Housing Wealth Across Countries:
The Role of Expectations, Institutions and Preferences

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Julia Le Blanc[1] — European Commission
Jiri Slacalek[2] — European Central Bank
Matthew N. White[3] — University of Delaware

Abstract

Homeownership rates and holdings of housing wealth differ immensely across countries. We specify and estimate a life cycle model with risky labor income and house prices in which households face a discrete–continuous choice between renting and owning a house, whose sale is subject to transaction costs. The model allows us to quantify three groups of explanatory factors for long-run, structural differences in the extensive and intensive margins of housing: homeownership rates and value of housing wealth of homeowners. First, in line with survey evidence, we allow for differences in expectations of house prices. Second, countries differ in the institutional set-up of the housing market: maximum loan–value ratio and costs of renting, maintaining and selling a house. Third, we allow for differences in household preferences: the dispersion in discount factors, the share of housing expenditure and the bequest motive. We estimate the model using micro data from five large economies and provide a decomposition to interpret what drives the cross-country differences in housing wealth. We find that all three groups of factors matter, although preferences less so. Differences in homeownership rates are strongly affected by (i) house price beliefs and (ii) the rental wedge, the difference between rents and maintenance costs, which reflects the quality of the rental market. Differences in the value of housing wealth are substantially driven by housing maintenance costs.

Keywords Housing, Homeownership, House Price Expectations, Housing Market Institutions, Cross-Country Comparisons

JEL codes D15, D31, D84, E21, G11, G51

[1]Le Blanc: European Commission, Joint Research Centre, Ispra, Italy, email: julia.le-blanc@ec.europa.eu [2]Slacalek: Research Department, European Central Bank, Frankfurt, Germany, http://www.slacalek.com/, email: jiri.slacalek@ecb.europa.eu [3]White: Econ-ARK and Department of Economics, University of Delaware, United States, email: mnwhite@gmail.com

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1 Introduction

Micro data document striking, persistent differences in household wealth across countries; for example, the median net wealth in Italy and Spain exceeds twice that in Germany (Figure 1.a). Given the substantial share of housing on total assets—around 80 percent, the bulk of this variation in wealth is driven by the extensive and the intensive margin of housing wealth: whether to own a house and how large. Among large developed economies, the homeownership rate varies immensely: between 44 percent in Germany and 80 percent in Spain, with many countries hovering around 65 percent (Figure 1.b). The considerable cross-country differences in housing remain over the whole life cycle.[1] In addition, as aggregate homeownership rates are sluggish, cross-country differences in the distribution of housing wealth persisted over several decades.[2]

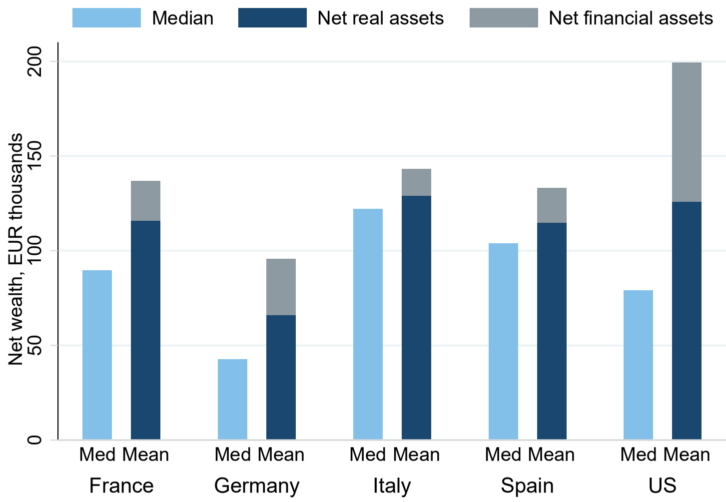
To complement the existing reduced-form estimates, we study the accumulation of housing wealth in a 'canonical,' state-of-the-art life cycle model with risky labor income and house prices, illiquid housing and a discrete–continuous choice between owning and renting a house. Our estimated model allows us to quantify three groups of explanatory factors for long-run, structural differences in housing wealth. First, in line with survey evidence, we allow for differences in expectations of house prices. Second, countries differ in the institutional set-up of the housing and rental market (maximum loan–value ratios, costs of renting, maintaining and selling a house). Third, preference parameters such as impatience and the share of housing expenditures are allowed to vary across households. We also allow for differences in house prices, incomes and demographics. Our model thus includes several features that are important for modeling housing: housing is illiquid subject to linear house selling costs, house size is continuous, house prices are risky, households face collateral constraints and their beliefs about house prices differ.

We use the simulated method of moments to match the model to micro data on age profiles of homeownership, housing wealth, rents and net wealth from a comprehensive

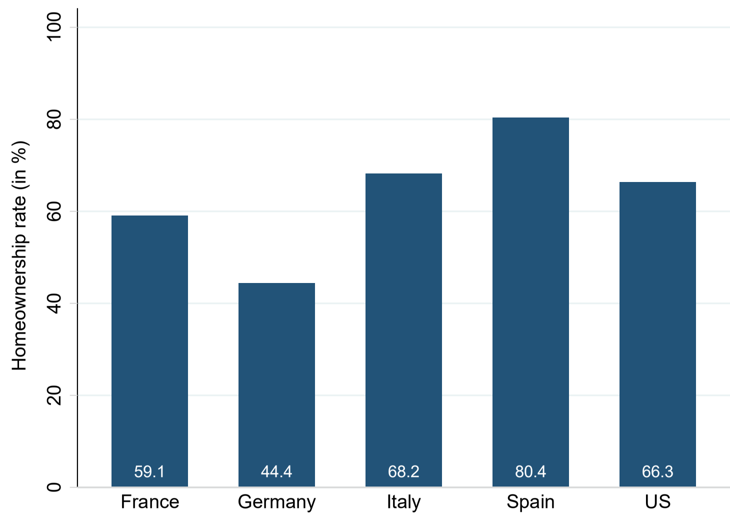
[1] Although the profiles of homeownership and wealth tend to increase for most of the lifetime, the substantial cross-country differences in levels do not narrow down over the life cycle (Figure 1.c–d): For example, the homeownership rate of Spanish households exceeds throughout their lives by at least 20 percentage points the homeownership rate in Germany.

[2] For long-run aggregate time series evidence see, e.g., Kohl (2017) for homeownership rates and Piketty and Zucman (2014) for wealth–income ratios.

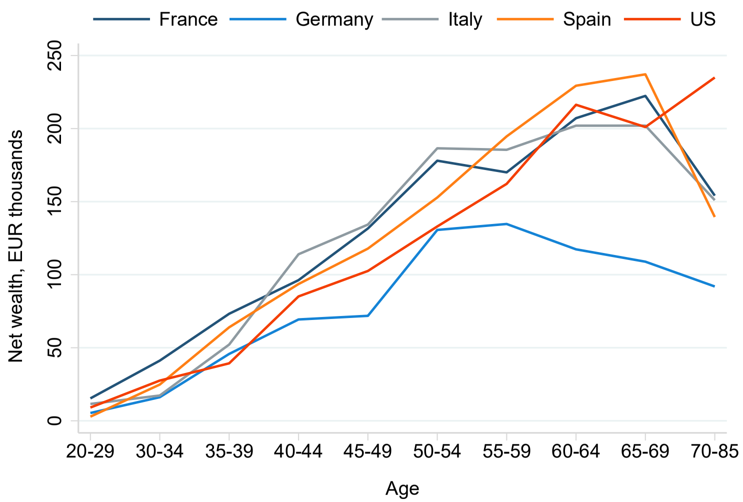
Figure 1 Wealth Holdings and Homeownership Rate Across Countries and over the Life Cycle



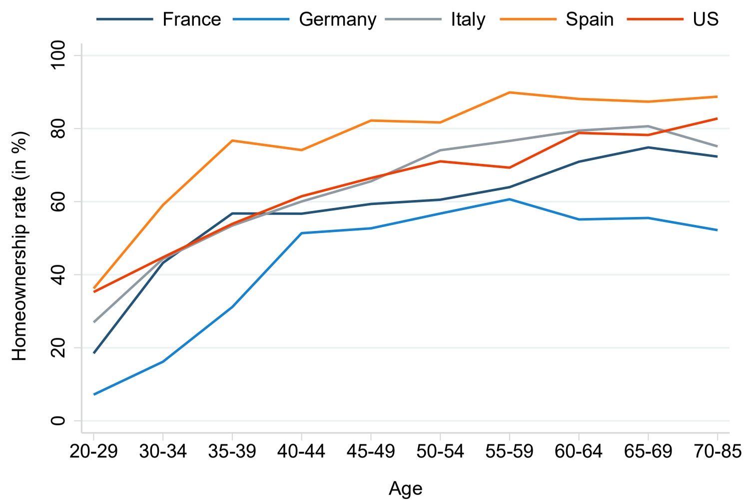
(a) Median and Mean Net Wealth



(b) Homeownership Rate



(c) Median Net Wealth by Age



(d) Homeownership Rate by Age

Source: Household Finance and Consumption Survey, wave 2014; Survey of Consumer Finances, 2016.
Note: The upper left panel shows the mean and median net wealth across countries for all households excluding the top 10 percent by net wealth. The upper right panel shows the homeownership rate across countries. The lower panels show how median net wealth and homeownership rate, respectively, vary by age of the reference person. Net wealth is the sum of real and financial assets net of total liabilities. Net housing assets are nonfinancial assets net of mortgage debt. Net financial assets are financial assets net of non-mortgage debt. Homeownership rate is measured using the indicator of ownership of the household main residence. Net wealth in the U.S. was converted to EUR using the exchange rate of 2016.

set of five advanced economies: France, Germany, Italy, Spain and the United States. We discuss and document how those moments in the data identify estimates of house price beliefs, housing market institutions and preferences. Our model fits reasonably well age profiles of homeownership rates and holdings of housing and total net wealth.

Through the lens of the estimated model, we then interpret the substantial differences in homeownership rates and housing wealth across the five countries. We propose a decomposition in which, moving from one country (Germany) to another (Spain), we switch one-by-one from the German estimated parameter values to the Spanish ones, in each step recording the effect of the given factor on the housing wealth variable (homeownership or mean housing wealth–income ratio).[3]

To our knowledge, this is the first paper that uses an estimated life cycle model of housing to systematically document drivers of differences in the extensive and intensive margins of housing across advanced economies. We find that all three groups of factors above contribute to explaining the cross-country differences in homeownership and housing wealth, although preferences much less than house price beliefs and housing market institutions.

As for the extensive margin of housing, differences in homeownership rates are strongly affected by two variables: (i) house price beliefs and (ii) the rental wedge, the difference between rents and maintenance costs, which reflects the quality of the rental market and the segmentation between rental and owner-occupied housing markets. These two factors are key for the decision whether to invest in housing: a higher rental wedge and more optimistic house price beliefs make renting less appealing and increase the share of homeowners. Both factors contribute roughly equally to explaining the gaps in homeownership rates across countries and both of them matter throughout the life cycle.

Quantitatively, we estimate that small differences in long-run house price beliefs and the rental wedge result in large differences in homeownership rates. The rental wedge

[3]Our model is far from linear due to house selling costs and precautionary saving. To account for this fact, in the decomposition we permute over all possible paths in which parameters can switch. We then report the average contribution of each factor and the spread across the paths. These statistics are informative about the average effect of each factor as well as the range of likely effects.

ranges from just above 2 percent per year in Germany, France and the U.S. to around 4 percent in Spain and Italy, reflecting a less efficient rental market. Our model implies that the 2 p.p. difference in rental wedges leads roughly to a 25–30 p.p. difference in homeownership rates between Germany vs. Spain and Italy. Mean long-run house price beliefs range between 0 percent in Italy and 3.2 percent in France, reflecting the historical growth in aggregate house prices. Across countries, a 1 p.p. difference in house price beliefs results roughly in a 15 p.p. difference in the homeownership rate. These considerations imply that small differences in long-run house price beliefs—well within the range documented in survey data—are in a model a powerful driver of homeownership, substantially affecting important economic decisions of households. Similarly, small differences in the rental wedge result in large differences in homeownership rates. As for other factors, tighter collateral constraints and steeply growing labor incomes reduce the homeownership rate especially of the youngest households.

As for the intensive margin of housing, differences in housing wealth of homeowners, as measured with the mean ratios of housing wealth to income, are mostly driven by housing maintenance costs, which in effect reduce homeowners' return on housing. Quantitatively, the estimated maintenance costs for Germany (3 percent of housing wealth) are roughly half those in France (6 percent) and the U.S. (7 percent), implying higher housing wealth in Germany by a multiple 2–4 worth of annual incomes. Other factors that matter for the accumulation of housing wealth (although less than maintenance costs) are: the rental wedge, house price beliefs and the consumption share of housing. Roughly twice as large as in Germany, the rental wedge in Spain and Italy reduces housing wealth as marginal buyers purchase smaller houses. More optimistic house price beliefs increase the amount of housing wealth in Spain and France (compared to Germany) as existing homeowners upgrade to buy larger houses. Finally, we estimate that Germany has a somewhat lower share of housing consumption (of 0.177) than the other countries (ranging between 0.207 and 0.271), which is reflected in a positive contribution of the parameter to housing wealth. The strength of the effects of the various factors on housing wealth rises with age, reflecting the gradual accumulation of the stock of housing wealth over the life cycle (relative to the flow of income).

Our paper also contributes to the existing literature with a solution method for models with illiquid housing, a variant of the discrete–continuous endogenous grid method (Carroll, 2006 and Iskhakov et al., 2017), which we implement so that it is fast and robust enough to estimate a realistic quantitative life cycle model across countries with widely ranging distributions of housing wealth. Different from Iskhakov et al. (2017), our solution method does not require adding taste shocks, given the presence of income and house price shocks, which naturally smooth out some kinks in the value function.

The paper is structured as follows. The next section relates our setup and findings to the literature. Section 3 describes and discusses the model. We then describe the model estimation and identification strategy in section 4. Section 5 presents the results and section 6 concludes. The Appendixes provide further details on the model and computational techniques.

2 Modeling Housing—Literature Review

The bulk of the work investigating cross-country differences in wealth is reduced-form. Most structural work on housing analyzes one or two countries or a role of a particular factor for the homeownership or accumulation of housing wealth (e.g., collateral constraints, transaction costs, quality of rental market or financial innovations). In contrast, our paper models various factors jointly and quantifies their contributions to differences in housing wealth in a 'horse race' in a single encompassing model estimated for the five countries. In addition to structural work on housing, our paper is also related to recent work measuring and modeling house price beliefs, housing market institutions and preference heterogeneity (in the discount factor).

Structural Modeling of Housing. Our model is based on the setup pioneered by Yao and Zhang (2005), Li et al. (2016), Bajari et al. (2013) and others, who solve and estimate a standard model of housing demand with adjustment costs. Compared to Li et al. (2016), our model includes heterogeneity in preferences and beliefs.

Existing calibrated or estimated models of housing were applied to analyze quantitatively various trends in the data, mostly focusing on the homeownership rate in the U.S. (different from our interest in quantifying long-run drivers of housing wealth). For example, Chambers et al. (2009) estimate that mortgage innovation (rather than demographics) accounted for about two thirds of the increase in the U.S. homeownership rate between 1965 and 2005. Attanasio et al. (2012) model individual demand for housing over the life cycle focusing on the effects of income, house prices and transaction costs. Analyzing the increasing homeownership rate in the U.S., Halket and Vasudev (2014) quantify the contribution of financial constraints, housing illiquidities and house price risk to homeownership and mobility over the life cycle. Focusing on the U.S. housing boom of the 2000s, Landvoigt (2017) investigates whether housing choices of households can be explained by a rational model with reasonable expectations about future house prices. Greenwald and Guren (2021) estimate the degree of segmentation between rental and owner-occupied housing markets in the U.S. and show that the highly frictional markets imply a large effect of credit shocks on house prices but a small effect on the homeownership rate. Paz-Pardo (2023) estimates that riskier and more unequal earnings contributed substantially to the decline in the homeownership rate among younger U.S. households (despite improvements in financial conditions).

A few recent papers focus on structural models of housing across countries. Kindermann and Kohls (2018) analyze how the quality of housing rental market affects wealth inequality. Compared to their model, we allow in our setup for differences in beliefs and preferences and estimate our model (to match the levels of housing wealth). Hintermaier and Koeniger (2018) study how differences in household finance affect the transmission of monetary policy to consumption. These models are calibrated, not estimated.

Compared to our setup, the existing life-cycle models are often calibrated, not estimated, do not include risky house prices, or capture house size on a discrete grid of a few values (not as a continuous variable).

House Price Beliefs. A booming literature has measured and analyzed empirical facts about subjective house price expectations of households (see, e.g., Adelino et al., 2018, Ben-David et al., 2018, Kuchler and Zafar, 2019 and the review of Kuchler et al., 2023). In general, this work finds pervasive differences in house price expectations across households with only a small part of the heterogeneity explained by observables.

Importantly for our results estimating the extent of differences in house price beliefs, Giglio et al. (2021) estimate heterogeneous and persistent *individual* fixed effects in beliefs. Similar to our modeling assumption, heterogeneity in beliefs is not well explained by observable respondent characteristics such as gender, age or wealth. In addition, they find a robust relationship between beliefs and portfolio allocations (documenting that beliefs matter for economic actions). Similarly, Liu and Palmer (2021) document that survey-based house price beliefs matter for real estate investment decisions (and more so when subjective past house price growth is used as an additional predictor of behavior even conditional on stated expectations).

Separate work uses structural models to analyze how various ways to process information and form beliefs about house prices matter for accumulation of housing and financial wealth (see, e.g., Bailey et al., 2018, Kaplan et al., 2020, Malmendier and Steiny Wellsjo, 2023, Kindermann et al., 2021 and others).

Housing Market Institutions. Large literature has recognized that differences in housing market institutions across countries affect accumulation of wealth and the response of the economy to shocks and policies; see Davis and Van Nieuwerburgh (2015) and Piazzesi and Schneider (2016) for reviews. Our calibrations and estimates below build on the work measuring the flexibility of the housing market institutions (e.g., Cardarelli et al., 2008 and Andrews et al., 2011) in terms of collateral constraints (down payment requirements), housing transaction costs and the quality of rental housing markets. For example, Kaas et al. (2021) model in detail three housing institutions in Germany relevant for the comparison with the U.S.: social housing sector, high transfer taxes when buying real estate (transaction costs) and no tax deductions for mortgage interest payments by owner-occupiers.[4]

Reduced-form empirical work has estimated the role of housing market institutions in household-level and aggregate data. For example, Chiuri and Jappelli (2003) find in household-level data that a wider availability of mortgage finance, as measured with down payment ratios, affects the age profile of homeownership, especially at the young end. We use a structural model to document a similar pattern: tighter collateral constraints reduce homeownership of young households (see section 5.2 below).

In aggregate time-series data across countries, it has been documented that monetary policy stimulates consumption, residential investment and house prices more strongly in countries with a larger flexibility and development of mortgage markets (Calza et al., 2013 and Corsetti et al., 2021).

Preference Heterogeneity: Impatience. Many empirical papers document substantial differences in estimates of the discount factor across households; see Frederick et al. (2002) for a review. Epper et al. (2020) estimate that time discounting reported in incentivized experiments is correlated in a stable way with individuals' positions in the distribution of wealth: more patient households accumulate more wealth.

Modeling work found it useful to allow for heterogeneity in impatience, to capture the extent of heterogeneity in wealth, financial assets and the marginal propensity to consume found in the data (Krusell and Smith, 1998, Carroll et al., 2017, Krueger et al., 2016, Calvet et al., 2019, Aguiar et al., 2023).

3 A 'Canonical' Life Cycle Model of Housing

Our model concerns a realistic life cycle of a household agent who derives (geometrically discounted) utility flows from its housing and non-housing consumption; upon death, the agent receives a "warm glow" terminal payout based on the amount of wealth he

[4]The transfer tax in Kaas et al. (2021) is in line with our sale costs; however, we focus on explaining differences in housing wealth across more countries. They find that reducing transaction costs to the U.S. level (by 4.7 p.p.) would shift homeownership in Germany up by 6 to 14 p.p. over working life. (The effect in our model is much smaller, more in line with the estimates of Halket and Vasudev, 2014.)

bequeaths. Each period, the household makes a discrete housing decision—whether to rent, stay in the currently owned house, or move to purchase another house—and then continuous decisions about how much to consume (versus save) and the size of home to purchase or rent.

Housing is an illiquid asset: selling a house is subject to transaction costs proportional to the value of the house. The household's end-of-period financial position is subject to a collateral constraint based on the house he owns: he can hold negative non-housing wealth, but only up to a percentage of the house value. Housing also serves as a risky asset, as house prices follow a geometric random walk with drift. For tractability, we treat housing debt as completely liquid, absorbed into the non-housing financial asset.

At the start of each period, the household faces three shocks: a permanent shock to labor income (permanent productivity), a purely transitory shock to labor income (including unemployment), and a shock to the value the house he owns (if any). Forward looking agents account for these future risks when making optimizing decisions about consumption and housing in the present. For details of our solution method, see Appendix A.[5]

3.1 Model Statement

We begin by specifying the model primitives. We then demonstrate that the model permits a normalization (by permanent income) that reduces the dimensionality of the state space (in each period) from four to two continuous dimensions.

