

Differences in Euro-Area Household Finances and their Relevance for Monetary-Policy Transmission ^{*}

Thomas Hintermaier^a
(University of Bonn)

Winfried Koeniger^b
(University of St.Gallen, CESifo, CFS, IZA)

February 14, 2018
Preliminary and Incomplete

Abstract

This paper quantifies the extent of heterogeneity in consumption responses to changes in real interest rates and relative house prices in the four largest economies in the euro area: France, Germany, Italy and Spain. We first calibrate a life-cycle incomplete-markets model with a liquid financial asset and illiquid housing to match the large heterogeneity of households asset portfolios, observed in the Household Finance and Consumption Survey (HFCS) for these countries. We then show that the heterogeneity in household finances implies that responses of non-housing consumption to changes in the real interest rate and in house prices differ substantially across the analyzed countries, and across age groups within these countries. The different consumption responses to changes in the real interest rate point towards important heterogeneity in monetary-policy transmission within the euro area.

Keywords: European household portfolios, consumption, monetary policy transmission, international comparative finance, housing.

JEL-codes: D14, D15, D31, E21, E43, G11

^{*}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.

a: University of Bonn, Adenauerallee 24–42, 53113 Bonn, Germany, thomas.hintermaier@uni-bonn.de;

b: University of St.Gallen, Varnbuelstrasse 14, 9000 St.Gallen, Switzerland, winfried.koeniger@unisg.ch.

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 illiquid housing assets which are costly to adjust.

This paper analyzes the consequences of the observed differences in household portfolios for the responses of non-housing consumption to changes in the real interest rate and relative house prices. To the best of our knowledge, we are the first to quantify the effect of household finances on these responses for the euro area.

The size of the *consumption response to changes in the real interest rate* is crucial for monetary-policy transmission in the canonical New-Keynesian representative-agent model. In this workhorse model for monetary-policy analysis, a change in the nominal policy rate set by a central bank changes the real interest rate due to price rigidities. The consumption Euler equation then implies intertemporal substitution of consumption.

We inspect the transmission from changes in the real interest rate to non-housing consumption in more detail by using a life-cycle incomplete-markets model. This model generates heterogeneity across households, in particular in terms of household finances, which is central to the analysis in this paper. We find that the non-housing consumption responses to changes in the real interest rate, implied by the model, are quite different across euro-area countries. A decrease of the real interest rate from 3% to 2% increases non-housing consumption by 1 percentage point more in Spain than in France. The cross-country differences in consumption responses are magnified if the decrease in the real interest rate is accompanied by an increase in the relative price for housing.¹ These results point to heterogeneity in monetary-policy transmission across the euro area and expose the limits of a uniform monetary policy across the euro area. The results suggest that there is scope for complementing monetary policy with country-specific fiscal policy. Such coordination between monetary and fiscal policy may also help to address the distributional effects across age groups that we find for each of the analyzed euro-area countries.

The size of the *consumption responses to changes in the relative 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 relative house-price change between 0.14 for Germany

¹We plan to decompose the differences in these responses so that we can quantify to which extent these differences are explained by differences in household portfolios.

	Germany	France	Italy	Spain
<i>Wealth composition</i>				
Housing wealth (main residence)	66,655	92,192	117,298	116,016
+ Financial assets	83,250	81,506	69,261	76,839
= Net worth	149,905	173,698	186,559	192,855
Rental rate (percent)	53.6	41.7	32.1	17.2
Labor income (incl. transfers)	24,596	20,731	19,011	15,854

Table 1: Household finances in the euro area

Notes: Means for households aged 26-75. Units for wealth and income are euro per adult equivalents.

Source: Authors' calculation based on the first wave of the Household Finance and Consumption Survey (HFCS), 2007–2010.

and 0.23 for Spain. These elasticities are quite similar to the model-implied elasticity of 0.2 in Kaplan et al. (2017) for the U.S. but below the range of empirical estimates for the U.S. of 0.25 to 0.4 obtained in Kaplan et al. (2016a) or 0.6 to 0.8 in Mian et al. (2013).

We use a model for computing the consumption responses to price changes because the Household Finance and Consumption Survey (HFCS) contains very detailed information on household balance sheets but only information on food consumption. Furthermore, the HFCS is a recent survey for the euro area whose structure largely follows the Survey of Consumer Finances (SCF) in the U.S. The HFCS currently only has two waves so that its panel component is still quite limited and empirical estimation of consumption responses would be problematic. Our approach is thus to set up a model that captures the observed heterogeneity in household finances, on which we have detailed data, and then infer the consumption responses to price changes from that model.

Our analysis proceeds in the following steps. In Section 2, we model households' portfolio choice of a liquid financial asset and a illiquid housing asset. We use a life-cycle incomplete-markets model to capture key dimensions of heterogeneity observed in the HFCS for euro-area countries. Our model solution allows for continuous portfolio choices to accurately capture the portfolio positions for the liquid financial asset and illiquid housing, which is 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 ensures that we match the observed means for financial assets, housing and the rental rate (defined as 1 - home ownership 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 good examples for

the observed heterogeneity in household finances across the euro area.

In Section 4, we then compute the non-housing consumption response after an unexpected change in the real interest rate or the relative house price for these four countries. We quantify the responses for different scenarios, in some of which we allow both the real interest rate and the relative house prices to change jointly.

1.1 Related literature

Below is a list of recent papers that are most closely related to our work.

- Consumption response to changes in the interest rate in the U.S.: Auclert (2017), Cloyne et al. (2015), Kaplan et al. (2016b),
- Consumption response to changes in house prices in the U.S.: Berger et al. (2015), Kaplan et al. (2017), Mian and Sufi (2011), Mian et al. (2013).
- Marginal propensity to consume across the wealth distribution: e.g., Carroll et al. (2017)
- Monetary policy, inequality and heterogeneity: e.g., Coibion et al. (2012), Hedlund et al. (2016)
- Regional heterogeneity in U.S. household finances and monetary-policy transmission: Beraja et al. (2017)
- Differences in euro-area household finances: e.g., Kaas et al. (2017), Kindermann and Kohls (2016), Pham-Dao (2016)

2 The common reference model

The model we use for our analysis is an instance of the common reference model for European household finances suggested by Hintermaier and Koeniger (2016). Our description here is organized according to the generic structure proposed there. This section describes all building blocks of the model and its features. 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.

