, 101(5):2132 – 2156.

OECD (2007). *Pensions at a Glance*. OECD.

Pessoa, A. S. (2021). Earnings Dynamics in Germany. CESifo Working Paper Series 9117, CESifo.

Pham-Dao, L. (2019). Public Insurance as a Driver of Wealth Inequality in the Euro Area. Working paper, Mimeograph.

Piazzesi, M. and Schneider, M. (2016). Housing and Macroeconomics. In *Handbook of Macroeconomics*, volume 2, pages 1547–1640. Elsevier.

Pijoan-Mas, J. and Sanchez-Marcos, V. (2010). Spain is Different: Falling Trends of Inequality. *Review of Economic Dynamics*, 13(1):154–178.

Slacalek, J., Tristani, O., and Violante, G. L. (2020). Household Balance Sheet Channels of Monetary Policy: a Back of the Envelope Calculation for the Euro Area. *Journal of Economic Dynamics and Control*, 115(103879).

Werning, I. (2015). Incomplete Markets and Aggregate Demand. Mimeograph, MIT.

Wong, A. (2019). Refinancing and the Transmission of Monetary Policy to Consumption. Working paper, Mimeograph.