3.1.1 Model Sequence

In time period t, when household i is headed by someone j_{it} years old, the household head's state (at the moment when he makes its decisions for the period) is characterized by four real values: liquid market resources M_{it}, the size of the house that he already owns $\overline{H}_{it}$, its permanent income level P_{it}, and the price level of housing relative to non-

[5] Our model is based on the influential work of Yao and Zhang (2005), Li and Yao (2007) and others.

housing goods π_t. An agent that does not own a house (because he rented at time $t-1$) has $\overline{H}_{it} = 0$.

The sequence of events in each discrete period t can be summarized as follows:

1. The living household agent experiences and observes a permanent income shock ψ_{it}, a transitory income shock θ_{it} and a shock to the value of his house η_t.

2. The agent receives capital income from his retained financial assets A_{t-1} and non-capital (labor) income Y_{it}.

3. The agent makes a discrete decision d_{it} about whether to rent a home ($d_{it} = 0$), stay in the currently owned house ($d_{it} = 1$), or move to a new house ($d_{it} = 2$).

4. The agent makes a continuous decision about how much to consume C_{it} and the size of house to live in H_{it}; the constraints of this decision depend on his discrete choice and his state.

5. The agent pays for his consumption and housing choice (depending on his discrete choice), leaving him with A_{it} in retained financial assets.

6. The agent transitions to the next period, experiencing a mortality shock; a surviving household ages to $j_{it+1} = j_{it} + 1$.

3.1.2 Household Preferences

We assume that agents have CRRA preferences (with coefficient ρ) over a Cobb–Douglas aggregation of consumption C_{it} and housing H_{it}, with a weight of ω on housing:

$$U(C_{it}, H_{it}) = \frac{(C_{it}^{1-\omega} H_{it}^{\omega})^{1-\rho}}{1-\rho}. \tag{1}$$

Note that from the perspective of current period utility flows, the agent is indifferent to whether he rents or owns the house—only the *size* of the house is relevant. The household agent discounts future (expected) utility flows at a rate of β per period.

If the household agent dies at the end of period t, he receives a terminal "warm glow" of utility based on his final net worth (discussed below), which also has a CRRA form with scaling factor L, representing bequest motive intensity:

$$B(\widehat{W}_{it}) = L \times \frac{\widehat{W}_{it}^{1-\rho}}{1-\rho}. \tag{2}$$

A household with age j_{it} dies at the end of the period with probability D_j and survives to the next period with complementary probability $1 - \mathsf{D}_j$. We assume that there is some maximum age J beyond which the agents cannot live, so $\mathsf{D}_J = 1$.

3.1.3 Exogenous Dynamics

The household's non-capital income Y_{it} follows a standard permanent–transitory process, with an age-dependent expected permanent income growth factor of Γ_j:

$$Y_{it} = \theta_{it} P_{it}, \qquad P_{it} = \Gamma_j \psi_{it} P_{it-1}. \tag{3}$$

We assume that the (mean one) permanent income shocks ψ_{it} are drawn iid and distributed lognormally. The transitory income shocks θ_{it} are likewise lognormally distributed, but with a point mass at $\underline{\theta}$ (representing unemployment benefits).

The price of housing relative to consumption π_t is also stochastic and follows a geometric random walk with drift (by factor G):

$$\pi_t = G \eta_t \pi_{t-1}. \tag{4}$$

The house price shock η_t is mean one and lognormally distributed, and assumed to be shared across all households i in period t.[6]

3.1.4 Choices and Budget

As noted above, the agent's decision-time state is characterized by $(M_{it}, \overline{H}_{it}, P_{it}, \pi_t)$, and he makes a discrete choice $d_{it} \in \{0, 1, 2\}$ followed by a continuous choice over C_{it} and H_{it}. When making his continuous choice, the agent must obey a collateral constraint on his end-of-period financial position, characterized by his end-of-period liquid wealth A_{it} and the size of house that he owns $\widehat{H}_{it}$ (which is zero for renters):

$$A_{it} + (1-\delta)\pi_t \widehat{H}_{it} \geq 0, \qquad \widehat{H}_{it} = \mathbf{1}(d_{it} > 0) H_{it}. \tag{5}$$

[6] Note that in our estimation, households can have different *subjective expectations* about the average growth rate of housing relative to other goods. For notational simplicity, we omit this complication when specifying the model.

That is, a household can end a period with negative financial assets, but he can only borrow proportionally to the value of its owned house. The parameter δ can be (roughly) interpreted as the required fraction of a home's value that must be provided as a down payment; its additive complement is the fraction of a home's value that can be used as loan collateral. Renters must hold non-negative end-of-period assets A_{it}.

If the household chooses to rent ($d_{it} = 0$) or to purchase a house ($d_{it} = 2$), any currently owned house is sold for its market value $\pi_t \overline{H}_{it}$; the agent pays proportional transaction cost ϕ, representing moving costs, selling costs, and transfer taxes. This leaves him with a single "net worth" level of:

$$W_{it} = M_{it} + (1 - \phi)\pi_t \overline{H}_{it}. \tag{6}$$

This value does not exist and is not relevant for an agent that chooses to remain in his already-owned home ($d_{it} = 1$).

Renter. We assume that the intensive margin of rental housing is purely transitory: the household can freely choose the size of his rented home each period, abstracting from any moving or search costs. Rent is charged according to the market value of the home, by proportion $\widehat{\alpha}$. Hence an agent who chooses to rent a home in period t will retain end-of-period financial assets of:

$$A_{it} = W_{it} - C_{it} - \widehat{\alpha}\pi_t H_{it} \text{ if } d_{it} = 0. \tag{7}$$

Total rental cost $\widehat{\alpha}$ represents the sum of maintenance cost proportion λ (discussed below) and a "rental wedge" parameter α, representing frictional costs or inefficiencies in the rental market.[7]

Stayer. A household agent that chooses to remain in his currently owned home can freely choose his consumption level C_{it} (subject to the constraint in (5)), but his choice of house size is strictly limited to that of the one he owns: $H_{it} = \overline{H}_{it}$ if $d_{it} = 1$. Such a household must pay *maintenance costs* (including property taxes) on his owned home

[7] We structurally estimate the parameter α, while $\widehat{\alpha} = \alpha + \lambda$ is the "household-facing" parameter.

at proportion λ of the house's value, so that end-of-period liquid assets will be:

$$A_{it} = M_{it} - C_{it} - \lambda \pi_t H_{it} \text{ if } d_{it} = 1. \tag{8}$$

Mover. After selling his prior owned house (if any), an agent that chooses to move to a new owned home can freely choose his level of consumption C_{it} and the size of house that he purchases H_{it} (again subject to the collateral constraint in (5)). However, he must pay maintenance costs on his newly purchased home, based on its value, hence his end-of-period liquid assets will be:

$$A_{it} = W_{it} - C_{it} - \lambda \pi_t H_{it} \text{ if } d_{it} = 2. \tag{9}$$

Note that (after selling his prior house) the mover's simultaneous decision on C_{it} and H_{it} is equivalent to a sequential decision on H_{it} only, followed by the stayer's decision over C_{it}.

If the agent dies, we assume that his estate is liquidated without transaction costs, resulting in a final net worth of:

$$\widehat{W}_{it} = M_{it} + \pi_t H_{it}. \tag{10}$$

3.1.5 Recursive Formulation and Normalization

At the terminal age J, when the household agent will surely die at the end of the period, the agent's maximum value of being in any state is given by:

$$V_J(M_{it}, \overline{H}_{it}, P_{it}, \pi_t) = \max_{C,H,d} U(C,H) + B(\widehat{W}_{it}) \qquad \text{s.t. (1)–(10).} \tag{11}$$

At any non-terminal age $j_{it} < J$, the agent's maximum value of being in any state (assuming he acts optimally in all future periods) can be expressed as:

$$V_j(M_{it}, \overline{H}_{it}, P_{it}, \pi_t) = \max_{C,H,d} U(C,H) + (1-\mathsf{D}_j)\beta \mathbb{E}_t \left[V_{j+1}(M_{it+1}, \overline{H}_{it+1}, P_{it+1}, \pi_{t+1}) \right] + \mathsf{D}_j B(\widehat{W}_{it})$$

$$\text{s.t. (1)–(10), for } j \in \{j_0, \cdots, J-1\}. \tag{12}$$

Following Li and Yao (2007), we simplify the problem by normalizing out the price state variables. Particularly, all money-metric variables are divided through by the agent's current permanent income level P_{it}, while the housing variables are first multiplied by the housing price level π_t and then divided by permanent income. We denote normalized variables by using lowercase:

$$m_{it} \equiv M_{it}/P_{it}, \qquad c_{it} \equiv C_{it}/P_{it}, \qquad a_{it} \equiv A_{it}/P_{it}, \qquad w_{it} \equiv W_{it}/P_{it}, \tag{13}$$

$$y_{it} \equiv Y_{it}/P_{it} = \theta_{it}, \qquad \overline{h}_{it} \equiv \overline{H}_{it}\pi_t/P_{it}, \qquad h_{it} \equiv H_{it}\pi_t/P_{it}, \qquad \widehat{h}_{it} \equiv \widehat{H}_{it}\pi_t/P_{it}.$$

The value function itself is normalized by the composite factor $(P_{it}/\pi_t^{\omega})^{1-\rho}$, so it can be expressed as:

$$V_j(M_{it}, \overline{H}_{it}, P_{it}, \pi_t) = (P_{it}/\pi_t^{\omega})^{1-\rho} v_j(m_{it}, \overline{h}_{it}). \tag{14}$$

With these substitutions, the normalized problem can be compactly written as:

$$\begin{aligned}
v_j\Big(m_{it}, \overline{h}_{it}\Big) &= \max_{d,c,h} U(c,h) + (1-\mathsf{D}_j)\beta\,\mathbb{E}_t\left[v_{j+1}\Big(m_{it+1}, \overline{h}_{it+1}\Big)\left(\frac{\Gamma_{j+1}\psi_{it+1}}{(G\eta_{t+1})^{\omega}}\right)^{1-\rho}\right] + \mathsf{D}_j B(\widehat{w}_{it}) \\
&\text{s.t.} \\
a_{it} &= \begin{cases} m_{it} + (1-\phi)\overline{h}_{it} - c - \widehat{\alpha}h & \text{if } d=0 \quad \text{Renter} \\ m_{it} - c - \lambda h, \qquad h = \overline{h}_{it} & \text{if } d=1 \quad \text{Stayer} \\ m_{it} + (1-\phi)\overline{h}_{it} - c - (1+\lambda)h & \text{if } d=2 \quad \text{Mover} \end{cases}, \\
\widehat{h}_{it} &= \mathbf{1}(d>0)h, \\
0 &\leq a_{it} + (1-\delta)\widehat{h}_{it}, \\
m_{it+1} &= \frac{R}{\Gamma_{j+1}\psi_{it+1}} a_{it} + \theta_{it+1}, \\
\overline{h}_{it+1} &= \frac{G\eta_{t+1}}{\Gamma_{j+1}\psi_{it+1}} \widehat{h}_{it}.
\end{aligned} \tag{15}$$

For any given parameterization, the normalized model can be solved recursively backward from the terminal age J to the earliest age in the model, j_0. We numerically solve the model using the endogenous grid method (EGM) first presented in Carroll (2004), employing a variation on the extension to discrete–continuous models discussed in Iskhakov et al. (2017).

Within each period, we separately solve the problems of the renter, the stayer, and the mover, computing a value function for each. The overall value function for the period is the upper envelope over the three discrete-choice-conditional value functions. As noted above, the choice problem for an agent that stays in the same house he already owns is univariate (consumption choice only), and the mover's problem can be treated as a sequential choice of house size (with only one continuous state) followed by the stayer's consumption problem. Moreover, the renter's problem is simplified by the fact that housing is also a consumption good in this context; with a Cobb–Douglas aggregator, the agent wants to use a *constant fraction* of his expenditure on housing, effectively reducing the control space to a single variable.

3.2 Discussion of the Model

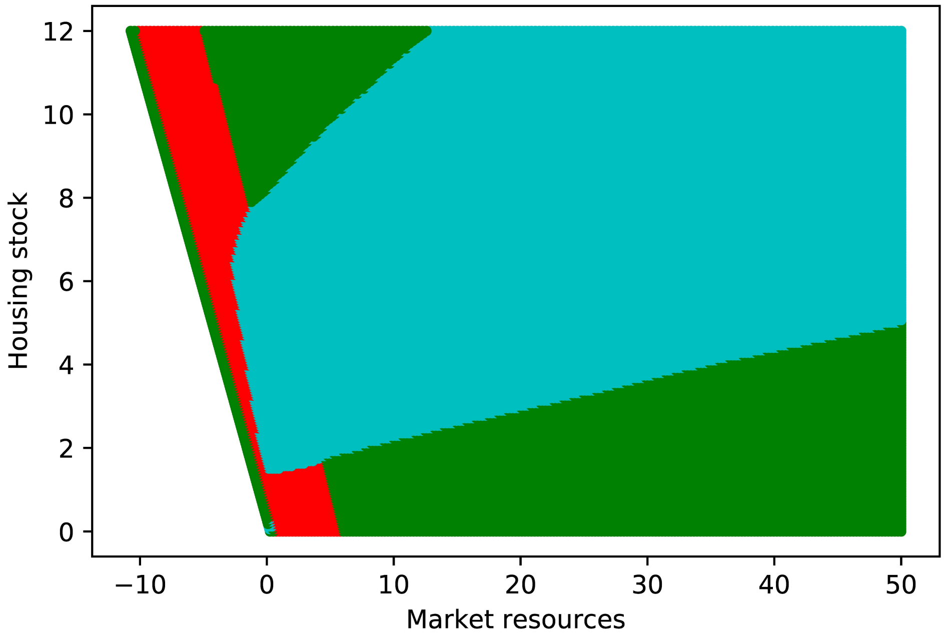
Our model is constructed to account for the key features of homeownership and housing wealth. Housing can either be owned or rented, and is modelled as a continuous variable whose adjustment is subject to transaction costs, proportional to the value of the house. These costs generate a region of inaction, so that homeowners adjust their house size only occasionally. Homeowners benefit from capital gains on housing and are subject to the collateral constraint, which tightens when house prices drop (from a shock to π_t).

The optimal housing status depends on liquid market resources and housing wealth, shown by example in Figure 2. When households hold market resources and housing wealth close to a certain ratio, they stay in the current house (the cyan region of inaction, "stay area"). When their market resources are too high or too low relative to the housing wealth, they move (upgrade or downgrade their house). When liquid market resources are low, households rent (red) and some of them save to accumulate wealth for a down payment.[8]

The size of the region of inaction (cyan) depends on preferences and house price beliefs. More patient households have a smaller stay area because they are more willing to pay the near term costs of moving. More patient households also have a smaller rent area because housing delivers a higher return than market resources. Similar, households more optimistic about house prices also have a smaller rent area. Compared to more

[8]At *very* low levels of liquid wealth, close to the collateral constraint, the agent will sell their current house and downgrade to a smaller one, rather than rent (the narrow green band to the left of the red band). Mathematically, households so close to the borrowing constraint prefer to own a very small home rather than to rent because it represents an additional asset they own in $t+1$. Likewise, an agent who does not own any home and finds themselves with *extremely* low assets will buy a *very* small home rather than rent (the tiny cyan streak in the bottom left corner). When the model is simulated, agents almost never visit these regions of the state space.

Figure 2 Optimal Housing Status as Function of Liquid Market Resources m and Housing Wealth h — An Example



Note: The figure shows an example of the optimal housing status as a function of liquid market resources m and housing wealth h (expressed as ratios of permanent income). The colors denote the optimal housing status: **Red**: Renter, **Cyan**: Stayer, **Green**: Mover ("Go").

pessimistic households, the stay area of more optimistic households is shifted upward: it is expanded upward as they are willing to hold a larger house (rather than downsize) because they believe staying in the house increases their wealth. In addition, the stay area of more optimistic households is reduced from below as households with low housing wealth are more willing to move, upgrade and benefit from the expected house price increases. The width of the "stay area" also scales with frictional transaction costs ϕ: as transaction costs go to zero, the region of inaction shrinks to nothing as households can costlessly move each period (as if they were model renters).

Our model is different from the models that study durable consumption (e.g., Carroll and Dunn, 1997 and Berger and Vavra, 2015) or portfolio choice between liquid and (generic) illiquid assets (e.g., Kaplan and Violante, 2014 and Bayer et al., 2019). Those models do not focus on the discrete choice between renting or owning a house; instead, they study the choice between adjusting or not the stock of durable goods or illiquid assets. Also, they do not target the life cycle profile of the homeownership rate and housing wealth, typically do not account for risky house prices and are usually calibrated, not estimated.

When estimating the model, we allow for a (modest) degree of heterogeneity in impatience and house price expectations. Specifically, we assume that the economy consists of households with varying degrees of impatience and expected mean growth rate of house prices. Beliefs about (average) house price growth $\widehat{G}$ are uniformly distributed with center $\grave{G}$ and half-width $\widetilde{G}$:

$$\widehat{G}_i = \grave{G} + \widetilde{G}\epsilon_{i1}, \qquad \epsilon_{i1} \sim \text{Uniform}[-1, 1]. \tag{16}$$

To allow correlation between the time discount factor and house price growth beliefs, we specify the (log) preference rate ϑ as uniformly distributed *conditional* on that individual's house price beliefs. This heterogeneity can be expressed as:

$$\beta_i = \Big(1 + \exp(\vartheta_i)\Big)^{-1}, \qquad \vartheta_i = \grave{\vartheta} + \widetilde{\vartheta}\epsilon_{i2} + \kappa\epsilon_{i1}, \qquad \epsilon_{i2} \sim \text{Uniform}[-1, 1]. \tag{17}$$

Here, κ represents the extent of correlation between house beliefs and patience: A negative value of κ implies that households optimistic about house prices (higher $\widehat{G}_i$) are more patient (higher β_i). This specification ensures that every individual's discount factor $\beta_i < 1$, no matter the distributional parameters. Note that the house price beliefs in our model $\widehat{G}$ are long-run beliefs about G, relating to the horizon over the rest of the lifetime.

We follow existing work which allows for preference heterogeneity and estimates its extent based on the data on wealth inequality, reaction of spending to income shocks and the structure of household portfolios (see, e.g., Krusell and Smith, 1998, Carroll et al., 2017, Krueger et al., 2016 and De Nardi and Fella, 2017 for heterogeneity in impatience, and Alan et al., 2018, Calvet et al., 2019 and Aguiar et al., 2023 for heterogeneity in risk aversion). In addition, substantial survey evidence documents that expectations of asset prices including house prices vary across households; see section 5.1.1 below. Importantly for our specification of heterogeneity in beliefs $\widehat{G}$ in (16), Giglio et al. (2021) estimate heterogeneous and persistent individual fixed effects in beliefs and find that this heterogeneity in beliefs is not well explained by observable respondent characteristics such as gender, age and wealth.

4 Estimation and Identification

This section describes how we estimate the model using microeconomic data on wealth from the five countries and explains how the empirical moments identify structural parameters. In the first stage, some parameters are calibrated using country-level aggregate or micro data (see Table 1). In the second stage, we estimate the remaining parameters by matching moments simulated from the model to those reported in household-level data on wealth.

4.1 Calibration

We begin with an overview of the calibration of parameters, including income processes, age profiles of wealth, house prices and housing market institutions. The model is calibrated, solved and simulated at annual frequency; for structural estimation we generate moments for five-year age brackets. We estimate the model country by country on cross-country comparable micro data from the 2014 wave of the Household Finance and Consumption Survey for France, Germany, Italy and Spain and the 2016 wave of the U.S. Survey of Consumer Finances.

Table 1 presents the calibration of key statistics of our model using various aggregate and micro data sources. Starting with the coefficient of the relative risk aversion, we fix its value at $\rho = 2$ in all countries. We take survival probabilities $1 - \mathsf{D}$ from the Human Mortality Database of the University of California, Berkeley. We calibrate the interest rate r at 3 percent, accounting for the fact that it reflects both return on saving and interest on mortgages.

Income Profiles and Processes. For the four European countries, the income processes were calibrated using micro data from the 2009–2019 EU Statistics on Income and Labour Conditions (EU SILC); for the U.S., we use income profiles based on PSID

Table 1 Calibration of Parameters

Parameter description	Symbol	Value					Source
		Germany	France	Italy	Spain	U.S.A.	
Preferences							
CRRA coefficient	ρ	2	2	2	2	2	
House prices							
Mean growth of house prices	G	1.010	1.032	1.000	1.023	1.026	Aggregate data, 1995–2020
Std dev of growth of house prices	$\text{std}(\eta)$	0.027	0.047	0.065	0.093	0.056	Aggregate data, 1995–2020
Income processes							
Share of college graduates		0.311	0.274	0.134	0.287	0.350	HFCN (2016), Table 1.3
Household head without a college degree							
Std dev of permanent income shock	$\text{std}(\psi)$	0.13	0.13	0.13	0.13	0.10	Le Blanc Georgarakos; CGM
Std dev of transitory income shock	$\text{std}(\theta)$	0.22	0.22	0.27	0.34	0.30	Le Blanc Georgarakos; CGM
Household head with a college degree							
Std dev of permanent income shock	$\text{std}(\psi)$	0.14	0.14	0.18	0.12	0.13	Le Blanc Georgarakos; CGM
Std dev of transitory income shock	$\text{std}(\theta)$	0.21	0.21	0.29	0.28	0.24	Le Blanc Georgarakos; CGM
Unemployment probability	$\underline{\theta}$	0.050	0.050	0.050	0.050	0.050	
Net Unemployment replacement rate	μ_U	0.59	0.68	0.74	0.78	0.59	OECD, 2020
Net Pension replacement rate	τ	0.50	0.75	0.90	0.85	0.58	OECD, 2018
Mandatory retirement period	T	45	45	45	45	45	
Maximum life cycle period	J	65	65	65	65	65	
Survival probability	$1-\mathsf{D}$						Human Mortality Database
Housing market institutions							
Down payment requirement	δ	0.35	0.20	0.40	0.25	0.20	EDW; ECB (2019), Chart 6
Cost of selling house (roundtrip)	ϕ	0.0783	0.120	0.120	0.110	0.0475	OECD (2012)
Risk-free interest rate	r	0.03	0.03	0.03	0.03	0.03	Aggregate data

Note: OECD 2018 refers to data from 2018 from the publication "Pensions at a Glance 2021: OECD and G20 Indicators," OECD Publishing, Paris. OECD 2020 refers to the publication "Benefits and Wages: Net Replacement Rates in Unemployment (edition 2020)," OECD Social and Welfare Statistics (database). CGM refers to Cocco et al. (2005).