Preferences

This building block specifies the time horizon and the preferences over consumption streams. The relevant consumption items for our analysis are nondurable consumption

and housing services obtained by choosing either to own or to rent housing. We use a life-cycle model with J periods, indexed by $j = 1, \dots, J$. Households maximize their expected utility over the life cycle. Expected lifetime utility is

$$\mathbb{E}_0 \left[\sum_{j=1}^J \beta^{j-1} \sigma_j u(c_j, \hat{s}_j) \right]$$

with β denoting the discount factor, σ_j the probability of surviving up to age j and c_j the nondurable consumption at age j . The flow of housing services for owners of a house of size 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

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

We assume a utility function that is log-separable in non-housing consumption and housing services:

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

Earnings and Portfolio items

For the purpose of introducing the model, it is useful to present these two building blocks jointly. They are visible in the following budget constraints, relying on the previously mentioned distinction of renters and homeowners.

An important difference between rented and owned housing is that the quantity of owned housing can only be adjusted at a cost. To generate inaction ranges and lumpy adjustment patterns, we specify an adjustment cost function that has a fixed-cost component² (needed for lumpiness) and a variable component that is proportional to the stock sold or bought with p_t denoting the relative price of housing:

$$\alpha_{p,j}(\hat{h}_j, \hat{h}_{j+1}) = \alpha_{0,j} + \alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1},$$

if the household adjusts to a new quantity of owned housing at age j , coded in terms of

²Allowing for age-dependence of the fixed cost component $\alpha_{0,j}$ is useful for situations with real income growth over calendar time. The adjustment of fixed costs over the individual life-cycle is made to simultaneously achieve the following properties in the model: First, we want to assure that individuals from different birth cohorts face the same terms when they are active on a market at a specific point in calendar time. Second, we want to assure that a single solution of the individual life-cycle choice problem is applicable to members of any cohort, independently of the time of birth. Our approach ensures that both of these properties are obtained, once the problem is considered as normalized by different units of account across cohorts.

a discrete decision as $d_j = 1$. This cost structure is motivated by two components: $\alpha_1 p_t \hat{h}_j$ from selling $\hat{h}_j$, and $\alpha_{0,j} + \alpha_2 p_t \hat{h}_{j+1}$ from purchasing $\hat{h}_{j+1}$. In any situation where a household decides to adjust his 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 decides not to adjust the existing quantity of owned housing, coded as $d_j = 0$, he does not incur adjustment cost.

If the household decides to rent, coded as the discrete decision $d_j = 2$, 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 of renting versus owning, and of adjustment versus non-adjustment.

*If the household chooses to consume housing as an **owner, not adjusting** his housing stock, coded as $d_j = 0$, the following relations apply:*

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

and the budget constraint

$$c_j + a_{j+1} = y_j(s_j) + (1 + r)a_j.$$

Uncertainty of earnings 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 idiosyncratic (household-specific) realization of the Markov state at age j by s_j .

The budget constraint thus takes into account the exogenously given endowment of earnings $y_j(s_j)$ at age j , and the choice of financial assets a_{j+1} . 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 stochastic. The idiosyncratic background risk cannot be fully insured and thus matters for the life-cycle profile of asset accumulation. To accurately capture this effect, as further explained in Section 3, we will calibrate the earnings variables for each country and ob-

tain country-specific life-cycle profiles and risk resulting from country-specific features of pay-as-you-go pensions, taxation and social security.

Asset accumulation is also restricted by a collateral constraint that limits borrowing:

$$a_{j+1} \geq -\mu p_t \hat{h}_j - g_{y,j+1},$$

where the parameter μ represents the loan-to-value (LTV) ratio and we have used $\hat{h}_{j+1} = \hat{h}_j$ given that we consider the constraint for a household who does not adjust the housing stock. The parameter $g_{y,j+1}$ denotes those pledgeable resources which are not related to asset holdings.

If the household chooses to consume housing as an **owner, adjusting** his housing stock, coded as $d_j = 1$, the budget constraint becomes

$$c_j + a_{j+1} + p_t \hat{h}_{j+1} + \alpha_{p,j}(\hat{h}_j, \hat{h}_{j+1}) = y_j(s_j) + (1+r)a_j + p_t \hat{h}_j,$$

and the collateral constraint reads

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

Note that these expressions feature the items available for portfolio choice between the financial assets a_{j+1} and the housing asset h_{j+1} , as well as the financial constraint depending on these endogenously chosen portfolio positions.

If the household chooses to consume housing as a **renter**, coded as $d_j = 2$, the budget constraint reads

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

and the collateral constraint simplifies to

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

Rental prices are assumed to be in a constant relation to prices for ownership, which we describe by

$$q_t = k p_t,$$

where the constant fraction k is referred to as a *rent-to-price ratio*.

In Appendix A we explain how we solve this model based on its recursive formulation.

	Germany	France	Italy	Spain
<i>Preferences</i>				
β	0.9946	0.9992	0.9996	0.9965
θ	0.78	0.73	0.69	0.74
ϕ_R^{ret}	0.9	0.9	0.75	0.85
<i>Rent-to-price ratio</i>				
k	0.0348	0.0354	0.0353	0.0371
<i>Proportional transaction cost</i>				
α_2	0.075	0.08	0.085	0.105
<i>Life-cycle income process: age profile std.dev. of innovation</i>				
$\sigma_{innovation}$	0.23	0.18	0.23	0.20
<i>Pension and tax system Survival probabilities</i>				

Table 2: Country-specific calibrated parameters

Notes: For common parameters across countries see Table 4 in Appendix B.

3 Calibration

We calibrate the model to match the large differences in household finances across the euro area, documented in Table 1. As shown in Table 2, we allow for differences across countries in the pension and tax system, survival probabilities, labor-income profiles and labor-income risk, transaction costs for housing, rent-to-price ratios and three preference parameters. Table 4 in Appendix B documents all other parameters that are common across countries in the calibration.

The strategy of our calibration is to explain the differences in household finances as much as possible by differences in the economic environment that have a counterpart in our model. We then explain any remaining differences with a country fixed effect that is captured in the model by differences in the following preference parameters: the discount factor β , the weight of non-housing consumption in the consumption basket θ and the rental efficiency in retirement determined by the service-flow rate out of rental housing ϕ_R^{ret} .

We account for key differences in the economic environment that influence household finances by changing incentives for asset accumulation and portfolio choices, for example,

by altering the strength of the precautionary or retirement saving motives. 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).³ We compute 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.

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 marginal 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 net earnings by regressing the logarithm of net earnings on a quartic age polynomial.⁴ The assumption of a Markov chain 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. The values are broadly in line with findings reported in table 2 of Pham-Dao (2016) who reports estimates based on the EU-SILC dataset, and with the variances of (net) earnings based on national datasets reported by Fuchs-Schuendeln et al. (2010) for Germany, Jappelli and Pistaferri (2010) for Italy and Pijoan-Mas and Sanchez-Marcos (2010) for Spain.