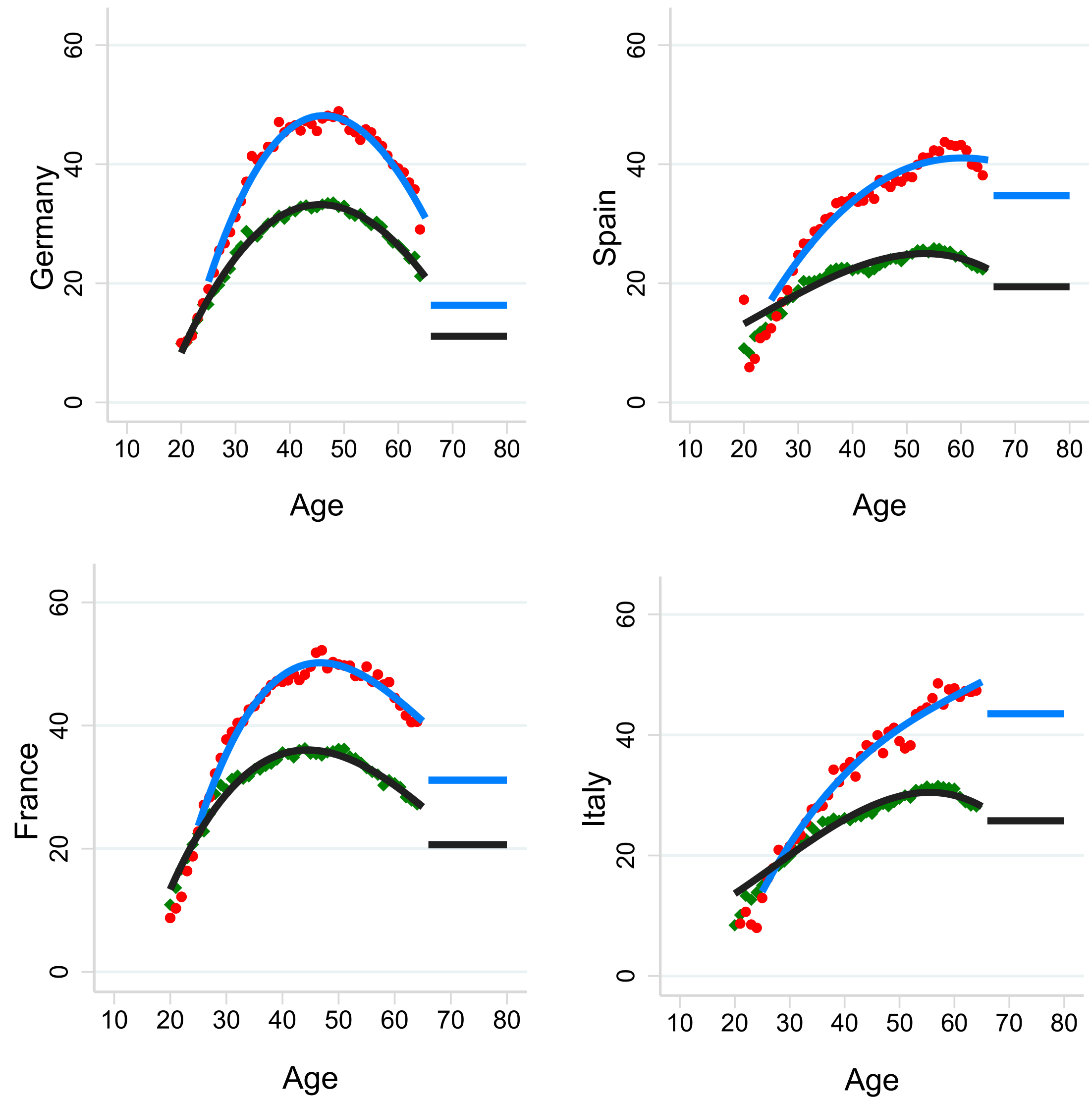
data as estimated in Cocco et al. (2005). Similar to other work (e.g., Cocco et al., 2005 and Calvet et al., 2019), we estimate income profiles for groups of households depending on their education: (i) households in which the head does not have a college degree and (ii) those with a college degree. The net unemployment replacement rates and net pension replacement rates were calibrated using OECD data (from Social and Welfare Statistics and Pensions at a Glance, respectively). All households are born at the age of 20 (with the initial time period $j_0 = 1$), retire at the age of 65 (i.e., $T = 45$) and the maximum age is 85 (i.e., $J = 65$). As in Cocco et al. (2005), the profiles were estimated by regressing net disposable income on the third degree polynomial of age (see Appendix C for details).

Income profiles differ substantially across the five countries (Figure 3). In the first group of countries (Germany, France and the U.S.) the profiles are strongly hump-shaped, peaking around the ages of 40–50 years. In contrast, in Italy and Spain, incomes keep rising until later in life or even until retirement age. In addition, in all countries, incomes irrespective of the educational attainment start around the same level for young people but incomes of college educated households rise steeply, so that roughly after the age of 30 they substantially exceed incomes of households without a college degree. The gap between the incomes of the two groups keeps widening almost until retirement.

The standard deviations of permanent and transitory income shocks were calibrated using the estimates of Le Blanc and Georgarakos (2013) (see also the special volume Review of Economic Dynamics, 2010 and Carroll et al., 2014, Table 1 for an overview of estimates in European data).

Wealth Profiles. The empirical moments of age profiles of the seven variables that we use in the SMM estimation below were calculated using micro data from the 2014 wave of the Household Finance and Consumption Survey (for France, Germany, Italy and Spain) and the 2016 wave of the U.S. Survey of Consumer Finances: (i) homeownership rate, (ii) average housing wealth–income ratio of homeowners, (iii) average rent–income ratio of renters, and (iv)–(vii) average and median net wealth–income ratios of homeowners

Figure 3 Median Non-asset Disposable Income



Source: EU Statistics on Income and Living Conditions, 2009–2019.
Note: The figure shows the average income levels (red and green dots) and smoothed income profiles (blue and black curves) calculated for two education levels, below college and college and above, as described in Appendix C.

and renters (see Appendix D for figures of all empirical moments, Figures 21–22). The moments were calculated using the corresponding wealth and income components (and applying household weights). The homeownership rate was calculated based on a dummy variable indicating households' ownership of the main residence. Housing wealth of homeowners reflects the value of the household main residence (and does not include the value of other real estate). Rent–income ratios reflect rent payments of renters as a share household income. Net wealth is the sum of housing wealth and financial wealth, net of total debt.[9]

The seven moments tend to rise with age, reflecting accumulation of wealth and its components over the life cycle, with only little de-cumulation during the retirement. The increases in homeownership rate at younger ages vary across countries, although the gaps between countries tend to persist throughout the life cycle, with the share of homeowners in Germany substantially lower than in Spain, the U.S. and Italy (Figure 21). The mean (gross) housing wealth–income ratios of homeowners tend to rise from around 4 to around 6, considerably boosted by the fall of income in retirement. Substantial differences persist across countries with low levels in the U.S. and high levels in Italy, Spain and France. Mean rent–income ratios range roughly between 0.15 and 0.35, with high levels in France and the U.S.

Figure 22 shows mean and median ratios of net wealth to income for homeowners and renters. All series tend to rise more steeply than housing wealth–income ratios, reflecting the repayment of (mortgage) debt and accumulation of financial wealth. For homeowners, ratios increase from around 2 to more than 10 for the mean and from around 2 to roughly 8 for the median.[10] For renters, the ratios of net wealth are much lower, ranging typically between 1 and 3 for the mean and well below 1 for the median, and tend to rise only modestly.

[9] As this paper focuses on capturing the extensive and intensive margins of housing wealth, we normalized mean aggregate net wealth–income ratio to be the same across the five countries, which strongly reduces the cross-country variation in estimated mean discount factors $\grave{\beta}$.

Net wealth–income ratios were topcoded at 50 for households younger than 65 years and at 200 for the remaining households. We dropped from the sample households with very low annual incomes (less than EUR 3,000).

[10] The net wealth–income ratios for homeowners in Italy at young ages are higher than in the other countries.

House Prices. Rather than structurally estimate the mean house price beliefs $\grave{G}$, we instead match it to actual, long-run average growth rate of real house prices in aggregate data, 1995–2020 for the five countries (Figure 19). This choice ensures that the average (long-run) expectations are rational (unbiased), and not unrelated to actual house prices. This feature is appealing also in light of the evidence that house price expectations fully revert toward the unconditional mean of actual house price growth within several years (Li et al., 2023).

The calibration uses aggregate time series on house prices (adjusted for inflation), 1995–2020, obtained from the OECD Analytical House Price Database (Figure 19). The values are: 0 percent for Italy, 1 percent for Germany, 2.3 percent for Spain, 2.6 percent for the U.S. and 3.2 percent for France. Similarly, the standard deviations of the house price shocks η are calibrated using aggregate house price data and range between 0.027 in Germany and 0.093 in Spain.

Housing Market Institutions. Our calibrations build on the work measuring housing market institutions (following Cardarelli et al., 2008 and Andrews et al., 2011). Specifically, we calibrated the down payment requirement δ primarily using data from Gaudencio et al. (2019), chart 6, p. 15. The statistics on down payment ratios were constructed using the European DataWarehouse (EDW), `https://www.eurodw.eu/`, which collects loan-level data on loans underlying asset-backed securities, including residential mortgage-backed securities. The dataset provides arguably the best available information on loan standards, collected consistently across euro area countries. We calibrate down payment requirements to range between 0.40 for Italy and 0.20 for the U.S. These values reflect similar calibrations in the literature, e.g., Cardarelli et al. (2008). Costs of selling a house were calibrated based on OECD (2012), chapter 2. They range between 4.75 percent in the U.S. and 12 percent in France and Italy.

4.2 Structural Estimation

We estimate the remaining model parameters with the simulated moments method (SMM). Specifically, we estimate structural parameters ξ consisting of (i) the spread of house price beliefs $\widetilde{G}$; (ii) housing market parameters, including the rental wedge α and the costs of maintaining a house λ; and (iii) preference parameters, including mean and spread of the (log) preference rate $\grave{\vartheta}$ and $\widetilde{\vartheta}$, the share of housing in the utility function ω, the magnitude of the bequest motive L, and the interaction between the discount factor and mean house price beliefs κ:

$$\xi \equiv \Big\{ \underbrace{\widetilde{G},}_{\substack{\text{House price}\\ \text{beliefs}}} \quad \underbrace{\alpha, \lambda,}_{\substack{\text{Housing market}\\ \text{institutions}}} \quad \underbrace{\grave{\vartheta}, \widetilde{\vartheta}, \omega, L, \kappa}_{\text{Preferences}} \Big\}.$$

Let $x = \{x_1, \ldots, x_N\}$ be the actual empirical data, $m(x)$ be moments based on these data, $\widetilde{x} = \{\widetilde{x}_1, \ldots, \widetilde{x}_S\}$ be S simulations of data from the model and $\widehat{m}(\widetilde{x}|\xi) = 1/S \sum_{s=1}^{S} m(\widetilde{x}_s|\xi)$ be the counterpart moments simulated from the model (averaged across simulations). The estimation procedure minimizes the distance between moments in the data $m(x)$ and those simulated from the model $\widehat{m}(\widetilde{x}|\xi)$:

$$\widehat{\xi} = \arg\min \Big(m(x) - \widehat{m}(\widetilde{x}|\xi)\Big)' \Omega^{-1} \Big(m(x) - \widehat{m}(\widetilde{x}|\xi)\Big),$$

For the weighting matrix Ω, we use a diagonal matrix with the inverse variances of each of the empirical moments, thus putting more weight on the moments for which the data is "more confident". The SMM estimator is then efficient and asymptotically normal:

$$\sqrt{N}(\widehat{\xi}_N - \xi_0) \rightarrow_d \mathcal{N}(0, \Sigma),$$

with the variance matrix $\widehat{\Sigma} = (\widehat{D}\,\widehat{\Omega}^{-1}\widehat{D'})^{-1}$, for which:

$$\widehat{D'} = \frac{\partial \widehat{m}(\widetilde{x}|\xi)}{\partial \xi'}\bigg|_{\xi=\widehat{\xi}}.$$

4.3 Identification

To estimate the model for each country, we choose as empirical moments m the following age profiles, using ten age brackets: homeownership rate, average rent–income ratio, average (gross) housing wealth–income ratio of homeowners, and both average and median net wealth–income ratios for homeowners and renters. These moments reflect the distribution of the extensive and the intensive margin of housing and net wealth over the life cycle. The moments are standard in similar work estimating life cycle models with housing, e.g., Li et al. (2016), Bajari et al. (2013) and Landvoigt (2017). The empirical moments $m(x)$ identify the parameters $\xi = \left\{\widetilde{G},\, \alpha, \lambda, \grave{\vartheta}, \widetilde{\vartheta}, \omega, L, \kappa\right\}$ as follows.

First, the overall *level* of homeownership (across ages) identifies the rental wedge parameter α. A homeowner pays a λ fraction of their home's value in maintenance costs, while a renter pays $\widehat{\alpha} = \lambda + \alpha$ fraction of their unit's value, so that the rental wedge represents the cost *beyond* ownership (representing inefficiency in the rental market, *inter alia*). Thus a higher value of α makes renting less appealing and increases the share of homeowners. Given the costless adjustment of housing for renters, the weight of housing ω in utility is pinned down by the empirical rent–income ratio. That is, our model predicts that agents will use a constant fraction of their spending on rent, and this fraction is strictly determined by ω.

Next, the spread of house price beliefs $\widetilde{G}$ is identified by the *slope or shape* of the homeownership profile. All else equal, someone being more optimistic about future house price growth makes them more likely to prefer home-owning over renting– and to purchase a home earlier in their lifecycle in order to benefit from high returns for longer. People who are very optimistic about future house price growth purchase their house at a young age, while those who are somewhat less optimistic buy their house later in life. This means that if the dispersion of house price beliefs is wider, the homeownership profile rises less steeply as some people buy a house early while others delay until later in life. Conversely, low dispersion in house price growth beliefs would cause the model to predict a sharp uptake of homeownership in a narrow range of ages.

The maintenance cost parameter λ is identified by the level of housing wealth of homeowners. It is a flow, per-period cost that affects how attractive it is to hold housing wealth relative to liquid wealth. In effect, maintenance costs reduce homeowners' return on housing, hence the more expensive it is to maintain the house, the smaller a house the homeowners buy relative to their income. Recall that the center (mean) of house price beliefs $\grave{G}$ is calibrated to recent historical data for each country. If we did not use aggregate time-series data on house prices to identify the mean house price beliefs, the two parameters $\grave{G}$ and λ would not be separately identified from the available moments.[11]

The shape and relative levels of the four wealth-to-income profiles (mean and median for homeowners and renters separately) identify the remaining preference parameters. As typical in consumption-saving models, an agent's (log) time preference rate ϑ is a strong determinant of the rate at which they accumulate assets over their working life: more patient households (lower ϑ) put more weight on the future, making them more willing to defer utility flows into the future. The relationship between ϑ and wealth accumulation is highly convex, with increases in patience associated with progressively more wealth accumulation. Hence the center $\grave{\vartheta}$ and spread $\widetilde{\vartheta}$ of (log) time preference rates are identified by the slope of wealth accumulation and the difference between mean and median (within homeowners and renters, but especially the former). Likewise, the interaction (correlation) between house price beliefs and time preferences κ is identified by the difference in wealth accumulation between owners and renters. That is, a positive value of κ means that optimistic households (who will tend to be owners) are also impatient (higher ϑ), so they will accumulate less wealth; a negative κ pushes owners to hold more total wealth than renters.[12] Finally, the strength of the bequest motive L is identified by the shape of the net wealth profile late in life. Households whose wealth declines less quickly are interpreted to have a stronger bequest motive.

5 The Results

This section describes the structural estimates and relates them to existing survey data on house price expectations and rental market institutions. We then propose a decomposition which quantifies the impact of house price beliefs, housing market institutions and preferences on homeownership rates and holdings of housing wealth.

5.1 Structural Estimates

Table 2 shows the structural estimates $\xi = \left\{\widetilde{G}, \alpha, \lambda, \grave{\vartheta}, \widetilde{\vartheta}, \omega, L, \kappa\right\}$ of three groups of parameters : (i) house price beliefs, (ii) housing market institutions and (iii) preferences.

The mean beliefs about house price growth $\grave{G}$ were calibrated at long-run growth rate of actual past house prices, 1995–2020, ranging between 0 percent in Italy and 3.2 percent in France.

The dispersion in house price expectations $\widetilde{G}$ is estimated to range between 1.7 percent in the U.S. and 3.7 percent for Spain; see Figure 4. (The corresponding band for expectations is twice as wide: $[\grave{G} - \widetilde{G}, \grave{G} + \widetilde{G}]$.) These values are in line with the dispersion of long-run house price expectations of households documented in survey data; see section 5.1.1 below.

The estimates of maintenance costs λ, which include property taxes, range between 2 percent in Spain and 7 percent in Italy and the U.S. Data measuring maintenance costs are rare. For the U.S., Li and Yao (2007) calibrate the costs at 3 percent, while Li et al. (2016) estimate them at 1.7 percent.

The user cost of owner-occupied housing, the sum of maintenance costs and interest rate net of housing capital gains: $\lambda + r - G$, implied by these values ranges between close to 2 percent in Spain and around 7 percent for Italy and the U.S. Himmelberg et al. (2005) estimate comparable user costs across 46 metropolitan areas in the U.S. (with available data) ranging between 3.3 and 7.1 percent.

[11] If we instead calibrated λ from some outside source, then the mean of house price growth beliefs $\grave{G}$ would be identified by the housing wealth profile.

[12] In our data, renters hold very little wealth, a fairly well known fact. This relationship is in line with survey evidence on expectations (discussed in section 5.1).

Table 2 Structural Estimates

Parameter	Description	Germany	Spain	France	Italy	U.S.A.
House price beliefs						
$\grave{G}$	Mean of house price growth factor beliefs	1.010	1.023	1.032	1.000	1.026
	(calibrated)	(—)	(—)	(—)	(—)	(—)
$\widetilde{G}$	Spread of house price growth factor beliefs	2.92e-2	3.69e-2	3.13e-2	2.65e-2	1.71e-2
		(0.19e-2)	(0.03e-2)	(0.07e-2)	(0.03e-2)	(0.04e-2)
Housing market institutions						
λ	Owned housing maintenance cost	3.03e-2	2.07e-2	5.91e-2	7.04e-3	6.79e-2
		(0.21e-2)	(0.09e-2)	(0.07e-2)	(0.64e-3)	(0.18e-2)
α	Rental wedge	2.05e-2	4.09e-2	2.56e-2	4.04e-2	1.76e-2
		(0.19e-2)	(0.09e-2)	(0.07e-2)	(0.07e-2)	(0.18e-2)
Preferences						
$\grave{\vartheta}$	Mean of log intertemporal discount rate	9.17e-2	4.84e-2	7.49e-2	5.57e-2	3.50e-2
		(0.02e-2)	(0.02e-2)	(0.01e-2)	(0.04e-2)	(0.08e-2)
$\widetilde{\vartheta}$	Spread of log intertemporal discount rate	0.298	0.231	0.145	9.50e-2	8.08e-2
		(0.005)	(0.001)	(0.000)	(0.09e-2)	(7.87e-2)
ω	Share of housing in utility function	0.177	0.207	0.271	0.198	0.233
		(0.003)	(0.007)	(0.002)	(0.003)	(0.002)
L	Bequest motive magnitude	20.26	21.21	10.51	17.87	4.488
		(0.81)	(0.32)	(0.18)	(0.44)	(0.641)
κ	Interaction factor between discount rate	-1.80e-2	-1.11e-2	-1.63e-2	-1.37e-2	-1.53e-2
	and house price growth beliefs	(0.04e-2)	(0.00e-2)	(0.01e-2)	(0.07e-2)	(0.02e-2)
	Optimal value of the objective function	589.689	366.200	1456.827	725.904	816.842

Note: Numbers in parentheses show standard errors calculated using the delta method.