We allow for 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.⁵ 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.

All other parameters in the model are set to common values across countries. Their values are summarized in Table 4 in Appendix B. The real interest rate is set to 3% and

³Pension 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.

⁴We convert the cross-sectional age profiles into life-cycle income profiles, accounting for cohort effects that result from average annual income growth of 1%.

⁵Kaas et al. (2017) emphasize the importance of transaction taxes to explain the lower home ownership rate in Germany compared to the U.S. Kindermann and Kohls (2016) 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.

	Germany		France		Italy		Spain	
	Data	Model	Data	Model	Data	Model	Data	Model
<i>Wealth composition</i>								
Housing wealth	66,655	67,168	92,192	92,330	117,298	117,142	116,016	115,853
+ Financial assets	83,250	83,437	81,506	81,973	69,261	69,990	76,839	76,565
= Net worth	149,905	150,605	173,698	174,064	186,559	187,132	192,855	192,418
Rental rate (percent)	53.6	53.8	41.7	41.5	32.1	31.5	17.2	17.4

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

we assume stable relative house prices. The maximal value of the loan-to-value ratio μ 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 $\mu^{ret} = 0.2$ during retirement. This shall capture that mortgage contracts typically feature substantial amortization payments 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.

The starting age in the model is age 24. Until retirement age 65, labor-income fluctuates stochastically around the deterministic age profile. Between ages 65 and age 85 agents receive a deterministic pension but have survival probabilities that are calibrated using mortality tables from Eurostat.⁶ These probabilities are available until age 85 so that we let agents die after reaching that age.

We simulate the model for 120,000 agents to compute model statistics. We draw from the initial distribution of net worth and housing wealth observed in the HFCS for households aged 20 to 30 and we draw the income shocks from the stationary distribution. We align the age composition across countries between the model and data by composing a synthetic survey for each country, based on the model solution and the weights for ages between 24 and 85 observed in the HFCS. When comparing the model with the data, we focus on agents between ages 26 and 75 because the predictions of the model become too sensitive to the certain death at age 85 for later ages. Agents between ages 26 and 75 account for 90% of the sample in the HFCS for the considered countries.

Table 3 shows that the model matches the averages of net worth, housing wealth and the rental rate very closely, given that we have complemented the key differences in the economic environment, that we have explained above, with some calibrated country-specific preference parameters and the rent-price ratio. Although the parameters are jointly calibrated, net worth is matched mostly by calibrating the discount factor β . The

⁶We use the mortality tables for the representative year 2009 which are available at <http://ec.europa.eu/eurostat/web/population-demography-migration-projections/deaths-life-expectancy-data/database>.

weight of non-housing consumption in the consumption basket θ allows to match the fraction of housing wealth in the portfolio and the rent-price ratio k helps to attain the targeted rental rate.

Table 2 shows that the model only requires notable differences in the preference parameter θ to match the country-specific data targets. The discount factor β and the rent-price ratio are rather similar across countries and the differences in ϕ_R^{ret} are relevant only for matching the age profiles of the rental rate, as we explain further below. Interestingly, the rent-price ratio implies values for its inverse, the price-rent ratio, between 27 and 29 across the four countries. These values are close to the empirical estimates for these countries reported in Kindermann and Kohls (2016), figure 29.⁷

Figures 1 to 4 show that the model predicts the age profiles of net worth, housing wealth, the rental rate and the loan-to-value ratio quite well. For Germany, the loan-to-value ratio decreases more quickly with age in the model than in the data and the opposite holds for Italy. But given that we are interested in consumption responses which depend on household leverage, it is encouraging to see that the model predictions for household leverage are broadly in line with the data. In order to match the age profile for the rental rate across countries, the model requires a lower ϕ_R^{ret} in Italy and Spain than in France and Germany. Without making rental less attractive during retirement for these two countries, the model would predict much more rental than empirically observed. We leave the question for further research whether there is an economic explanation for why rental is seemingly less attractive in Italy and Spain during retirement.

4 Consumption responses

We use the model to compute responses of non-housing consumption to changes in the real interest rate and relative house prices. These responses are important for monetary-policy transmission and have received considerable attention for the U.S.⁸ We find substantial heterogeneity of these responses across the major euro-area countries. This poses challenges for monetary policy that is common across these countries and suggests scope for complementing monetary policy with fiscal policy to contain the distributional effect of changes in the real interest rate or relative house prices.

⁷We have chosen to calibrate the rent-price ratio because the price comparison between rented and owned units may be confounded by quality differences. The true quality-adjusted rent-price ratio is unobserved. Nonetheless, it is comforting to see that the rent-price ratios implied by the model are in the same ballpark as their existing empirical counterparts. A rent-price ratio of 3.5% seems also plausible in our benchmark with stable relative house prices if one considers a user cost for owned housing that equals the sum of the real interest rate of 3% and a depreciation rate of 0.5%.

⁸See, for example, Auclert (2017), Berger et al. (2015), Beraja et al. (2017), Hedlund et al. (2016), Kaplan et al. (2017) and Kaplan et al. (2016b) for analyses on the U.S. and Cloyne et al. (2015) for evidence on the U.S. and the U.K.

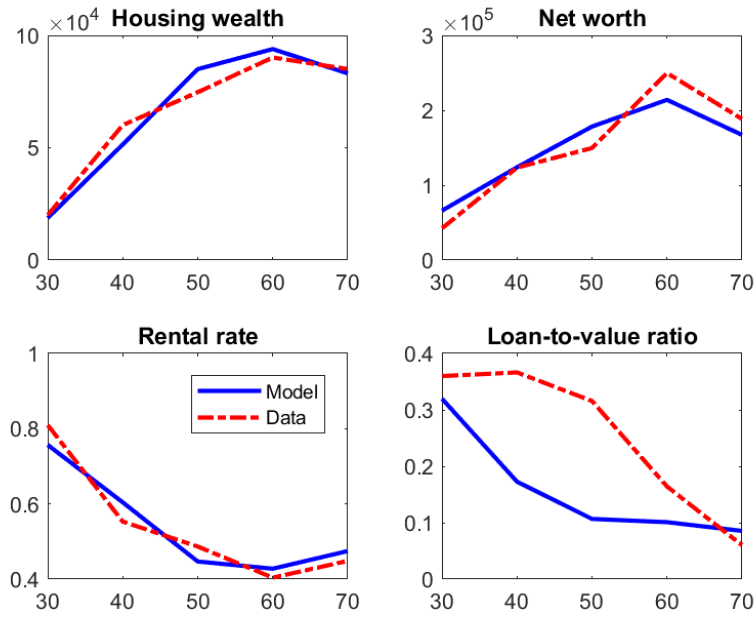


Figure 1: Age profiles for Germany: data (dashed line) and model predictions (solid line)
Notes: Averages for groups with ages 26-35, 36-45, 46-55, 56-65, 66-75. Units of net worth and housing are euro per adult equivalent.

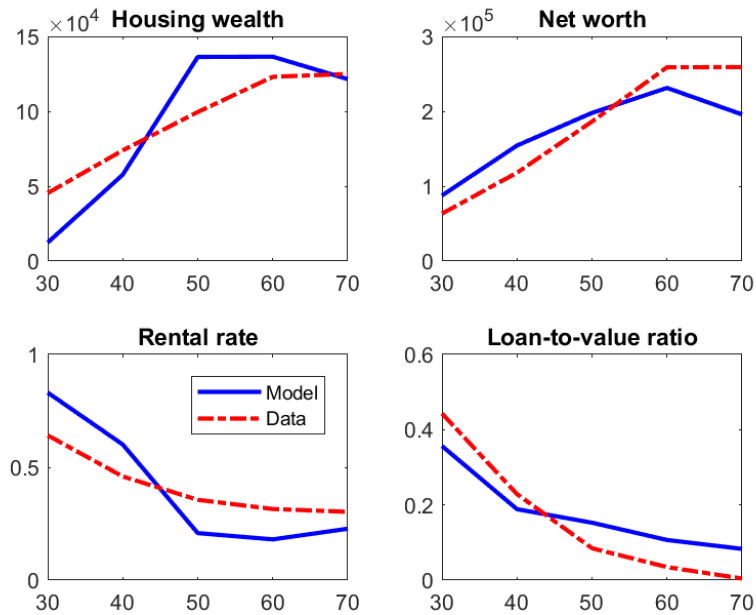


Figure 2: Age profiles for France: data (dashed line) and model predictions (solid line)
Notes: see notes for Figure 1.

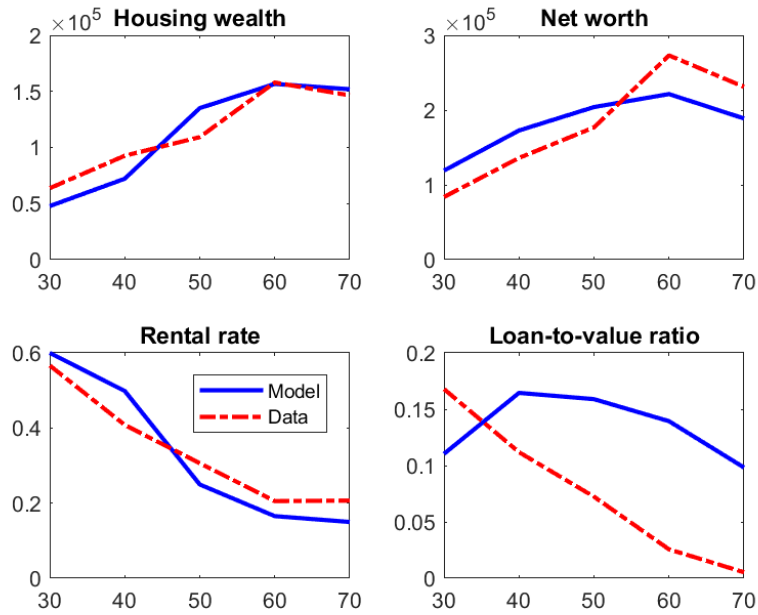


Figure 3: Age profiles for Italy: data (dashed line) and model predictions (solid line)
Notes: see notes for Figure 1.

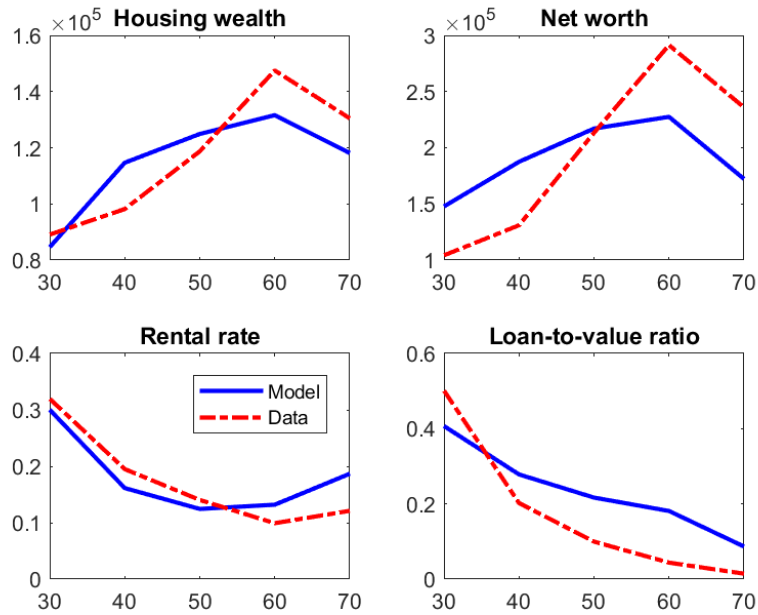


Figure 4: Age profiles for Spain: data (dashed line) and model predictions (solid line)
Notes: see notes for Figure 1.