The rental wedge α, the difference between rents and maintenance costs, varies substantially across countries ranging from around 2 percent in the U.S., Germany and France to 4 percent in Spain and Italy. A higher wedge reflects a lower quality of rental housing and a higher segmentation between rental and owner-occupied housing markets, making housing for renting harder to substitute with housing for owning: it makes renting less appealing and increases the share of homeowners.[13] Our structural estimates of the rental wedge correspond to the measures of the quality and segmentation of the rental markets in a separate literature (Kindermann and Kohls, 2018, Andrews et al., 2011, Greenwald and Guren, 2021, Malmendier and Steiny Wellsjo, 2023; see also section 5.1.2 below).[14]

Our estimates of the total rental cost implied by maintenance costs and the rental wedge, $\widehat{\alpha} = \lambda + \alpha$, range between 5 percent (of the housing wealth) in Italy and Germany and 8.5 percent in the U.S. These values are somewhat higher than the historical time series evidence on rent–price ratios of Jordà et al. (2019) of around 4 percent. For the U.S., Li and Yao (2007) calibrate rental cost at 7.5 percent and Li et al. (2016) estimate them at 4.9 percent (consisting of maintenance costs of 1.7 percent and the rental premium of 3.2 percent).

Similar to house price beliefs, we assume that the (log) preference rate ϑ as uniformly distributed (conditional on the individual's house price beliefs) over an interval, which we estimate. The parameters $\grave{\vartheta}$ and $\widetilde{\vartheta}$ are pinned down by the distribution of net wealth (mean and median for renters and homeowners). To limit the differences in discount factors across countries, we normalize the mean net wealth in each country to coincide (at the value of its mean across countries). The implied mean discount factors $\grave{\beta}$ lie at around 0.91–0.97, values in line with many estimates in the literature. The dispersion $\widetilde{\vartheta}$ conditional on expected house price beliefs is quite small (Figure 4).

[13]In Greenwald and Guren (2021)'s general equilibrium model the segmentation between rental and owner-occupied housing markets determines the slope of the housing "tenure supply" curve, the menu of house price–rent ratios at which landlords are willing to supply different amounts of rented housing to the owner-occupied market. When it is difficult to convert between renter-occupied and owner-occupied housing, the tenure supply curve is steeper, implying that housing demand shocks (e.g., due to changing credit availability) strongly affect the price–rent ratio and only slightly the homeownership rate. In such setup with substantial segmentation the rental wedge is high.

[14]While we model the rental wedge differently from Kindermann and Kohls (2018), our interpretation of it as a proxy summarizing the various institutional features of the rental markets is similar to theirs.

The estimated share of housing expenditures on total consumption ω ranges between 0.177 in Germany and 0.271 in France. These values correspond quite well to the share of spending on housing measured in national accounts and micro data on consumption expenditures (see, e.g., Andrews et al., 2011, Figure 1).

The bequest magnitude L in Spain, Germany and Italy ($L = 18$ to 21) substantially exceeds the magnitude in France ($L = 11$) and especially in the U.S. ($L = 4$). For the U.S., Li et al. (2016) estimate the bequest strength of 7.6.[15]

We estimate a strong positive relationship between the discount rate and the mean expected growth of house prices, κ (Figure 4).[16] This means that more patient households are more optimistic about house prices and want to accumulate housing wealth. In contrast, less patient people, who accumulate less total wealth, are pessimistic about house prices and rent housing rather than buying it: Renters are thus both impatient and pessimistic about house prices and, consequently, prefer consuming to accumulating net wealth and do not want to buy a house either.

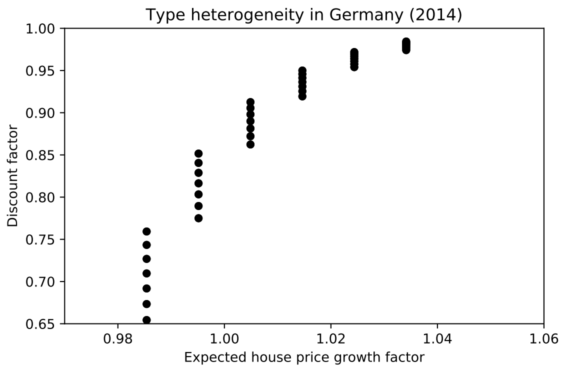
The positive relationship between the discount rate and optimism about house prices is in line with additional evidence. First, a key fact in the data is that renters accumulate much less net wealth than homeowners (partly perhaps because illiquid housing serves as a commitment for the accumulation of wealth as in Kovacs et al., 2021): While renters typically hold around one annual income worth in net wealth (or even less), homeowners own wealth worth a multiple of around 4–10 of income (see Figure 22). Second, survey data on expectations document that high-economic status households (who tend to be more patient) are more optimistic, see, e.g., Das et al. (2020). The positive relationship between patience and wealth accumulation has also been documented in Epper et al. (2020).

The model fits the data reasonably well; see Figure 5 for a summary of the two moments for housing wealth and Figures 10–14 for all seven moments. The overall fit is

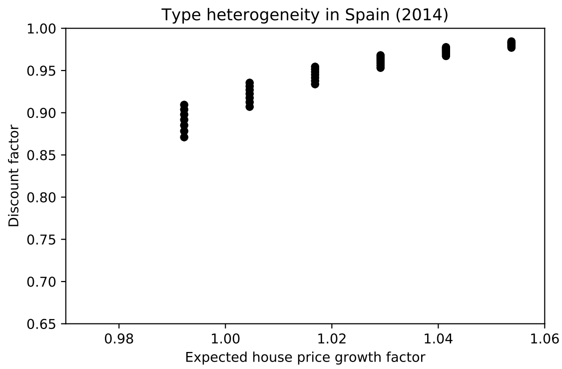
[15] Angelini et al. (2014) and Nakajima and Telyukova (2016) document cross-country difference in housing and saving behavior of retirees. The decumulation of wealth late in life is affected by other factors not included in our model, e.g., out-of-pocket medical expenses, capital gains taxation or pension systems.

[16] We impose a nonlinear (logistic) transformation to make sure that the discount factor lies below 1. The relationship was estimated for 7 household types by discount factor times 6 types by house price expectations.

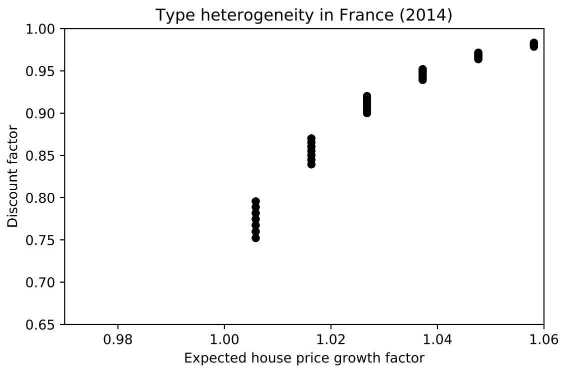
Figure 4 Estimated Relationship Between the Discount Factor and House Price Expectations



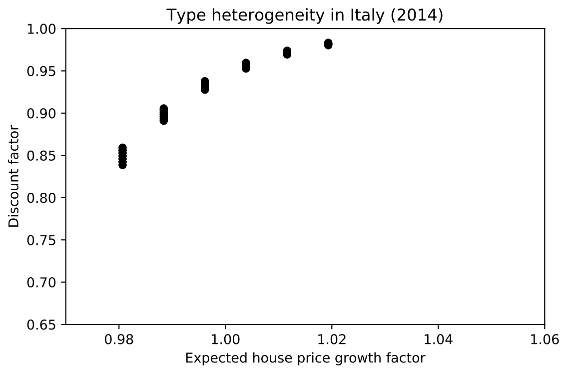
(a) Germany



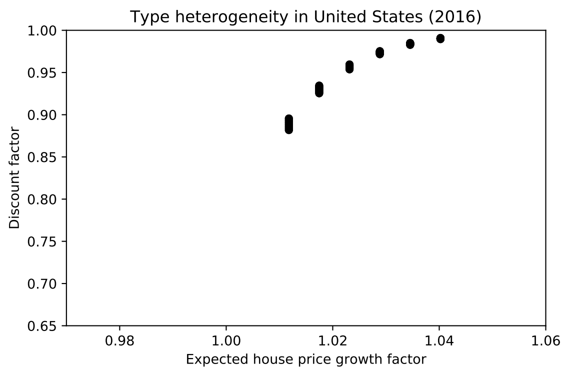
(b) Spain



(c) France



(d) Italy

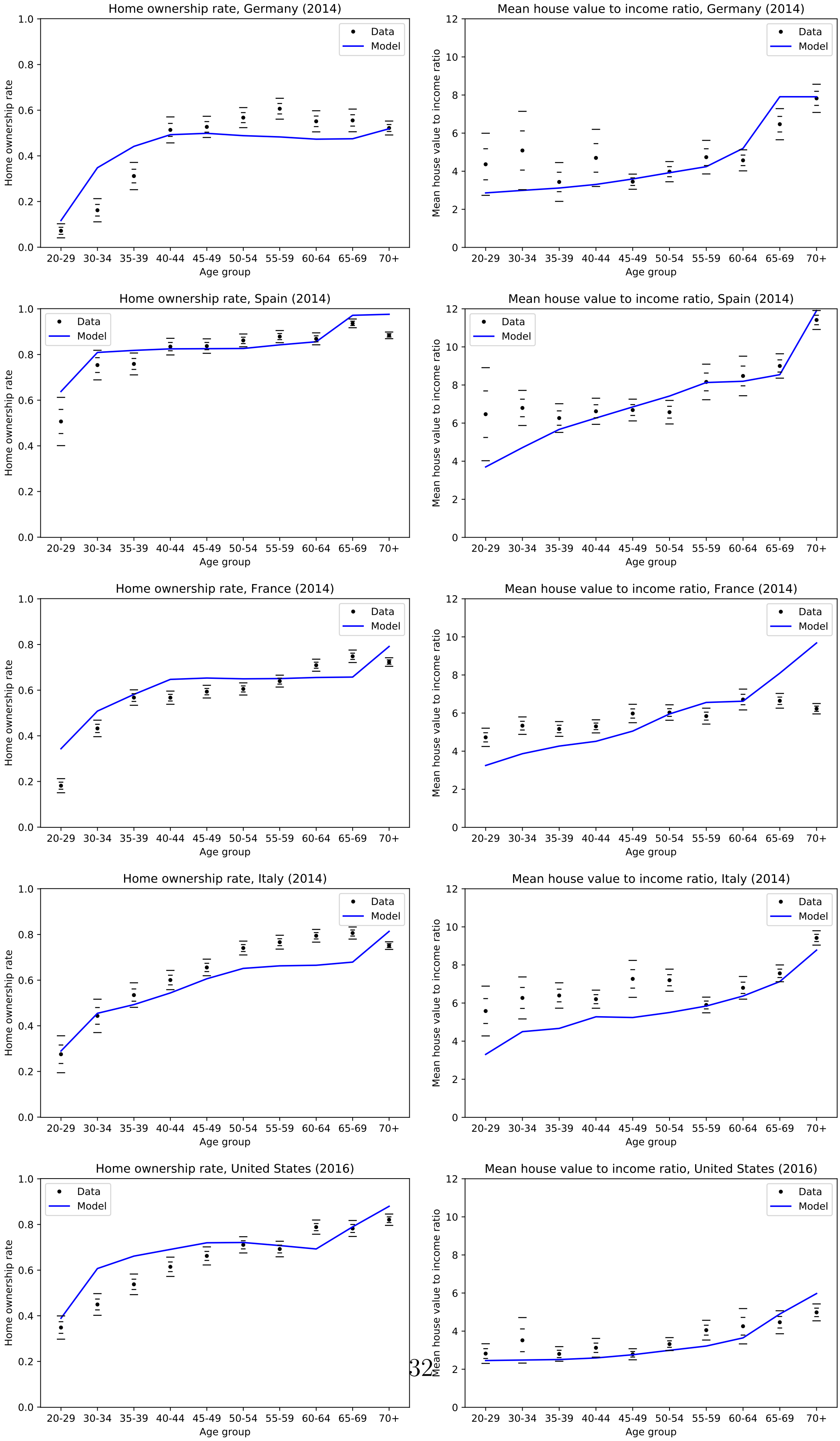


(e) United States

Note: The figure shows the estimated relationship between the discount factor β and the expected house price growth $\widehat{G}$. The relationship was estimated for 7 household types by discount factor times 6 types by house price expectations, imposing a logistic transformation, which ensures that the discount factor lies below 1 for all households. The same 42 types are used for each of the two education groups.

good in Spain and Germany, as reflected by the optimal value of the objective function

Figure 5 Fit of Moments: Homeownership Rates and Housing Wealth–Income Ratios



Source: Household Finance and Consumption Survey, wave 2014; Survey of Consumer Finances, 2016.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

of around 600, and is worse in particular in France (with the value of about 1450; see Table 2).

Given our interest in housing, let us focus on the homeownership rates and holdings of housing wealth (shown in the Figure 5). The model captures quite well the shape of the age profile of the homeownership over the life cycle. For some countries (Germany, France, the U.S.) the model overestimates homeownership for younger households[17], while for some it underestimates it for households around the age of 60 (Italy). As for the holdings of housing wealth relative to income, the model also generally does a good job at fitting the level. For some countries though (France), it is not able to match the flat profile and implies an increase over the life cycle, driven by the the rising trend in house prices. The model generally fits reasonably well the moments for rents and net wealth.

5.1.1 Evidence from Survey-Based House Price Expectations

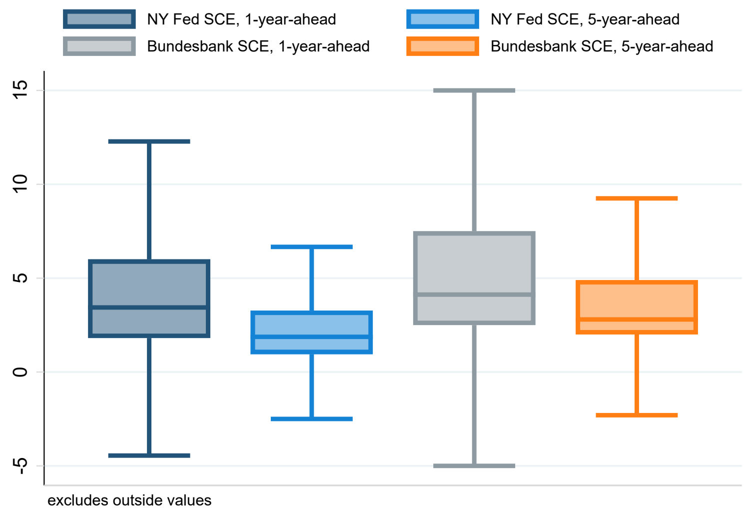
Let us compare our structural estimates of the spread in house price beliefs $\widetilde{G}$ to the spread documented in survey data on expectations. Burgeoning literature is documenting pervasive heterogeneity in measures of subjective expectations of households elicited in surveys (Adelino et al., 2018, Ben-David et al., 2018, Kuchler and Zafar, 2019, Das et al., 2020, Kuchler et al., 2023 and others).

So far the literature on self-reported expectations has however predominantly focused on documenting stylized facts in the data. Instead, our structural model estimates how much heterogeneity in house price expectations is needed to improve the fit of a model with housing, and our decomposition below quantifies the effect of beliefs on housing wealth.

Dispersion of households' subjective expectations of house price growth for the 1-year-ahead horizon exceeds that for the 5-year-ahead horizon; the interquartile range for the

[17] Differences in homeownership rates at the beginning of the life cycle across countries are well documented and due to co-habitation of young adult household members with older generations, in particular in Southern European countries. Using an overlapping generations model, Grevenbrock et al., 2023 show that the preference of younger households to live with their parents can rationalise these differences for Germany vs. Italy. We do not include similar preferences in our model as accounting for co-habitation accounts for almost no differences in homeownership rates of young households in between Germany, France and the US.

Figure 6 Dispersion of 1-Year and 5-Year Ahead House Price Growth Expectations



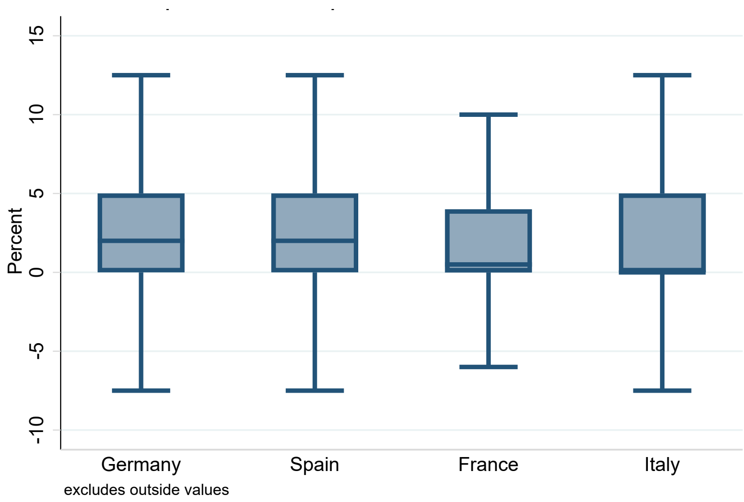
Source: New York Fed Survey of Consumer Expectations, 2014–2019; Bundesbank Survey on Consumer Expectations, 2019.
Note: The figure shows the dispersion of household expectations at the 1-year and annualized 5-year horizons for the U.S. and Germany in percent. The box plot shows the lower adjacent value, the 25th percentile, the median, the 75th percentile and the upper adjacent value. The adjacent values are the 25th percentile − 1.5×interquartile range and the 75th percentile + 1.5×interquartile range.

former is around 5 percent, while for the latter around 3 percent (Figure 6). In our setup (of section 3) and for our purpose (explaining long-run difference in homeownership and housing wealth), long-run house price beliefs (over the remaining lifetime) matter much more than short-run beliefs (over the next year), which are much less important for investment in housing given the substantial house-selling costs. Data from the U.S. and Germany document that for the 5-year horizon, the interquartile range is roughly around 3 percent, in line with our estimates of the spread $\widetilde{G}$ in Table 2.[18]

The interquartile range for the 1-year horizon is roughly 5 percent, reflecting the higher volatility of short-run expectations and their sensitivity to contemporaneous and recent house price changes (see Armona et al., 2018 and others). Figure 7 documents in data from the ECB Consumer Expectations Survey that the interquartile range of

[18]Most available surveys measure house price expectations only at the short, 1 year ahead. The two surveys shown in Figure 6 are to our knowledge the only ones that report household expectations at the 5-year horizon (and horizons longer than 1 year).
Li et al. (2023) document that experts' long-horizon forecasts of house prices are less dispersed than short-horizon forecasts.

Figure 7 Dispersion of 1-Year Ahead House Price Growth Expectations



Source: ECB Consumer Expectations Survey, April 2020–May 2023.
Note: The figure shows the dispersion of household expectations at the 1-year horizon for Germany, Spain, France and Italy in percent. The box plot shows the lower adjacent value, the 25th percentile, the median, the 75th percentile and the upper adjacent value. The adjacent values are the 25th percentile − 1.5×interquartile range and the 75th percentile + 1.5×interquartile range.

the 1-year-ahead forecasts does not vary much across the four European countries and is roughly stable at around 5 percent.

These facts mirror qualitatively a similar finding of Li et al. (2023) for professional forecasters that dispersion in short-run forecasts is higher than in long-run forecasts. In addition, Li et al. (2023) report that long-horizon (4-year ahead) house price expectations are fully mean-reverting toward the realized long-run unconditional house price growth. This fact suggests that also for households 5-year ahead house price expectations shown in Figure 6 are a useful data benchmark for comparison of our model-based estimates of the dispersion of house price beliefs $\widetilde{G}$.

5.1.2 Evidence on the Quality of Rental Markets

Our structural estimates of the rental wedge α, the difference between rents and maintenance costs, correspond to the measures of the quality of the rental and housing market institutions and the segmentation of housing markets in separate empirical literature. Extensive work has collected indicators of various aspects of these institutions across countries: tax benefits of homeownership (tax relief on mortgages used to finance owner-occupied housing), rent controls, tenant protection (measures of tenant–landlord regulations, tenure security and ease of tenant eviction), availability of social housing, legal formalism and others; see Cardarelli et al. (2008), Andrews et al. (2011), Cuerpo et al. (2014), Kaas et al. (2021) and others.

Our estimates of the rental wedge imply that rental markets in the U.S., Germany and France (with the rental wedge of around 2 percent) are more efficient than in Spain and Italy (where the wedge is 4 percent).

Andrews et al. (2011) and Cuerpo et al. (2014) provide a detailed summary and quantitative measures of the various features of rental and housing markets across advanced economies. First, countries differ in the tax treatment of debt financing of the owner-occupied housing. The tax relief is more generous in the U.S. than in Spain, France and especially Italy (Andrews et al., 2011, Figure 17). In Germany, interest paid on mortgages for own-use properties is not tax-deductible.

Second, regulations which cover rental market and tenant–landlord relationships vary substantially across countries. Rent controls in the private rental market in France and especially Germany are stricter than in Spain, Italy and the U.S. (Andrews et al., 2011, Figure 19). Tenant–landlord regulations (including the ease of tenant eviction, tenure security and deposit requirements) provide more protection for tenants in Germany, Spain, Italy and France than in the U.S. (Andrews et al., 2011, Figure 20).[19]

In addition, the degree of procedural formalism of the legal system (which is related to the length of dispute resolution and enforceability of contracts) matters for the size of the rental market. Legal formalism in Spain and Italy exceeds that in France and Germany and is low in the U.S. (Djankov et al., 2003).