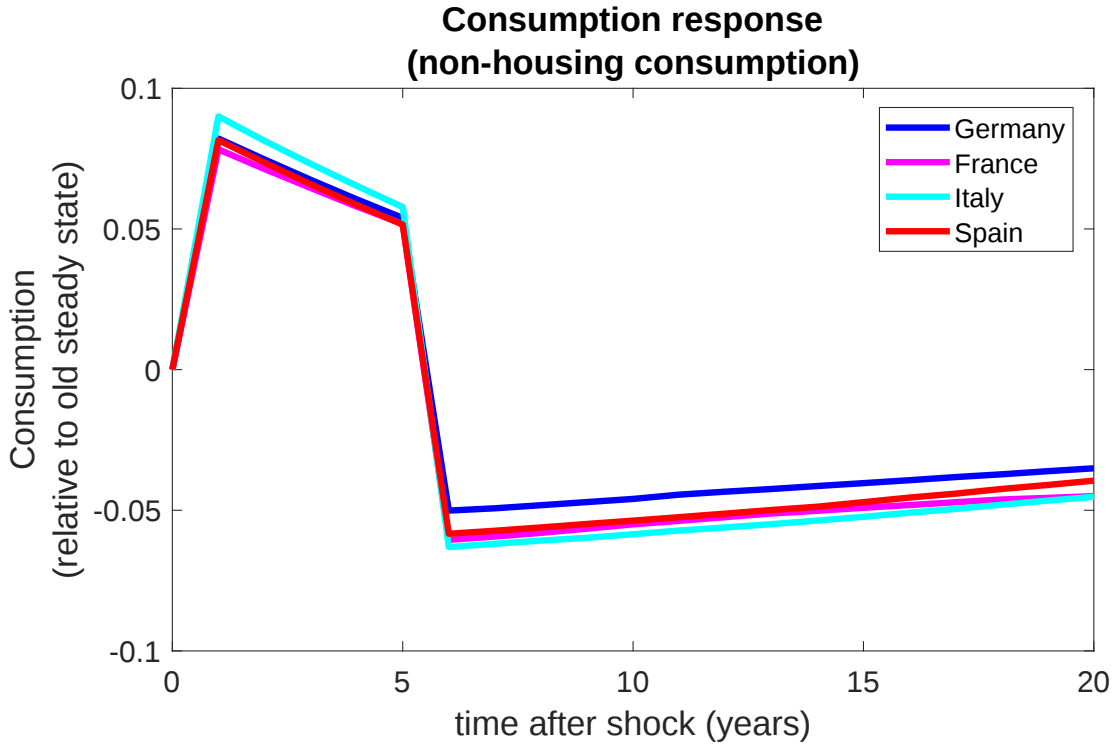


Figure 5: Unexpected fall of the real interest rate from 3% to 2%, with a contemporaneous reduction of the rent-to-price ratio by 1 percentage point (reversed after 5 years)

4.1 A fall in the real interest rate

Figure 5 shows the response of non-housing consumption in an experiment with a sequence of measure-zero events: a reduction of the real interest rate by 1 percentage point from 3% to 2% which is reversed after five years. We assume that the reduction in the real interest rate is accompanied by an analogous reduction of the rent-to-price ratio by 1 percentage point, supposing that the lower user cost for housing is fully passed on to renters while the relative house price remains stable. For the responses displayed in Figure 6 we make the alternative assumption that the reduction of the rent-to-price ratio is driven by an increase of the relative house price. This then implies an increase of the relative house price between 35% and 40% across the considered countries.

Figure 5 shows that a fall in the real interest rate by 1 percentage point increases non-housing consumption on impact between 7.8% in France and 9% in Spain. If accompanied by the relative house price increase between 35% and 40%, Figure 6 shows that the responses become larger and are between 14.6% in Germany and 18.8% in Italy.

The responses of non-housing consumption are large, possibly because the measure-zero events imply that the changes in the real interest rate are expected to last forever which, for real interest rates, may be a strong assumption. We thus plan to relax this assumption in future work. The experiments nonetheless already deliver interesting in-

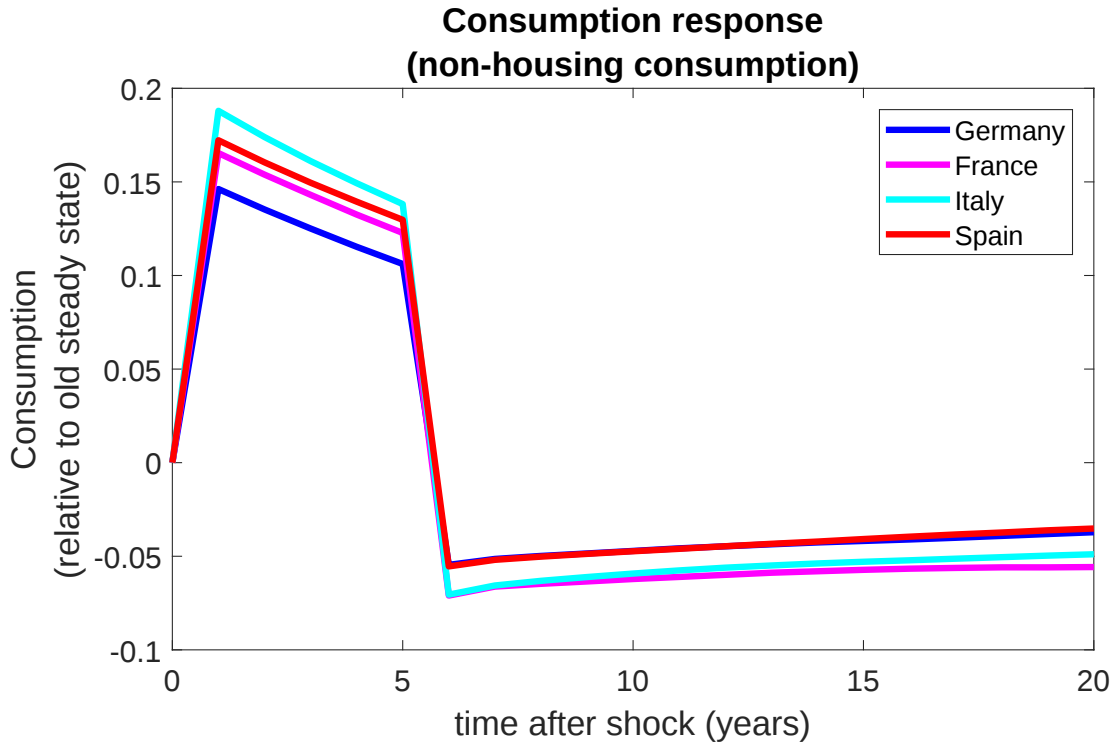


Figure 6: Unexpected fall of the real interest rate, with a contemporaneous reduction of the rent-to-price ratio by 1 percentage point and the implied maximal increase of the relative house price (reversed after 5 years)

sights. The change in non-housing consumption is asymmetric when the changes are reversed after five years. Non-housing consumption then falls *below* its initial value. The reason is that the fall of the real interest rate induces large portfolio shifts from the financial asset, whose return has fallen, into housing. Since housing can only be adjusted at a cost, this portfolio shift is not fully reversed at the time when the real interest rate returns to its initial value. As visible in Figures 5 and 6, non-housing consumption returns to its initial value very slowly. If we plotted the response for a longer time period after the shocks, it would become apparent that consumption is close to its initial value only after more than 50 years.

The lesson from the experiments is that a fall in the real interest rate induces portfolio shifts towards the illiquid housing asset. This increases the responsiveness of non-housing consumption to changes in the real interest rate and thus can exacerbate the slump in non-housing consumption when a period with a low real interest rate comes to an end unexpectedly.

The experiments also reveal interesting differences across the age dimension. Results which are not reported show that while young agents shift their portfolio into housing wealth after the decrease in the real interest rate, older agents do the opposite and become renters. The intuition is that the lower real interest rate is accompanied by a lower rent-

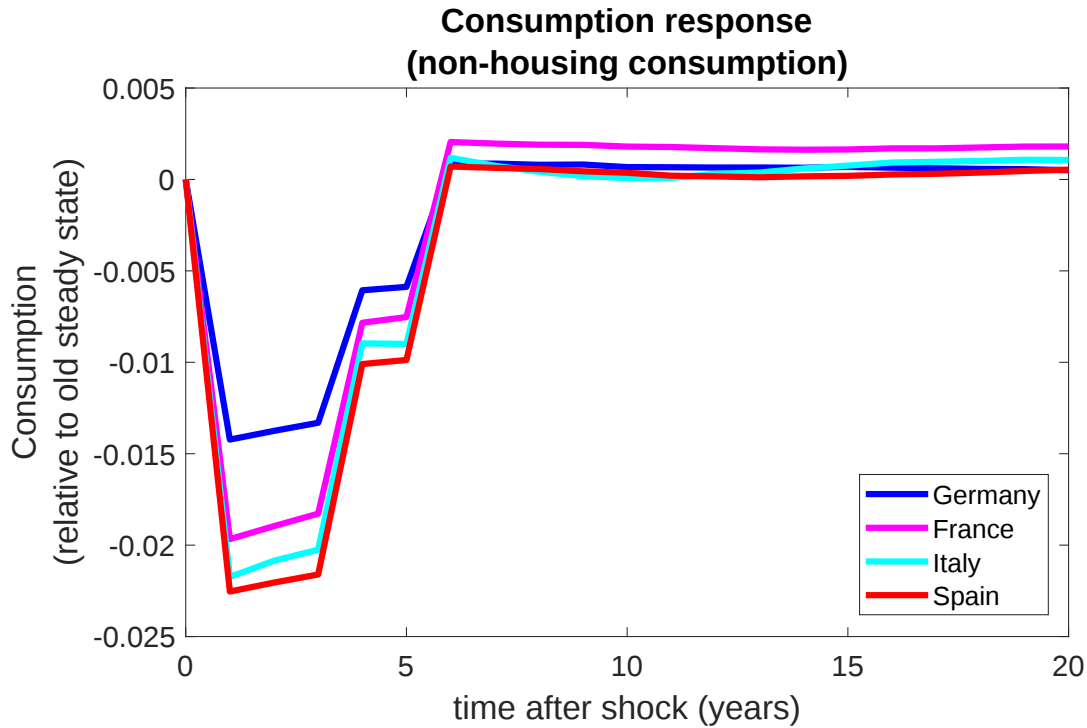


Figure 7: Unexpected fall of the relative house price by 10%, reversed in two steps within 5 years

to-price ratio and owned housing has less collateral value during retirement because the loan-to-value ratio is restricted at 0.2 during retirement instead of 0.8 during the working age.

4.2 A fall in the relative house price

Figure 7 shows the non-housing consumption responses after a 10% drop in house prices that is reversed in two steps within five years. Again, this is implemented as a sequence of measure-zero events. The responses are intuitively larger in those countries in which home ownership rates are higher. Non-housing consumption falls by 2.3% in Spain, 2.2% in Italy, 2% in France and 1.4% in Germany. These responses imply elasticities between 0.14 and 0.23 and thus encompass the model-implied elasticity of 0.2 in Kaplan et al. (2017) obtained for the U.S.⁹

The drop in house prices also has heterogeneous effects on consumption across the age dimension. Results that are not reported reveal that non-housing consumption of older agents with more housing decreases relatively more.

⁹The 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.

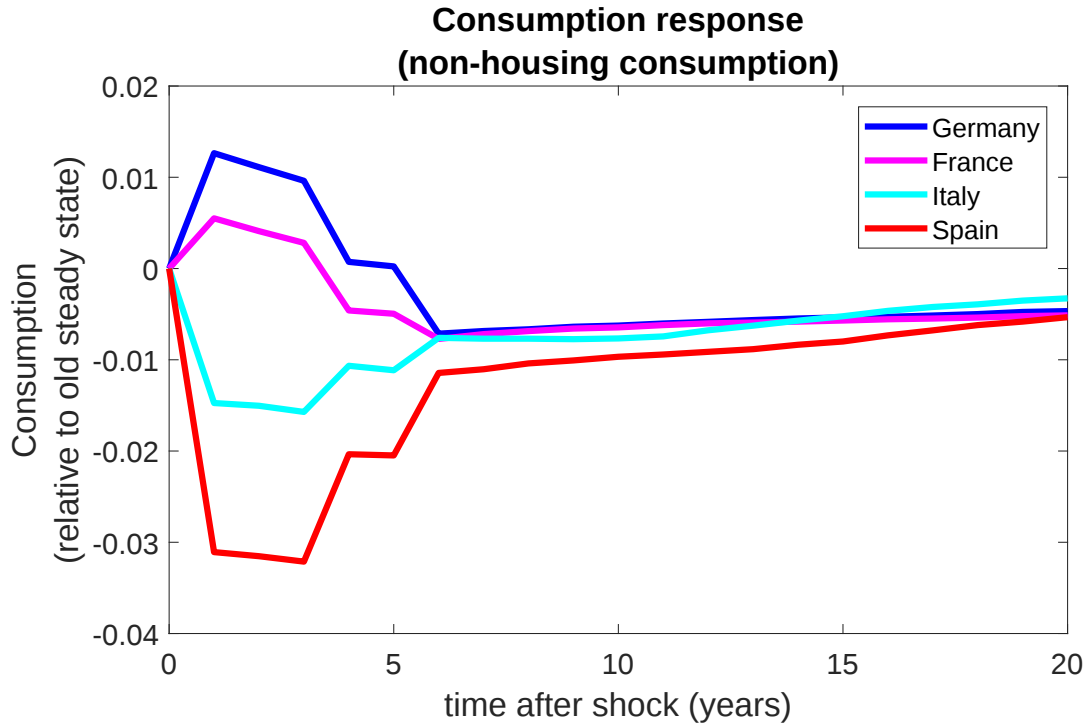


Figure 8: Observed country-specific fall of the relative house price accompanied by a reduction of the real interest rate by 25 basis points, reversed in two steps within 5 years

4.3 A fall of both the relative house price and the real interest rate

We perform an experiment in which we illustrate policy challenges in the euro area that arise due to the heterogeneity of consumption responses across euro-area countries. We feed a drop of relative house prices into the model whose size corresponds to the fall in the relative house price observed within a five-year period during the last recession for each of the four euro-area countries. Based the deflated house-price index for 2006 to 2016 from Eurostat, we let the relative price for housing drop by 5% in Germany and France, by 15% in Italy and by 20% in Spain.¹⁰ At the same time we suppose that a central bank engineers a reduction of the real interest rate by 25 basis points. These measure-zero events are then reversed in two steps within five years.