Separate work by Greenwald and Guren (2021) estimates for the U.S. a substantial degree of segmentation of betwen rental and owner-occupied housing markets. The fact that these two types of housing markets are highly frictional—close to fully segmented—implies that shocks such as changes in credit standards have a large effect on house

[19]The share of social rental dwellings on all dwellings in the five countries we investigate is below 5 percent, except for France, where it amounts to 14 percent, and has been declining (OECD, 2020).

prices and the price–rent ratios, but a small and statistically insignificant effect on the homeownership rate (see Landvoigt et al., 2015 for related results).

5.2 Cross-Country Differences in Housing Wealth—A Decomposition

We want to use our model to quantify which factors contribute to the substantial differences in the extensive and intensive margins of housing wealth across countries: homeownership rates and the value of housing wealth of homeowners. Concretely, we investigate how differences in parameters estimated in two countries (and other objects, such as income profiles) contribute to the differences in the fitted moments across the countries. The differences in estimated parameters $\widehat{\xi}$ across countries (together with the calibrated parameters) capture how the model fits the data moments.

Let us describe a decomposition for the example of the difference in fitted homeownership rates between Germany and Spain: $\widehat{m}(\widehat{\xi}^{DE}) \to \widehat{m}(\widehat{\xi}^{ES})$, where $\widehat{m}(\widehat{\xi}^{c})$ denotes the homeownership rate in country c (Germany or Spain) fitted by our model. We decompose the contributions of the various factors as follows. Starting from the parameter values for Germany we switch one by one each element of $\widehat{\xi}^{DE}$ to its Spanish value, so that we eventually end up at the fitted homeownership values for Spain. Thus, we investigate for each parameter by how much moving from German parameters to the Spanish affects homeownership.

Our model turns out to be substantially non-linear due to house selling costs and precautionary saving. This implies that the effect of each parameter on homeownership depends on the order in which it switches from its German to its Spanish value. To address this fact we estimate the decomposition for all possible orderings of parameters. We then report the mean effect (averaged across the orderings).

Specifically, we focus on nine factors that matter the most: the rental wedge (rents minus maintenance costs), house price beliefs (mean and spread), collateral constraint, discount factor (mean and spread), other preference parameters (share of housing and bequest motive), variance of actual house prices, maintenance costs, labor income and all other factors. For nine factors, there are $9! = 362,880$ orderings across which we average. In addition to the mean effect of each factor, we also report what we label as “90 percent confidence intervals,” which depict the dispersion between the 10th and 90th percentile of the effect across the orderings. The width of this interval indicates how nonlinear the model is; for an additive model the ordering of the factors would not matter and the interval would have zero width.

5.2.1 The Extensive Margin of Housing: Homeownership Rates

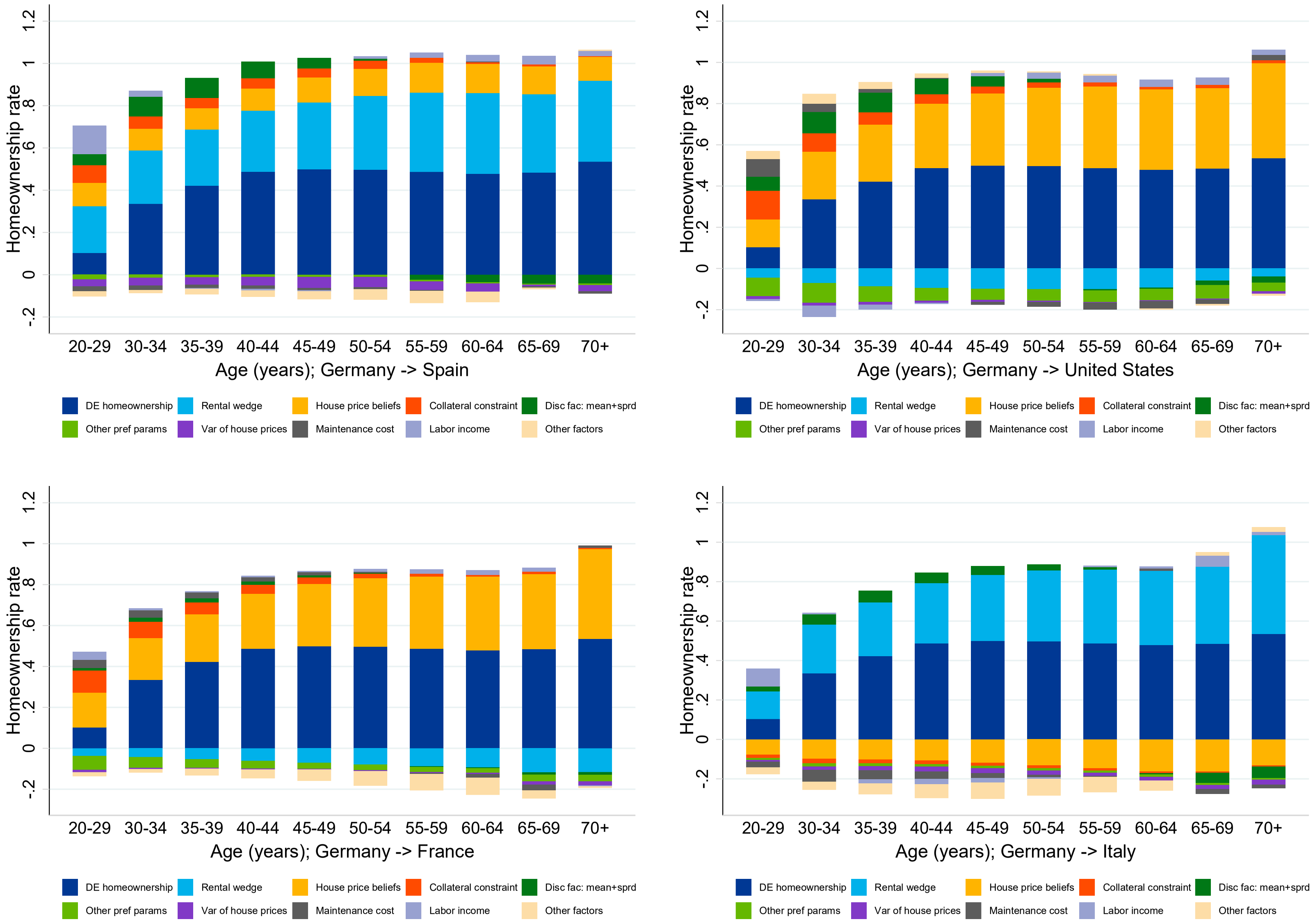
Let us start with the case of the extensive margin of housing, the homeownership rate; Figure 8 reports how the various factors contribute to explaining the gaps between Germany and the other four countries (see also Figure 15).[20] Throughout the life cycle, differences in homeownership rates are strongly affected by two variables: (i) house price beliefs and (ii) the rental wedge, the difference between rents and maintenance costs.

Quantitatively, these two variables matter roughly the same (with some differences across countries, depending on the relevant differences in parameters and homeownership gaps across the pairs of countries). House price beliefs range between 0 percent in Italy and 3.2 percent in France, with 1 percent in Germany and around 2.5 percent in Spain and the U.S. (see the aggregate house prices in Figure 19). Figures 8 and 15 document that a 1 p.p. difference in house price beliefs results roughly in a 15 p.p. difference in the homeownership rate. The rental wedge in Germany, France and the U.S. is just above 2 percent, while it amounts to around 4 percent in Spain and Italy, reflecting a less efficient rental market. Roughly speaking, the 2 p.p. difference in rental wedges implies a 25–30 p.p. difference in homeownership rates between Germany vs. Spain and Italy (keeping in mind that the model is non-linear).

Rents and house price beliefs (expected capital gains on housing) are key factors for the decision whether to rent or own a house. Households compare the expected user cost of owning, the total maintenance and mortgage financing costs net of housing capital gains $\lambda + r - \grave{G}$ to the cost of renting $\widehat{\alpha}$. In a frictionless model, these two objects would

[20] We choose Germany as the ‘base’ country because of its very low homeownership rate.

Figure 8 Decomposition of Homeownership Rates; Levels



Note: The dark blue bars show the fitted homeownership rate in the base country (Germany). The other bars reflect the impact of various factors on homeownership, averaged across the permutations of factors. The sum of all bars results in the homeownership rate the second country (Spain, the U.S., France or Italy). "Other pref parameters" consist of the share of housing consumption ω and the strength of the bequest motive L. "Other factors" include mortality, transaction costs, realized house price growth and interest rate.

equally strongly affect the homeownership rate.[21] It turns out that also in our setup with transaction costs and nonlinearities the effect of the rental wedge and house price beliefs is roughly the same: A 1 p.p. change in any of them implies a 15 p.p. effect on homeownership.

These considerations imply that small differences in long-run house price beliefs—smaller than those documented in survey data—are in a model a powerful driver of homeownership. Similarly, small differences in the rental wedge result in large differences in homeownership rates.

As for other factors, collateral constraints and to some extent also differences in labor income processes affect the homeownership rate especially at younger ages. Tighter collateral constraints reduce the homeownership rate of young households: A higher down payment requirement by 15 p.p. (in Germany) lowers the homeownership of households younger than 30 years roughly by 10 p.p. (compared, e.g., to Spain, the U.S. or France). Similarly, a steeper labor income profile in Germany contributes by about 10 p.p. to lower homeownership of youngest households.[22]

5.2.2 The Intensive Margin of Housing: Housing Wealth

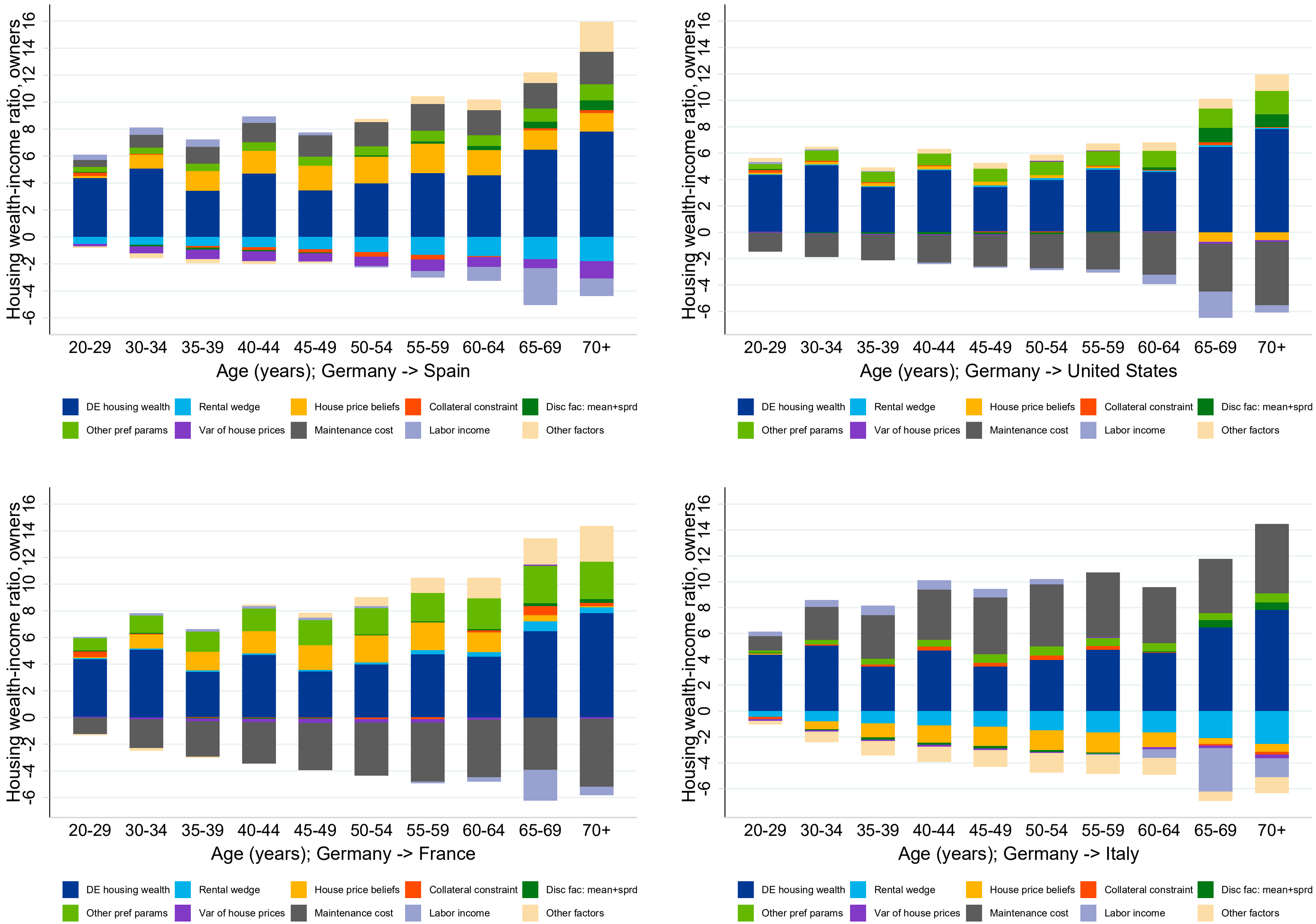
As for the intensive margin of housing, differences in housing wealth of homeowners, as measured with the mean ratios of housing wealth to income, are mostly driven by housing maintenance costs, which in effect reduces homeowners' return on housing (Figures 9 and 16). Quantitatively, the estimated maintenance costs for Germany (0.03) is roughly twice smaller than in France (0.06), the U.S. (0.07) and much larger than in Italy (0.007). Compared to Germany, these values imply lower holdings of housing wealth in France and the U.S.—by roughly a multiple of 2–4 worth of annual incomes—and higher housing wealth in Italy.

Other factors that matter less for the accumulation of housing wealth are: the rental wedge α, house price beliefs and preference parameters (especially the consumption share

[21]In a setup with transaction costs the expected user cost of onwer-occupied housing should also account for the expected transaction costs when adjusting the house.

[22]In contrast to collateral constraints and income profiles, the effects of house price beliefs and rental wedge tend to rise with age.

Figure 9 Decomposition of the Mean Gross Housing Wealth–Income Ratio of Homeowners; Levels



Note: The dark blue bars show the fitted mean housing wealth–income ratio of homeowners in the base country (Germany). The other bars reflect the impact of various factors on housing wealth–income ratio, averaged across the permutations of factors. The sum of all bars results in the housing wealth–income ratio the second country (Spain, the U.S., France or Italy). “Other pref parameters” consist of the share of housing consumption ω and the strength of the bequest motive L. “Other factors” include mortality, transaction costs, realized house price growth and interest rate.

of housing ω). Roughly twice as large as in Germany, the rental wedge in Spain and Italy reduces the accumulation of housing wealth due to a selection effect: Increasing the rental wedge makes additional people switch from renting to homeowning, but the marginal buyers purchase smaller houses and thus reduce the average housing wealth.

More optimistic house price beliefs in Spain and France than in Germany tend to increase the amount of housing wealth. An analogous selection effect is at work as for the rental wedge, lowering somewhat housing wealth in Spain and Italy as new homeowners tend to buy smaller than average houses. However, this effect is outweighed by an increase in housing wealth among existing homeowners who buy larger houses.

Finally, we estimate that Germany has a somewhat lower share of housing consumption ω (of 0.177) than the other countries (ranging between 0.207 and 0.271), which is reflected in a positive contribution of the parameter to housing wealth outside of Germany.[23]

The strength of the effects on housing wealth rises with age, reflecting the gradual accumulation of the stock of housing wealth over the life cycle (relative to the flow of income).

As we estimate the model country by country, our decompositions provide an upper bound on how large differences in preferences across countries are needed to explain differences in homeownership and housing wealth. It turns out that very little preference heterogeneity is needed to explain the gaps in homeownership, around 5 p.p. or less.

Figures 17–18 show the mean effects together with what we label as “90 percent confidence intervals,” which depict the dispersion across the various permutations. While the width of these intervals indicates that the model is quite far from linear, we still find that the effects of the various factors are substantially different from zero, across most permutations.

[23] Higher variance of house price shocks reduces both margins of housing by a few percentage points.

6 Conclusions

To our knowledge, this is the first paper that uses an estimated life cycle model of housing to systematically quantify drivers of differences in the extensive and intensive margins of housing across advanced economies. We find that house price beliefs and housing market institutions matter substantially and household preferences less so. More specifically, differences in homeownership rates are strongly affected by (i) house price beliefs and (ii) the rental wedge, the difference between rents and maintenance costs, which reflects the quality of the rental market and segmentation of the housing markets. Differences in the value of housing wealth are substantially driven by housing maintenance costs.

This paper focuses on the long-run, structural differences in housing across countries and could be extended in several ways. Our model could be used to study how various economies respond to shocks and economic policies at higher, business-cycle frequencies.[24] Our partial equilibrium model could also be embedded in a general equilibrium setup to analyze feedbacks between direct and indirect effects of shocks. Future work could also zoom in on population groups, for example middle class or young households, and study how their respective position in the wealth distribution and their homeownership status are affected by shocks and housing market institutions.

[24]See Hintermaier and Koeniger (2018) for work focusing on the effects of monetary policy.

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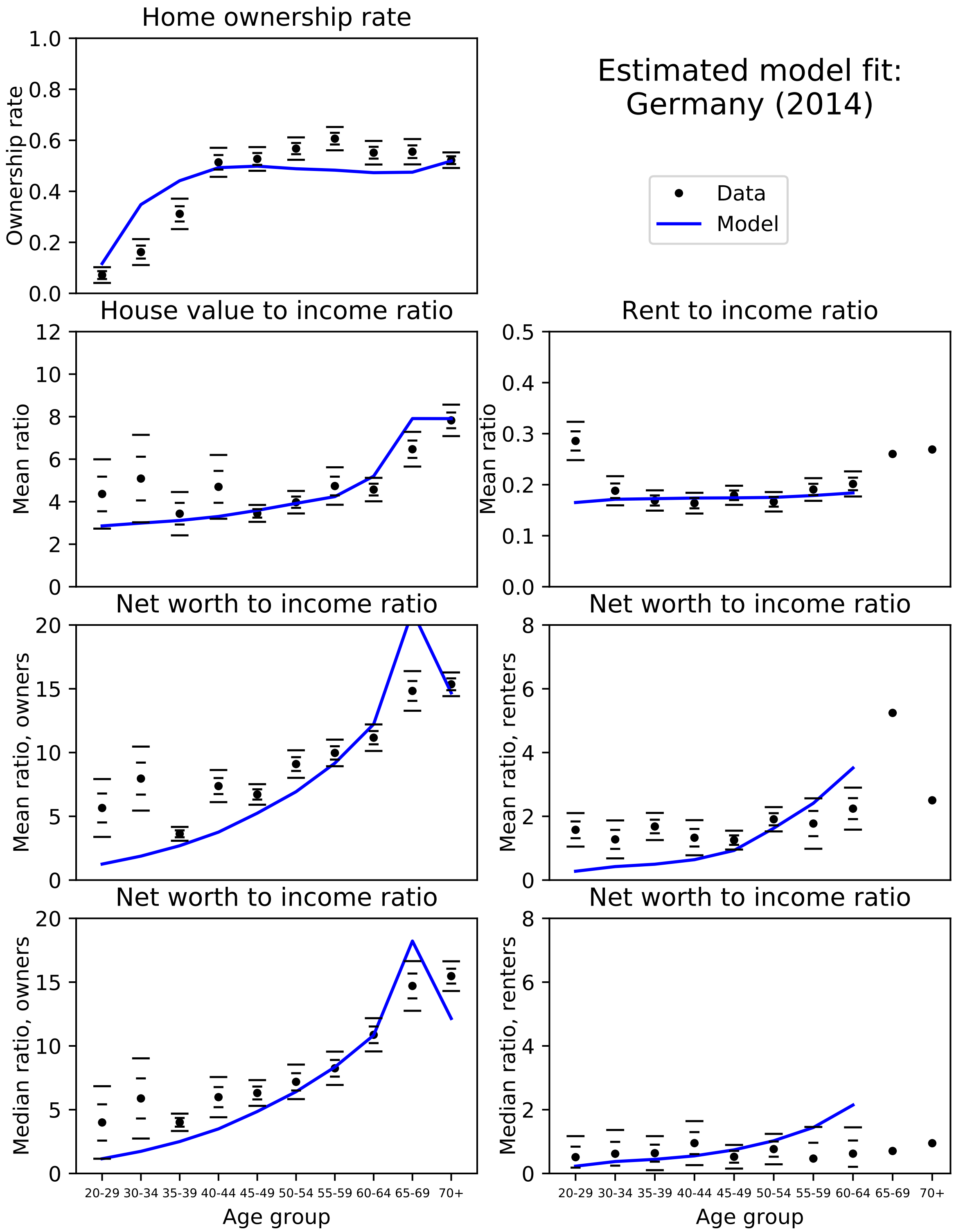
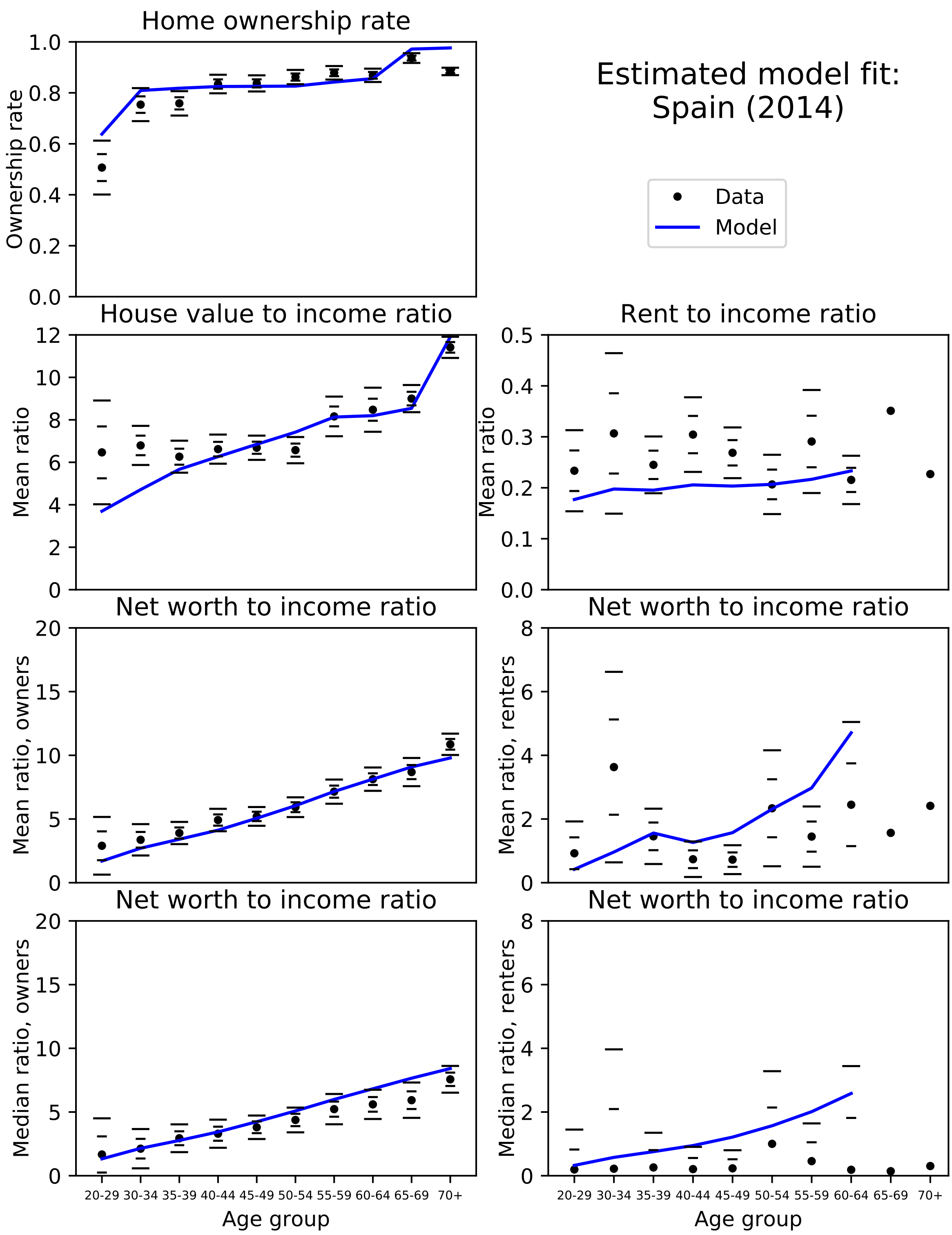
Figure 10 Fit of Moments—Germany



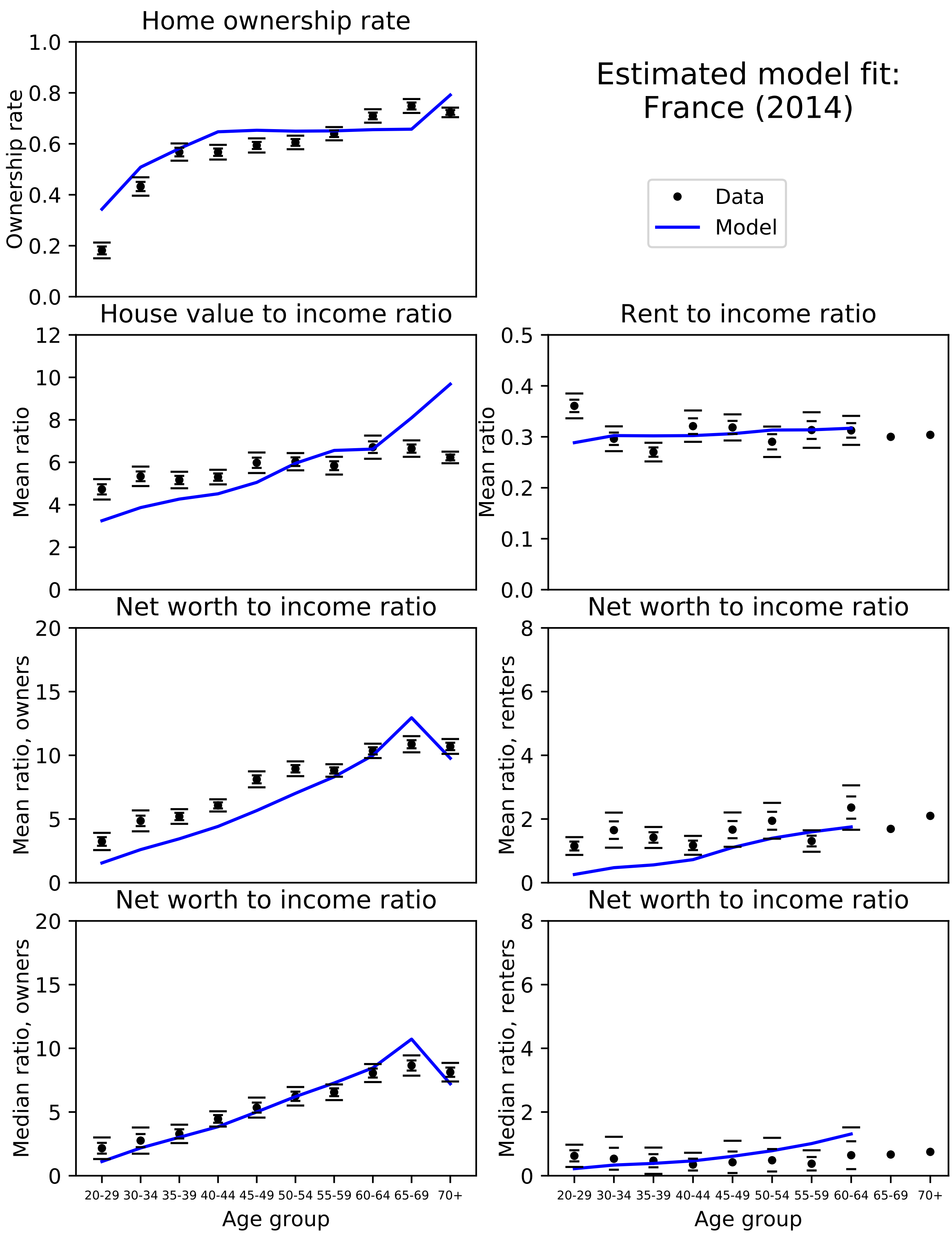
Source: Household Finance and Consumption Survey, wave 2014.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

Figure 11 Fit of Moments—Spain



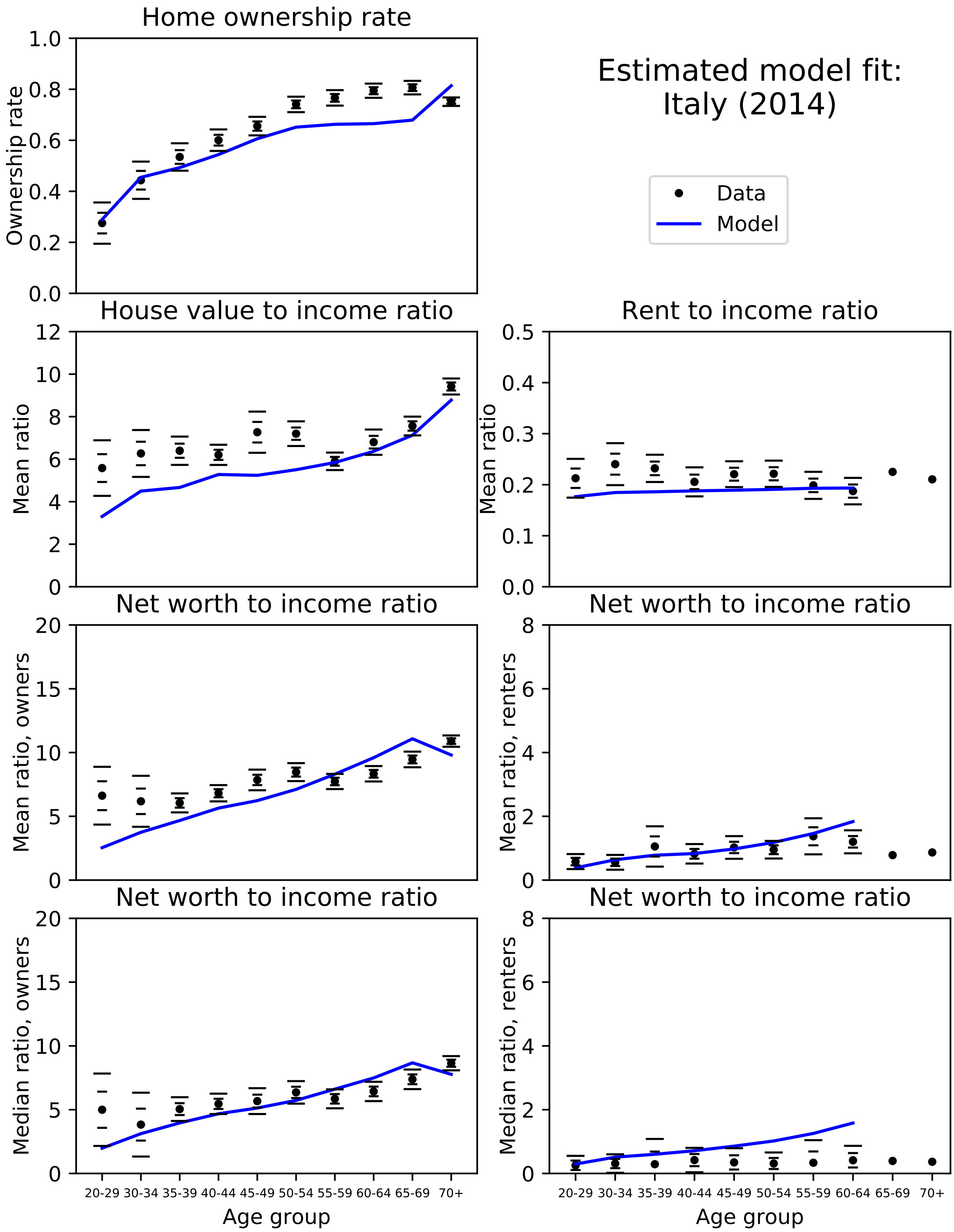
Source: Household Finance and Consumption Survey, wave 2014.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

Figure 12 Fit of Moments—France



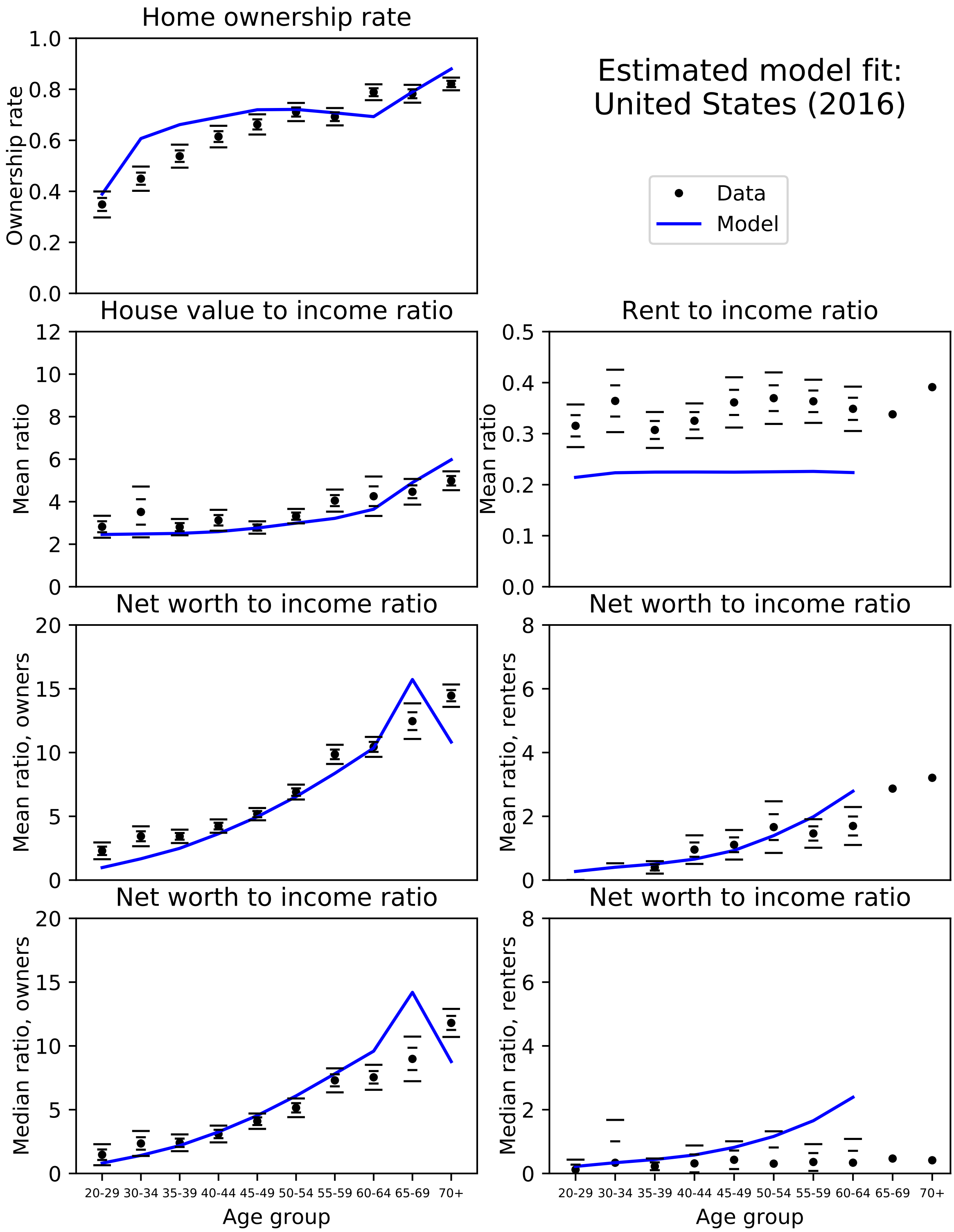
Source: Household Finance and Consumption Survey, wave 2014.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

Figure 13 Fit of Moments—Italy



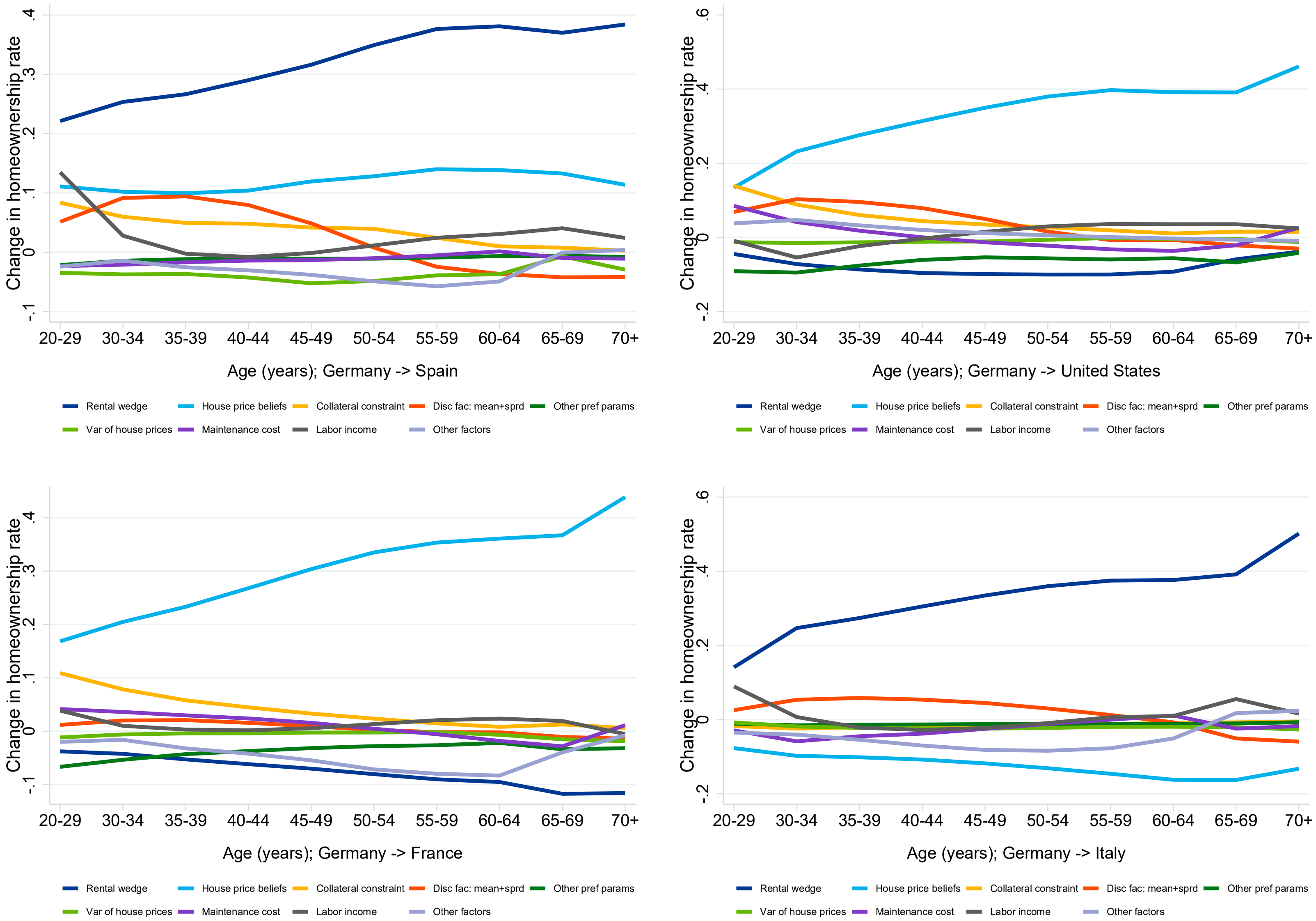
Source: Household Finance and Consumption Survey, wave 2014.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

Figure 14 Fit of Moments—United States



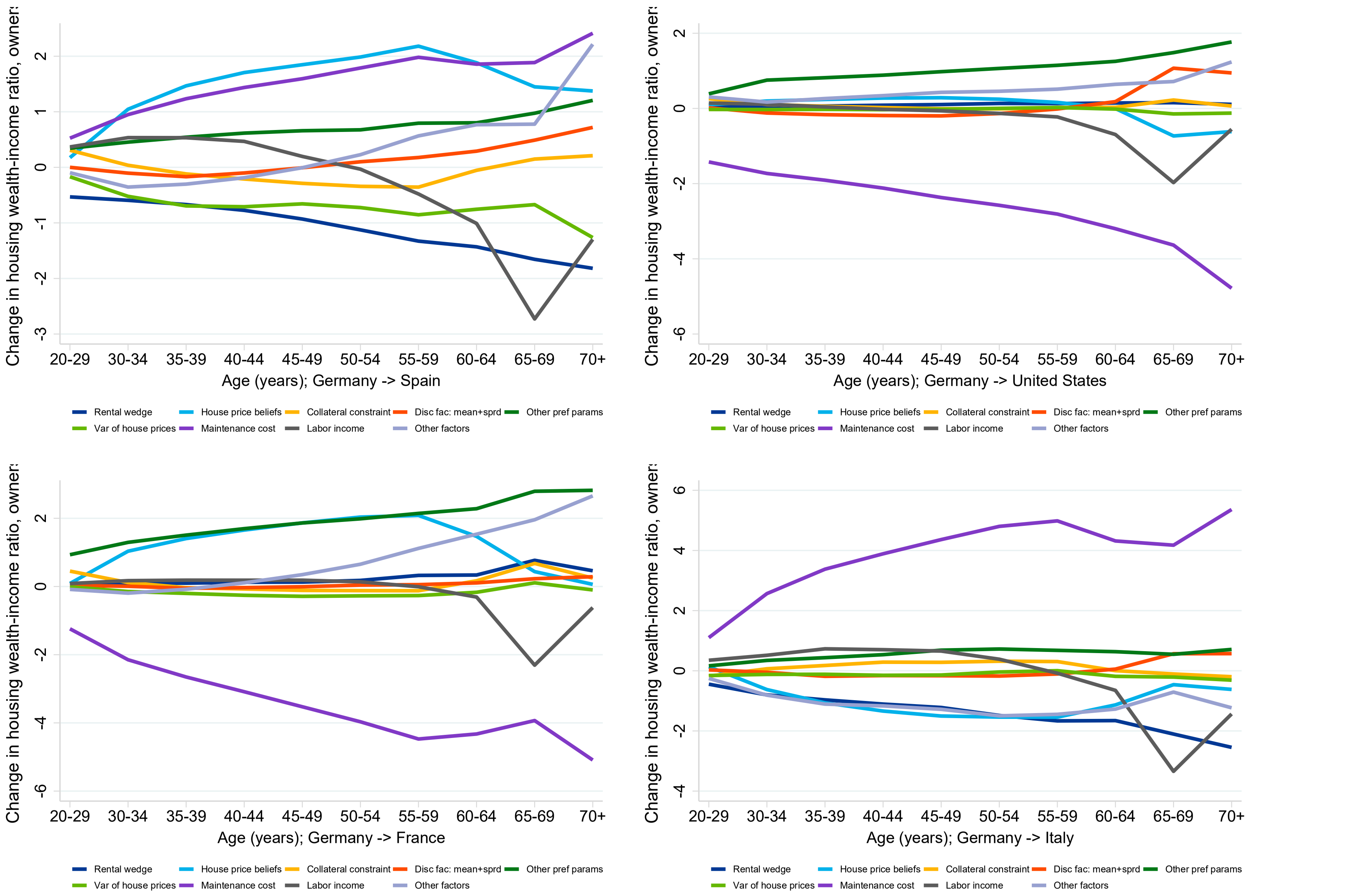
Source: Survey of Consumer Finances, 2016.
Note: The dots denote data; the brackets around them denote one and two standard error bands. The blue line shows the moments fitted by the model.