Figure 8 shows the consumption response for this experiment. For Germany and France, the fall in the real interest rate by 25 basis points more than compensates the negative effect on consumption resulting from the fall in the relative house price. For Italy and Spain instead, the fall in the real interest rate does not suffice to compensate the negative effect on consumption resulting from the housing bust. Not only is the fall in the relative house price larger for these countries but also, as we have seen in Figure 7, a

¹⁰The index is available at <http://ec.europa.eu/eurostat/web/macroeconomic-imbalances-procedure/house-price-index-deflated>.

given drop of the relative house price triggers a larger negative response of consumption. The stronger positive consumption response to a fall in the real interest rate in Italy than in Germany or France, visible in Figure 5, does not overturn this result for Italy. For Spain the consumption response to a fall in the real interest rate, shown in Figure 5, is quantitatively similar to France and Germany so that the effect of the fall in the relative house price certainly dominates.¹¹

The results for the experiments suggest that they are trade-offs if one attempts to stabilize consumption in the euro area not only because of heterogeneous shocks but also because of the heterogeneity in the transmission from changes in real interest rates and relative house prices to consumption. In ongoing work we decompose the aggregate consumption responses and analyze the role of differences in household finances for the responses in more detail.

5 Conclusion

We have analyzed the consumption responses to changes in the real interest rate and relative house prices for the four largest euro-area countries: France, Germany, Italy and Spain. Our quantitative analysis has revealed sizable differences in the transmission from changes in the real interest rate and the relative house prices to (non-housing) consumption. We have illustrated how the differences in the consumption responses expose the limits of a uniform monetary policy across the euro area. This suggests that there is scope for coordinated country-specific fiscal policy. Taxes or transfers may serve as complementary policy instruments to mitigate not only the distributional effects of monetary policy across countries but also the distributional effects across age groups that we find for each of the analyzed euro-area countries.

A Appendix on the 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 neither the price level p_t nor the rental price level q_t enter as separate state variables. We define *price-transformed variables* in the following way.

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

¹¹We have also performed an experiment in which we computed the consumption response to a decrease of the maximal loan-to-value ratio from 80% to 70%. We found rather small effects on non-housing consumption, possibly because few agents in our model simulations are close to the borrowing limit.

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

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

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

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

Normalizing the objective function

In the log-separable case we have that

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

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

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

Therefore, utility is equivalently¹² described by

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

For the log-separable case, the formulation in terms of valued units does not require any adjustment of the discount factor. We can use

$$\tilde{\beta} = \beta$$

for having a clearly distinct notation of the discount factor in the normalized problem.

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** his 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*

¹²For the equivalence in terms of the forward-looking objective function, also the time-separability of discounted utility plays a role.

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 Π ,

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

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

$$c_j + a_{j+1} = y_j(s_j) + (1 + r)a_j ,$$

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

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

Ownership choice, adjusting

If the household chooses to consume housing as an **owner, adjusting** his 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

$$\begin{aligned}\alpha_{p,j}(\hat{h}_j, \hat{h}_{j+1}) &= \alpha_{0,j} + \alpha_1 p_t \hat{h}_j + \alpha_2 p_t \hat{h}_{j+1} \\ &= \alpha_{0,j} + \alpha_1 \frac{p_t}{p_{t-1}} h_j + \alpha_2 h_{j+1} \\ &= \alpha_{0,j} + \alpha_1 \Pi h_j + \alpha_2 h_{j+1} .\end{aligned}$$

Denoting

$$\alpha_j(h_j, h_{j+1}) = \alpha_{0,j} + \alpha_1 \Pi h_j + \alpha_2 h_{j+1} ,$$

the budget constraint

$$c_j + a_{j+1} + p_t \hat{h}_{j+1} + \alpha_{p,j}(\hat{h}_j, \hat{h}_{j+1}) = y_j(s_j) + (1+r)a_j + p_t \hat{h}_j$$

becomes

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

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

$$c_j + a_{j+1} + h_{j+1} + \alpha_j(h_j, h_{j+1}) = y_j(s_j) + (1+r)a_j + \Pi h_j .$$

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

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

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 constant rent-to-price ratio k in $q_t = kp_t$, the budget constraint

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

becomes

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

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

$$c_j + a_{j+1} + kf_j + \alpha_R(h_j) = y_j(s_j) + (1+r)a_j + \Pi h_j .$$

The collateral constraint is

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

The recursive formulation

We denote

$$V_j(a_j, h_j, s_j) = \max_{d_j, c_j, f_j, a_{j+1}, h_{j+1}} \{U(c_j, \bar{s}_j) + \widetilde{\beta} E_{s_{j+1}|s_j} V_{j+1}(a_{j+1}, h_{j+1}, s_{j+1})\} ,$$

where the maximization is subject to the above-mentioned collection of discrete-choice-specific constraints, and where the expectation operator $E_{s' | s} f(\cdot, s') = \sum_{s' \in S} \pi_{s, s'} f(\cdot, s')$.

Conditional on a discrete choice, we denote

$$v_j(a_j, h_j, s_j | d_j) = \max_{c_j, f_j, a_{j+1}, h_{j+1}} \left\{ U(c_j, \bar{s}_j) + \widetilde{\beta} E_{s_{j+1}|s_j} V_{j+1}(a_{j+1}, h_{j+1}, s_{j+1}) \right\} ,$$

where the maximization is subject to the constraint set specific to the discrete choice d_j .