Figure 15 Decomposition of Homeownership Rates; Differences



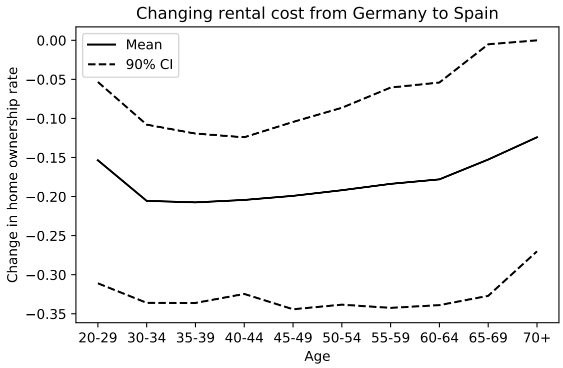
Note: The lines reflect the impact of various factors on the fitted homeownership rate, averaged across the permutations of factors. This figure shows the same effects as Figure 8, abstracting from the level of the homeownership rates. The sum of all lines results in the difference between the fitted homeownership rate in the base country (Germany) and the second country (Spain, U.S., France or Italy). "Other pref parameters" consist of the share of housing consumption ω and the strength of the bequest motive L. "Other factors" include mortality, transaction costs, realized house price growth and interest rate.

Figure 16 Decomposition of the Mean Gross Housing Wealth–Income Ratio of Homeowners; Differences

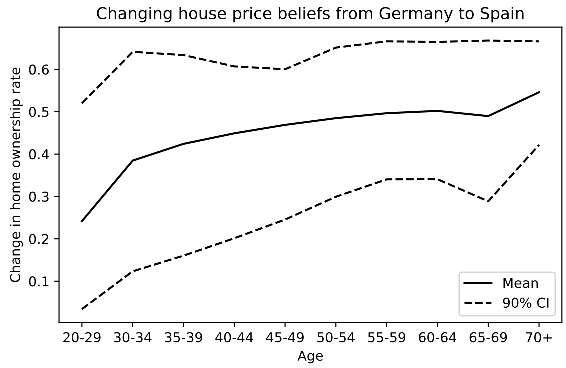


Note: The lines reflect the impact of various factors on housing wealth–income ratio, averaged across the permutations of factors. This figure shows the same effects as Figure 9, abstracting from the level of the housing wealth–income ratios. The sum of all lines results in the difference between the fitted mean housing wealth–income ratio in the base country (Germany) and the second country (Spain, U.S., France or Italy). "Other pref parameters" consist of the share of housing consumption ω and the strength of the bequest motive L. "Other factors" include mortality, transaction costs, realized house price growth and interest rate.

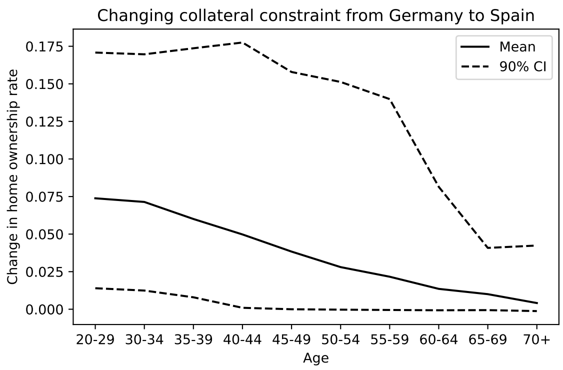
Figure 17 Decomposition of Homeownership Rates: Germany → Spain I.



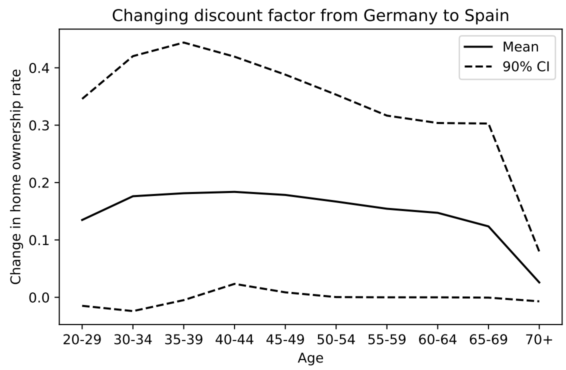
(a) Rental Cost



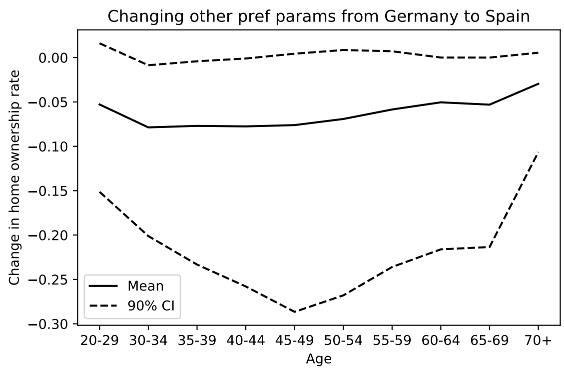
(b) Mean House Price Beliefs



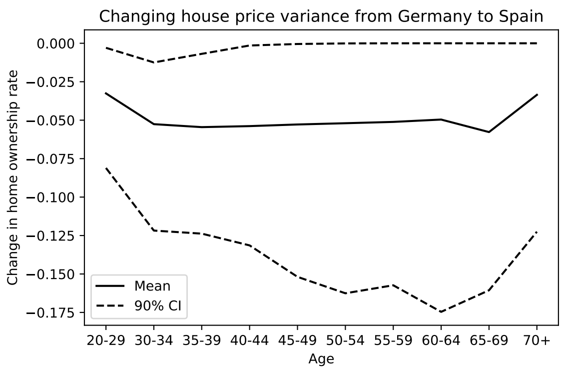
(c) Collateral Constraint



(d) Mean Discount Factor



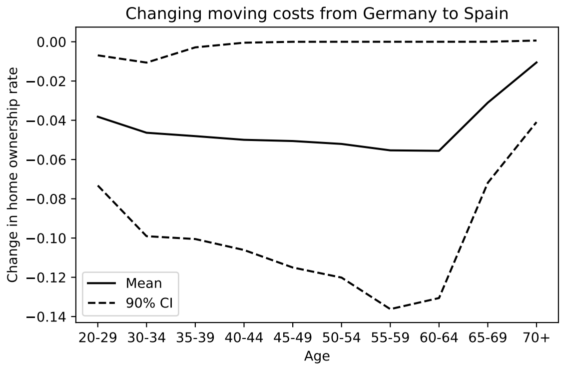
(e) Other Preference Parameters



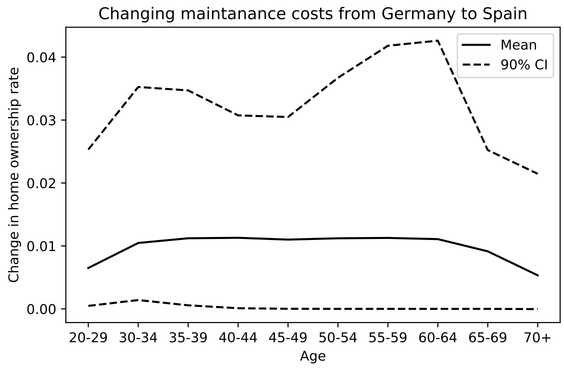
(f) Variance of House Price Beliefs

Note: The solid line shows the mean effect of various factors on the homeownership rate, averaged across the orderings of the factors for an example of the decomposition between Germany and Spain. The dashed lines show the spread across the decompositions, reflecting the 90 percent range across the orderings.

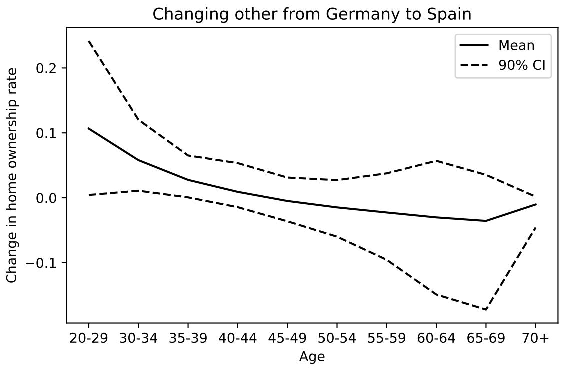
Figure 18 Decomposition of Homeownership Rates: Germany → Spain II.



(a) House Selling Costs



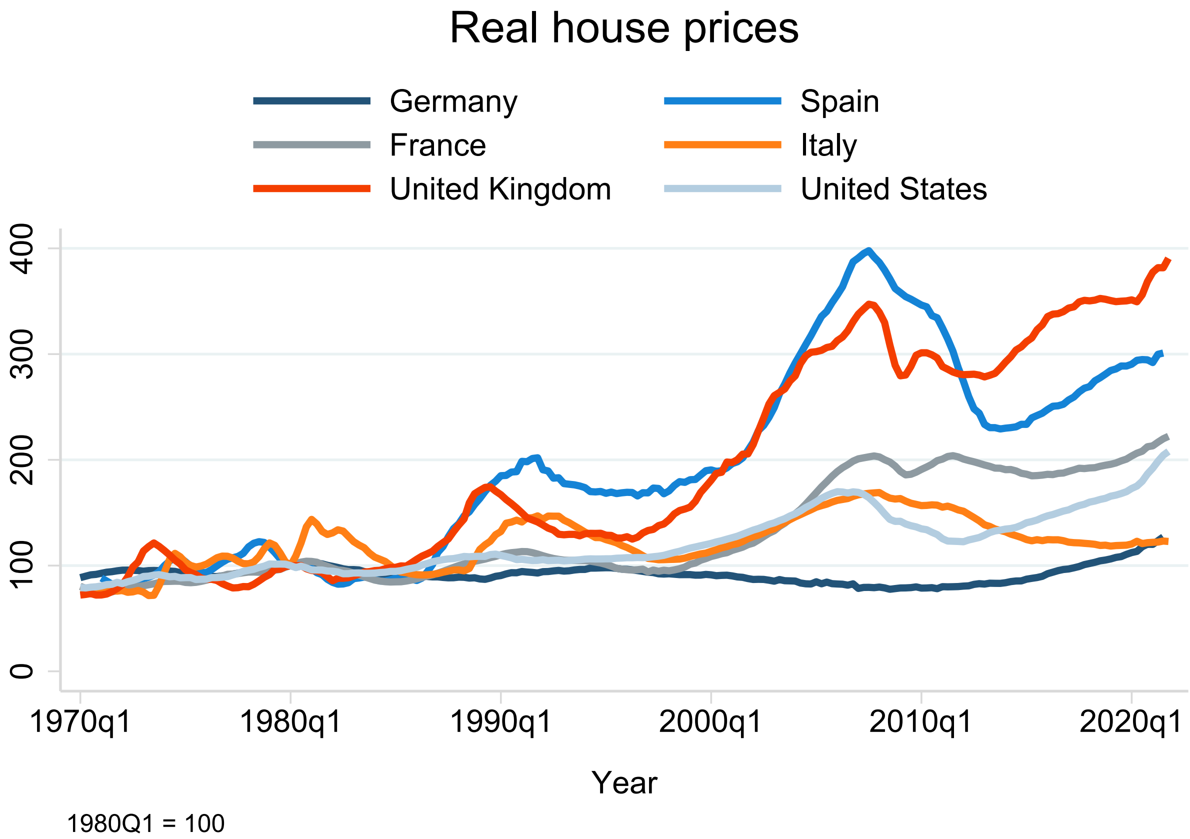
(b) Maintenance Costs



(c) All Other Factors

Note: The solid line shows the mean effect of various factors on the homeownership rate, averaged across the orderings of the factors for an example of the decomposition between Germany and Spain. The dashed lines show the spread across the decompositions, reflecting the 90 percent range across the orderings. "All other factors" include mortality, transaction costs, realized house price growth and interest rate.

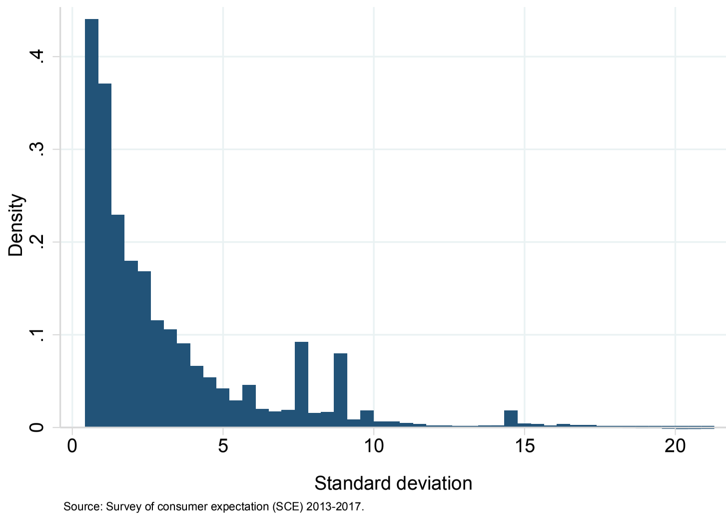
Figure 19 Real House Prices



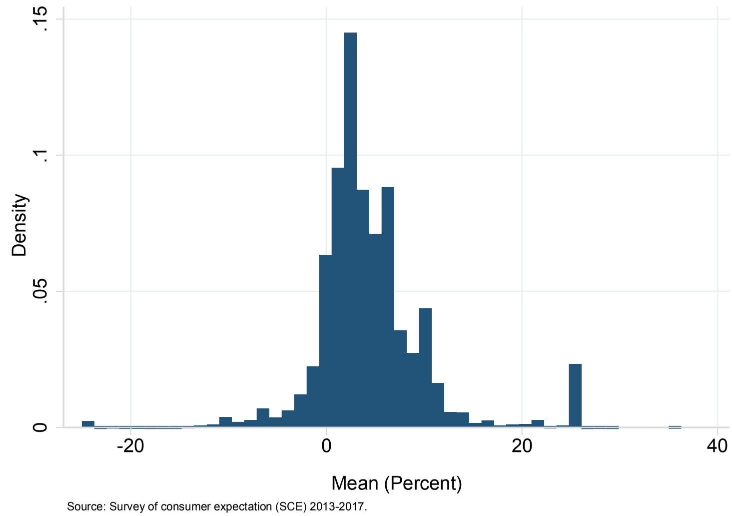
Source: OECD Analytical House Price Database, 1970–2021.

Figure 20 shows for the U.S. expectations of house prices how the expected mean growth and its uncertainty vary across the income distribution (see also the corresponding evidence in Ben-David et al., 2018, Figure 5). The key result is that households with low incomes perceive house prices twice as risky in terms of standard deviation as households with high incomes. The variation in the mean growth rate is less pronounced.

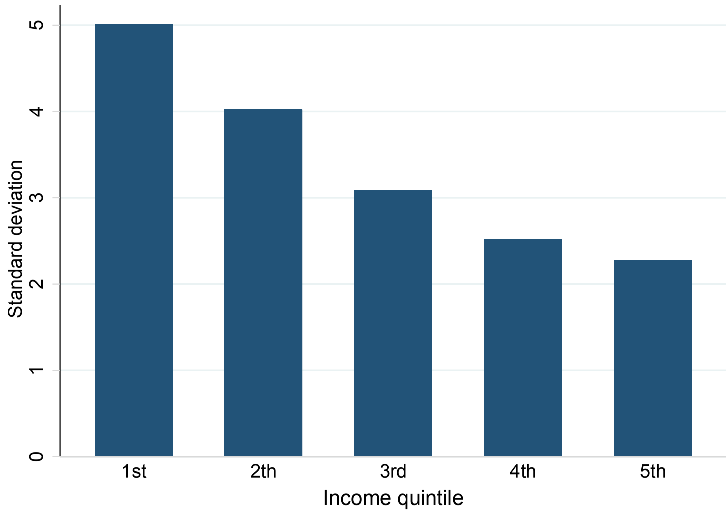
Figure 20 Heterogeneity in Self-Reported House Price Expectations



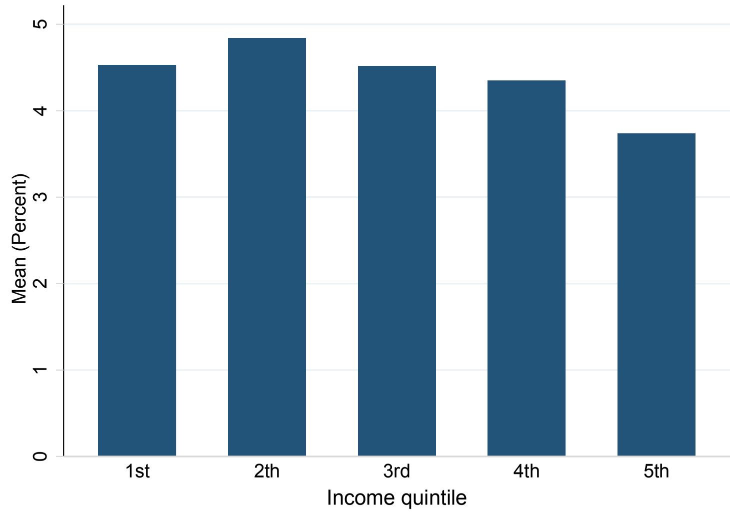
(a) Uncertainty: Standard Deviation



(b) Mean



(c) Uncertainty: Standard Deviation, by Income Quintile



(d) Mean, by Income Quintile

Source: Survey of Consumer Expectations, Federal Reserve Bank of New York.
Note: The top panels show the distribution of standard deviations and means of house price expectations across individual households. The bottom panels show how standard deviations and means vary by income quintile.

Appendixes

A The Model in Detail and the Solution Method

This appendix describes in detail the model with risky income and illiquid risky housing. The model concerns an agent who derives a utility flow in discrete time period t characterized by CRRA preferences over a Cobb–Douglas aggregation of the size of the house he lives in H_t and his level of consumption C_t. At the beginning of each period, the agent faces shocks to his income and the price of housing relative to consumption. After observing these shocks, he first makes a choice among renting a house, living in the house he already owns, or purchasing a different house; he then immediately chooses his level of consumption and housing, subject to constraints that depend on his ownership choice. In general, an agent's end-of-period position is subject to a collateral constraint based on the house he owns.

Beginning a period, preferences, and discrete choice

Agent i enters age z in absolute time period t with A_{it-1} in net financial position (liquid assets less mortgage balance), owns a house of size $\bar{H}_{it-1}$ from the previous period[25], and has a permanent income level of P_{it-1}; the relative price of housing was π_{t-1}. The agent is immediately hit with period t shocks to his income and the relative price of housing:

$$M_{it} = RA_{it-1} + Y_{it}, \qquad Y_{it} = \theta_{it} P_{it}, \qquad P_{it} = \Gamma_z \psi_{it} P_{it-1}, \qquad \pi_t = G\eta_t \pi_{t-1}, \tag{18}$$
$$\widehat{H}_{it} = \bar{H}_{it-1}, \qquad \theta_{it} \sim F_{\theta z}, \qquad \psi_{it} \sim F_{\psi z}, \qquad \eta_t \sim F_{\eta}.$$

This leaves him with market resources M_{it} and owning a house of size $\widehat{H}_{it}$, with new levels of permanent income and the relative price of housing.[26] At this moment, the agent makes a choice among {Rent, Stay, Move}. If the agent does *not* choose to stay in the house he currently owns, then he must sell this house. After paying transactions costs proportional to the house value, this will leave him with a net wealth position of:

$$W_{it} = M_{it} + (1-\phi)\pi_t \widehat{H}_{it}. \tag{19}$$

Agents derive utility flow according to utility function $U(C, H)$:

$$U(C,H) = \frac{(H^{\omega} C^{1-\omega})^{1-\rho}}{1-\rho}. \tag{20}$$

The agent is an expected lifetime utility maximizer who geometrically discounts future flows at a factor of β per period. The agent dies stochastically at the end of each age z with probability D_z; death yields a "grave utility" based on net worth given by:

$$\grave{U}(O) = L\frac{O^{1-\rho}}{1-\rho}, \qquad O_t = A_t + \bar{H}_{it}\pi_t. \tag{21}$$

[25]If the agent rented in period $t-1$, or this is the very first period, then $\bar{H}_{it-1} = 0$. Thus the housing stock variable always exists, but is irrelevant in some circumstances.