We handle the discrete-choice options in the recursive problem according to the approach suggested by Iskhakov et al. (2017), keeping for simplicity the same notation for

functions $V(\cdot)$ and $v(\cdot)$. 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

$$V_j(a_j, h_j, s_j, \eta_j) = \max_{d_j \in D_j} \{v_j(a_j, h_j, s_j | d_j) + \eta_{d_j}\},$$

where η_{d_j} denotes the realization of the random component specific to a discrete choice d_j , and the vector η_j contains the collection of all realizations at age j for the set of all available discrete choices D_j . Note that for simplicity we have kept the same notation for function $V()$. This randomness is considered for the discrete-choice-specific value functions so that

$$\begin{aligned} v_j(a_j, h_j, s_j | d_j) &= \max_{c_j, f_j, a_{j+1}, h_{j+1}} \left\{ U(c_j, \bar{s}_j) + \widetilde{\beta} E_{s_{j+1}|s_j} \left[E_{\eta_{j+1}} V_{j+1}(a_{j+1}, h_{j+1}, s_{j+1} | \eta_{j+1}) \right] \right\} \\ &= \max_{c_j, f_j, a_{j+1}, h_{j+1}} \left[U(c_j, \bar{s}_j) + \widetilde{\beta} E_{s_{j+1}|s_j} \lambda(\mathbf{v}_{j+1}(a_{j+1}, h_{j+1}, s_{j+1} | d_{j+1}), D_{j+1}; \sigma) \right] \end{aligned}$$

with¹³

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

Ownership choice, not adjusting

In the case of non-adjustment, we use $h_{j+1} = \Pi h_j$ and the budget constraint conditional on this discrete choice so that

$$v_j(a_j, h_j, s_j | d_j = 0) = \max_{a_{j+1}} \left[U(y_j(s_j) + (1+r)a_j - a_{j+1}, \phi \Pi h_j) + \widetilde{\beta} E_{s_{j+1}|s_j} \lambda(\mathbf{v}_{j+1}(a_{j+1}, \Pi h_j, s_{j+1} | d_{j+1}), D_{j+1}; \sigma) \right],$$

subject to the collateral constraint

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

Ownership choice, adjusting

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

¹³The notation with a boldface variable $\mathbf{x}$ in the expression $(\mathbf{x} | d_{j+1}), D_{j+1}$ is shorthand for denoting the corresponding collection of discrete-choice-specific variables by $\{(x | d_{j+1}) : d_{j+1} \in D_{j+1}\}$

$$v_j(a_j, h_j, s_j | d_j = 1) = \max_{a_{j+1}, h_{j+1}} [U(y_j(s_j) + (1+r)a_j + \Pi h_j - a_{j+1} - h_{j+1} - \alpha_{0,j} - \alpha_1 \Pi h_j - \alpha_2 h_{j+1}, \phi h_{j+1}) \\ + \widetilde{\beta} E_{s_{j+1}|s_j} \lambda(\mathbf{v}_{j+1}(a_{j+1}, h_{j+1}, s_{j+1} | d_{j+1}), D_{j+1}; \sigma)]$$

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

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

Rental choice

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

$$v_j(a_j, h_j, s_j | d_j = 2) = \max_{f_j, a_{j+1}} [U(y_j(s_j) + (1+r)a_j + \Pi h_j - a_{j+1} - k f_j - \alpha_1 \Pi h_j, \phi_R f_j) \\ + \widetilde{\beta} E_{s_{j+1}|s_j} \lambda(\mathbf{v}_{j+1}(a_{j+1}, 0, s_{j+1} | d_{j+1}), D_{j+1}; \sigma)]$$

The collateral constraint in this case is

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

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 Appendix on calibration

B.1 Pensions

To be completed.

B.2 Taxation of labor income

To be completed.

	<i>Adjustment costs</i>
α_0	5,000
α_1	0.025
	<i>Loan-to-value ratio before and after retirement</i>
μ	0.8
μ^{ret}	0.2
	<i>Pledgeable share of income</i>
ξ	0.6
	<i>Autocorrelation of income shocks</i>
ρ	0.95
	<i>Real interest rate</i>
r	0.03
	<i>Price growth factor</i>
Π	1.0
	<i>Taste shocks for discrete choice</i>
σ_ϵ	0.01
	<i>Service-flow rate out of rental housing quantity before retirement</i>
ϕ_R	0.965

Table 4: Common parameters across countries

Notes: Country-specific parameters are contained in Table 2.

B.3 Estimation of the income age profile and calibration of income risk

To be completed.

B.4 Transaction taxes

For Germany we add the 5% *Grunderwerbssteuer* to fees of 2.5% for real-estate agents. The *Grunderwerbssteuer* varies between 3.5% and 6.5% across regions. Unfortunately, we cannot exploit this variation because we do not have information about regions 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 a 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.

References

- Auclert, A. (2017). Monetary Policy and the Redistribution Channel. NBER Working Papers 23451, National Bureau of Economic Research, Inc.
- Beraja, M., Fuster, A., Hurst, E., and Vavra, J. (2017). Regional Heterogeneity and Monetary Policy. NBER Working Papers 23270, National Bureau of Economic Research, Inc.
- Berger, D., Guerrieri, V., Lorenzoni, G., and Vavra, J. (2015). House Prices and Consumer Spending. NBER Working Papers 21667, National Bureau of Economic Research, Inc.
- 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.
- Cloyne, J., Ferreira, C., and Surico, P. (2015). Monetary Policy when Households have Debt: New Evidence on the Transmission Mechanism. CEPR Discussion Papers 11023, C.E.P.R. Discussion Papers.
- Coibion, O., Gorodnichenko, Y., Kueng, L., and Silvia, J. (2012). Innocent Bystanders? Monetary Policy and Inequality in the U.S. NBER Working Papers 18170, National Bureau of Economic Research, Inc.
- ECB (2009). Housing Finance in the Euro Area. Working paper, European Central Bank, Occasional Paper Series, No. 101.
- 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.
- 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.
- Hedlund, A., Karahan, F., Mitman, K., and Ozkan, S. (2016). Monetary Policy, Heterogeneity, and the Housing Channel. Working paper, Mimeograph.
- 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. (2016). Towards understanding differences in European household finances. Working Paper Series 017, ADEMU.

- 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.
- Kaas, L., Kocharkov, G., Preugschat, E., and Siassi, N. (2017). Low Homeownership in Germany - A Quantitative Exploration. Working paper, Mimeograph.
- Kaplan, G., Mitman, K., and Violante, G. L. (2016a). Non-durable Consumption and Housing Net Worth in the Great Recession: Evidence from Easily Accessible Data. NBER Working Papers 22232, National Bureau of Economic Research, Inc.
- Kaplan, G., Mitman, K., and Violante, G. L. (2017). The Housing Boom and Bust: Model Meets Evidence. NBER Working Papers 23694, National Bureau of Economic Research, Inc.
- Kaplan, G., Moll, B., and Violante, G. L. (2016b). Monetary Policy According to HANK. NBER Working Papers 21897, National Bureau of Economic Research, Inc.
- Kindermann, F. and Kohls, S. (2016). Rental Markets and Wealth Inequality in the Euro-Area. Working paper, Mimeograph.
- 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.
- Pham-Dao, L. (2016). Public Insurance and Wealth Inequality – A Euro Area Analysis. Working paper, Mimeograph.
- Pijoan-Mas, J. and Sanchez-Marcos, V. (2010). Spain is Different: Falling Trends of Inequality. *Review of Economic Dynamics*, 13(1):154–178.