[26]Note that there is no subscript i on the price of housing (or its shock), as this is assumed to be shared across all agents, rather than drawn idiosyncratically. Likewise, there is no age subscript z on this process.

The renter's problem

After making the decision to *rent*, the agent's state is characterized by his net wealth W_{it}, his permanent income level P_{it}, and the relative price of housing π_t. He can choose to rent a house of any size H_{it} he can afford, paying a fraction of its current market value. The agent will own no house at the end of the period, so he is constrained to end the period with non-negative assets (having no house to use as collateral). The renter's problem is thus to choose consumption C_{it} and rental house size H_{it} subject to:

$$A_{it} = W_{it} - C_{it} - \alpha \pi_t H_{it}, \qquad A_{it} \geq 0, \qquad \bar{H}_{it} = 0. \tag{22}$$

The stayer's problem

After making the decision to *stay*, the agent's state is characterized by his market resources M_{it}, the size of the house he currently owns $\widehat{H}_{it}$, his permanent income level P_{it}, and the relative price of housing π_t. His choice of the size of house to live in is trivial, but he must pay maintenance costs proportional to his house's value. The stayer's problem is thus to choose consumption C_{it} and house size H_{it} subject to:

$$H_{it} = \widehat{H}_{it}, \qquad A_{it} = M_{it} - C_{it} - \lambda \pi_t H_{it}, \qquad A_{it} + (1-\delta)\pi_t \bar{H}_{it} \geq 0, \qquad \bar{H}_{it} = H_{it}. \tag{23}$$

An agent who owns a house may have negative end-of-period assets, but cannot borrow more than a $(1-\delta)$ proportion of his house value.[27]

The mover's problem

After making the decision to *move*, the agent's state is characterized by his net wealth W_{it}, his permanent income level P_{it}, and the relative price of housing π_t. The mover's problem is to choose consumption and house size subject to the collateral constraint. He must pay maintenance costs on the house he moves into this period. The renter's problem is thus to choose consumption C_{it} and house size H_{it} subject to:

$$A_{it} = W_{it} - C_{it} - (1+\lambda) H_{it} \pi_t, \qquad A_{it} + (1-\delta)\pi_t \bar{H}_{it} \geq 0, \qquad \bar{H}_{it} = H_{it}. \tag{24}$$

Recursive formulation

The agent's problem is characterized by the preference parameters $\{\beta, \rho, \omega, L\}$ and market parameters $\{R, \alpha, \phi, \lambda, \delta, G\}$, as well as the income and mortality processes $\{\Gamma_z, F_{z\theta}, F_{z\psi}, \mathsf{D}_z\}$ for $z \in \{\underline{z}, \cdots, \overline{z}\}$, where $\underline{z}$ is the age at model entry and $\overline{z}$ is such that $\mathsf{D}_{\overline{z}} = 1$. The problem can be phrased recursively, defining $V_z(\cdot)$ as the value function at age z at the time the ownership choice is made. In all situations, definitions and transitions (18), (20), (21) hold.

The renter's problem can be written as:

$$\breve{V}_z(W_{it}; P_{it}, \pi_t) = \max_{C_{it}, H_{it}} U(C_{it}, H_{it}) + \beta \not{\mathsf{D}}_z \mathbf{E}\left[V_{z+1}(M_{it+1}, \widehat{H}_{it+1}; P_{it+1}, \pi_{t+1})\right] + \mathsf{D}_z \grave{U}(O_{it}) \text{ s.t. } (22). \tag{25}$$

[27]Note that the renter is also subject to the same collateral constraint, because $\bar{H}_{it} = 0$ for him.

The stayer's problem can be written as:

$$\bar{V}_z(M_{it}, \widehat{H}_{it}; P_{it}, \pi_t) = \max_{C_{it}, H_{it}} U(C_{it}, H_{it}) + \beta \not{D}_z \mathbf{E}\left[V_{z+1}(M_{it+1}, \widehat{H}_{it+1}; P_{it+1}, \pi_{t+1})\right] + \mathsf{D}_z \grave{U}(O_{it}) \text{ s.t. (23).} \tag{26}$$

The mover's problem can be written as:

$$\hat{V}_z(W_{it}; P_{it}, \pi_t) = \max_{C_{it}, H_{it}} U(C_{it}, H_{it}) + \beta \not{D}_z \mathbf{E}\left[V_{z+1}(M_{it+1}, \widehat{H}_{it+1}; P_{it+1}, \pi_{t+1})\right] + \mathsf{D}_z \grave{U}(O_{it}) \text{ s.t. (24).} \tag{27}$$

The agent's problem when he makes his ownership decision is thus:

$$V_z(M_{it}, \widehat{H}_{it}; P_{it}, \pi_t) = \max\left\{\breve{V}_z(W_{it}; P_{it}, \pi_t), \bar{V}_z(M_{it}, \widehat{H}_{it}; P_{it}, \pi_t), \hat{V}_z(W_{it}; P_{it}, \pi_t)\right\} \text{ s.t. (19).} \tag{28}$$

Note that the RHS of each sub-problem[28] is identical but for the transition constraints in each situation. The problem has been written so that the agent "chooses" the size of house to live in each period, even if this choice is from a singleton set when staying. Likewise, housing stock at the beginning of $t+1$ is trivially $\widehat{H}_{it+1} = 0$ when renting, but this is explicitly captured in (22). This formulation allows us to characterize the continuation payoff as based only on end-of-period assets A_{it} and size of house owned $\bar{H}_{it}$, no matter what discrete ownership choice was made. Along with a clever normalization with respect to prices, this enables us to use a variation on the endogenous grid method to efficiently solve the model.

Normalization by price variables

Following Li and Yao (2007), the model can be normalized with respect to *both* price levels (P_{it} and π_t), eliminating them as state variables. Generally, variables measured in real money units are normalized by P_{it}, while variables measured in utility are normalized by $(P_{it}/\pi_t^{\omega})^{1-\rho}$.

$$a_{it} \equiv A_{it}/P_{it}, \quad c_{it} \equiv C_{it}/P_{it}, \quad y_{it} \equiv Y_{it}/P_{it} = \theta_{it}, \quad m_{it} \equiv M_{it}/P_{it}, \quad w_{it} \equiv W_{it}/P_{it},$$
$$\hat{h}_{it} \equiv \widehat{H}_{it}\pi_t/P_{it}, \quad h_{it} \equiv H_{it}\pi_t/P_{it}, \quad \bar{h}_{it} \equiv \bar{H}_{it}\pi_t/P_{it}, \quad v_z(\cdot) \equiv V_z(\cdot)/(P_{it}/\pi_t^{\omega})^{1-\rho}. \tag{29}$$

Substituting (29) into (18) and (19) and simplifying yields a new set of transition dynamics:

$$m_{it} = Ra_{it-1}/(\Gamma_z\psi_{it}) + \theta_{it}, \quad \hat{h}_{it} = (G\eta_t)\bar{h}_{it-1}/(\Gamma_z\psi_{it}), \quad w_{it} = m_{it} + (1-\phi)\hat{h}_{it}, \tag{30}$$
$$o_{it} = a_{it} + \bar{h}_{it}, \quad \theta_{it} \sim F_{\theta z}, \quad \psi_{it} \sim F_{\psi z}, \quad \eta_t \sim F_{\eta}.$$

We can now divide (25), (26), and (27) by $(P_{it}/\pi_t^{\omega})^{1-\rho}$ to yield the normalized forms of the three subproblems. The renter's normalized problem is:

$$\breve{v}_z(w_{it}) = \max_{c_{it}, h_{it}} U(c_{it}, h_{it}) + \beta \not{D}_z \mathbf{E}\left[\left(\frac{\Gamma_{z+1}\psi_{it+1}}{(G\eta_{t+1})^{\omega}}\right)^{1-\rho} v_{z+1}(m_{it+1}, \hat{h}_{it+1})\right] + \mathsf{D}_z \grave{U}(o_{it}) \text{ s.t.} \tag{31}$$

$$a_{it} = w_{it} - c_{it} - \alpha h_{it}, \quad a_{it} \geq 0, \quad \bar{h}_{it} = 0.$$

[28] As a mnemonic device, the *breve* on $\breve{V}$ means that the agent only briefly lives in the rental, the bar on $\bar{V}$ represents staying pat in the same house, and the hat on $\hat{V}$ stands for choosing a new roof to live under.

The stayer's normalized problem is:

$$\bar{v}_z(m_{it},\hat{h}_{it}) = \max_{c_{it},h_{it}} U(c_{it},h_{it}) + \beta\not{D}_z\mathbf{E}\left[\left(\frac{\Gamma_{z+1}\psi_{it+1}}{(G\eta_{t+1})^{\omega}}\right)^{1-\rho} v_{z+1}(m_{it+1},\hat{h}_{it+1})\right] + \mathsf{D}_z\grave{U}(o_{it}) \text{ s.t.} \tag{32}$$

$$h_{it} = \hat{h}_{it}, \qquad a_{it} = m_{it} - c_{it} - \lambda h_{it}, \qquad a_{it} + (1-\delta)\bar{h}_{it} \geq 0, \qquad \bar{h}_{it} = h_{it}.$$

The mover's normalized problem is:

$$\hat{v}_z(w_{it}) = \max_{c_{it},h_{it}} U(c_{it},h_{it}) + \beta\not{D}_z\mathbf{E}\left[\left(\frac{\Gamma_{z+1}\psi_{it+1}}{(G\eta_{t+1})^{\omega}}\right)^{1-\rho} v_{z+1}(m_{it+1},\hat{h}_{it+1})\right] + \mathsf{D}_z\grave{U}(o_{it}) \text{ s.t.} \tag{33}$$

$$a_{it} = w_{it} - c_{it} - (1+\lambda)h_{it}, \qquad a_{it} + (1-\delta)\bar{h}_{it} \geq 0, \qquad \bar{h}_{it} = h_{it}.$$

The discrete ownership choice normalized problem is:

$$v_z(m_{it},\hat{h}_{it}) = \max\left\{\breve{v}_z(m_{it} + (1-\phi)\hat{h}_{it}), \bar{v}_z(m_{it},\hat{h}_{it}), \hat{v}_z(m_{it} + (1-\phi)\hat{h}_{it})\right\}. \tag{34}$$

To further simplify the problem and motivate the numeric solution, we can define end-of-period (marginal) value functions, based on end-of-period assets and housing stock:

$$\mathfrak{v}_z(a_{it},\bar{h}_{it}) \equiv \beta\not{D}_z\mathbf{E}\left[\left(\frac{\Gamma_{z+1}\psi_{it+1}}{(G\eta_{t+1})^{\omega}}\right)^{1-\rho} v_{z+1}(Ra_{it}/(\Gamma_{z+1}\psi_{it+1}) + \theta_{it+1}, (G\eta_{t+1})\bar{h}_{it}/(\Gamma_{z+1}\psi_{it+1}))\right] + \mathsf{D}_z\grave{U}(a_{it}+\bar{h}_{it}), \tag{35}$$

$$\mathfrak{v}^a_z(a_{it},\bar{h}_{it}) \equiv R\beta\not{D}_z\mathbf{E}\left[\frac{(\Gamma_{z+1}\psi_{it+1})^{-\rho}}{(G\eta_{t+1})^{\omega(1-\rho)}} v^m_{z+1}(Ra_{it}/(\Gamma_{z+1}\psi_{it+1}) + \theta_{it+1}, (G\eta_{t+1})\bar{h}_{it}/(\Gamma_{z+1}\psi_{it+1}))\right] + \mathsf{D}_z\grave{U}'(a_{it}+\bar{h}_{it}),$$

$$\mathfrak{v}^h_z(a_{it},\bar{h}_{it}) \equiv \beta\not{D}_z\mathbf{E}\left[\frac{(\Gamma_{z+1}\psi_{it+1})^{-\rho}}{(G\eta_{t+1})^{\omega(1-\rho)-1}} v^h_{z+1}(Ra_{it}/(\Gamma_{z+1}\psi_{it+1}) + \theta_{it+1}, (G\eta_{t+1})\bar{h}_{it}/(\Gamma_{z+1}\psi_{it+1}))\right] + \mathsf{D}_z\grave{U}'(a_{it}+\bar{h}_{it}).$$

First order conditions and model solution

The renter's problem can be easily solved if we notice that housing is merely a consumption good for the renter, as he makes the choice of house size for exactly one period with no penalty. We can thus define $x_{it} = h^{\omega}_{it}c^{1-\omega}_{it}$, the composite good. Using the well known solution to the Cobb–Douglas form, a ω proportion of spending $c_{it} + h_{it}$ will be on housing and a $1-\omega$ portion will be on consumption. Thus a unit of x can be purchased at price φ when acting optimally, and the renter's problem is:

$$\breve{v}_z(w_{it}) = \max_{x_{it}} \hat{U}(x_{it}) + \mathfrak{v}_z(a_{it},0) \text{ s.t. } a_{it} = w_{it} - \varphi x_{it}, \qquad \hat{U}(x) = x^{1-\rho}/(1-\rho). \tag{36}$$

This problem has one first order condition, with respect to x_{it}:

$$x^{-\rho}_{it} - \varphi\mathfrak{v}^a_z(a_{it},0) = 0 \Longrightarrow x_{it} = (\varphi\mathfrak{v}^a_z(a_{it},0))^{-1/\rho} \Longrightarrow w_{it} = a_{it} + \varphi x_{it}. \tag{37}$$

In this way, we can find the endogenous gridpoint w_{it} associated with any end-of-period assets

a_{it}. The composition of x_{it} is dictated by the Cobb–Douglas solution:

$$c_{it} = \left(\frac{1-\omega}{\omega/\alpha}\right)^{\omega} x_{it}, \qquad h_{it} = \frac{\omega}{1-\omega}\left(\frac{1-\omega}{\omega/\alpha}\right)^{\omega} x_{it}, \qquad \varphi = \frac{1}{1-\omega}\left(\frac{1-\omega}{\omega/\alpha}\right)^{\omega}. \tag{38}$$

With a simple application of the envelope theorem, marginal value of wealth is:

$$\breve{v}_z'(w_{it}) = \mathfrak{v}_z^a(w_{it} - \varphi x_{it}, 0) = \mathfrak{v}_z^a(a_{it}, 0). \tag{39}$$

The stayer's problem can be written in simplified form as:

$$\bar{v}_z(m_{it}, \hat{h}_{it}) = \max_{c_{it}} \hat{h}_{it}^{\omega(1-\rho)}\tilde{U}(c_{it}) + \mathfrak{v}_z(a_{it}, \hat{h}_{it}) \text{ s.t. } a_{it} = m_{it} - c_{it} - \lambda\hat{h}_{it}, \quad \tilde{U}(c) = \frac{c^{1-(\rho+\omega-\omega\rho)}}{1-\rho}. \tag{40}$$

This problem has one first order condition, with respect to c_{it}:

$$\frac{1-(\rho+\omega-\omega\rho)}{1-\rho}\hat{h}_{it}^{\omega(1-\rho)} c_{it}^{-(\rho+\omega-\omega\rho)} - \mathfrak{v}_z^a(a_{it}, \hat{h}_{it}) = 0 \Longrightarrow \tag{41}$$

$$c_{it} = \left(\frac{1-\rho}{1-(\rho+\omega-\omega\rho)}\hat{h}_{it}^{-\omega(1-\rho)}\mathfrak{v}_z^a(a_{it}, \hat{h}_{it})\right)^{-1/(\rho+\omega-\omega\rho)} \equiv \mathfrak{c}_z(a_{it}, \hat{h}_{it}), \qquad m_{it} = a_{it} + c_{it} + \lambda\hat{h}_{it}.$$

Thus we can find the endogenous $(m_{it}, \hat{h}_{it})$ gridpoint for any end-of-period state $(a_{it}, \bar{h}_{it} = \hat{h}_{it})$. Using the envelope theorem we can calculate marginal value with respect to market resources or the housing stock:

$$\bar{v}_z^m(m_{it}, \hat{h}_{it}) = \mathfrak{v}_z^a(a_{it}, \hat{h}_{it}), \qquad \bar{v}_z^h(m_{it}, \hat{h}_{it}) = U^h(c_{it}, \hat{h}_{it}) + \mathfrak{v}_z^h(a_{it}, \hat{h}_{it}). \tag{42}$$

The mover's problem is a bit more complex, but can be written in simplified form as:

$$\hat{v}_z(w_{it}) = \max_{c_{it}, h_{it}} U(c_{it}, h_{it}) + \mathfrak{v}_z(a_{it}, h_{it}) \text{ s.t. } a_{it} = w_{it} - c_{it} - (1+\lambda)h_{it}. \tag{43}$$

This problem has two first order conditions, with respect to c_{it} and h_{it}:

$$U^c(c_{it}, h_{it}) - \mathfrak{v}_z^a(a_{it}, h_{it}) = 0, \qquad U^h(c_{it}, h_{it}) - (1+\lambda)\mathfrak{v}_z^a(a_{it}, h_{it}) + \mathfrak{v}_z^h(a_{it}, h_{it}) = 0. \tag{44}$$

For any end-of-period state $(a_{it}, \bar{h}_{it} = h_{it})$, we can solve for the value of c_{it} that solves the first order condition for consumption identically to the stayer's problem: $c_{it} = \mathfrak{c}_z(a_{it}, h_{it})$. Substituting this into the first order condition for h_{it}, we get a unified first order condition:

$$U^h(\mathfrak{c}_z(a_{it}, h_{it}), h_{it}) - (1+\lambda)\mathfrak{v}_z^a(a_{it}, h_{it}) + \mathfrak{v}_z^h(a_{it}, h_{it}) \equiv \mathfrak{H}_z(a_{it}, h_{it}) = 0. \tag{45}$$

Solving this equation requires the use of a numeric rootfinding operation to find the value(s) of a_{it} that satisfy $\mathfrak{H}_z(a_{it}, h_{it}) = 0$ for a given value of $h_{it} = \bar{h}_{it}$. Once a root has been found, the accompanying endogenous wealth gridpoint is:

$$w_{it} = a_{it} + \mathfrak{c}_z(a_{it}, h_{it}) + (1+\lambda)h_{it}. \tag{46}$$

The envelope theorem tells us that the marginal value of wealth of the mover is simply:

$$\hat{v}_z'(w_{it}) = \mathfrak{v}_z^a(a_{it}, h_{it}). \tag{47}$$

B Computation

To be written

C Estimation of Income Processes

This appendix describes the estimation of income profiles and variances of permanent and transitory income shocks.

C.1 Income Variable

The income variable is net household disposable income excluding income from rental of a property or land and interest, dividends, profit from capital investments in unincorporated business. Using the EU SILC variable names,

net disposable income = HY020 − HY040N − HY090N, where:

- Total disposable household income HY020 = HY010 − HY120G − HY130G − HY140G
- Total household gross income HY010 = HY040G + HY050G + HY060G + HY070G + HY080G + HY090G + HY110G + [for all household members](PY010G + PY021G + PY050G + PY080G + PY090G + PY100G + PY110G + PY120G + PY130G + PY140G), where:
  - Income from rental of a property or land (HY040G),
  - Family/children related allowances (HY050G),
  - Social exclusion not elsewhere classified (HY060G),
  - Housing allowances (HY070G),
  - Regular inter-household cash transfers received (HY080G),
  - Interests, dividends, profit from capital investments in unincorporated business (HY090G),
  - Income received by people aged under 16 (HY110G)),
  - Gross employee cash or near cash income (PY010G),
  - Company car (PY021G),
  - Gross cash benefits or losses from self-employment (including royalties) (PY050G),
  - Pensions received from individual private plans (other than those covered under ESSPROS) (PY080G),
  - Unemployment benefits (PY090G),
  - Old-age benefits (PY100G),
  - Survivor benefits (PY110G),
  - Sickness benefits (PY120G),
  - Disability benefits (PY130G),
  - Education-related allowances (PY140G).
- Regular taxes on wealth (HY120G),
- Regular inter-household cash transfer paid (HY130G),

- Tax on income and social insurance contributions (HY140G),
- Income from rental of a property or land (net) (HY040N),
- Interest, dividends, profit from capital investments in unincorporated business (net) (HY090N).

Income is deflated with the HICP price index.

C.2 Regression Specification—Age Profiles

For workers we regress the median income on the third degree polynomial of age. (For retirees, we assume constant income given by the retirement replacement rate and the pre-retirement income.) This specification follows Cocco et al. (2005) and many others.

C.3 Winsorizing

We winsorize income by country and education level (low and high) for the top and bottom 1 percent.

C.4 Sample

We use EU SILC annual cross-sectional data from years 2009–2019. The sample size in our sample is about 13,000 persons per year for Germany, about 12,000 for Spain, about 10,000 for France and about 18,000–20,000 for Italy. Households younger than 16 years were excluded.

The income profiles for the U.S. were taken from Cocco et al. (2005).

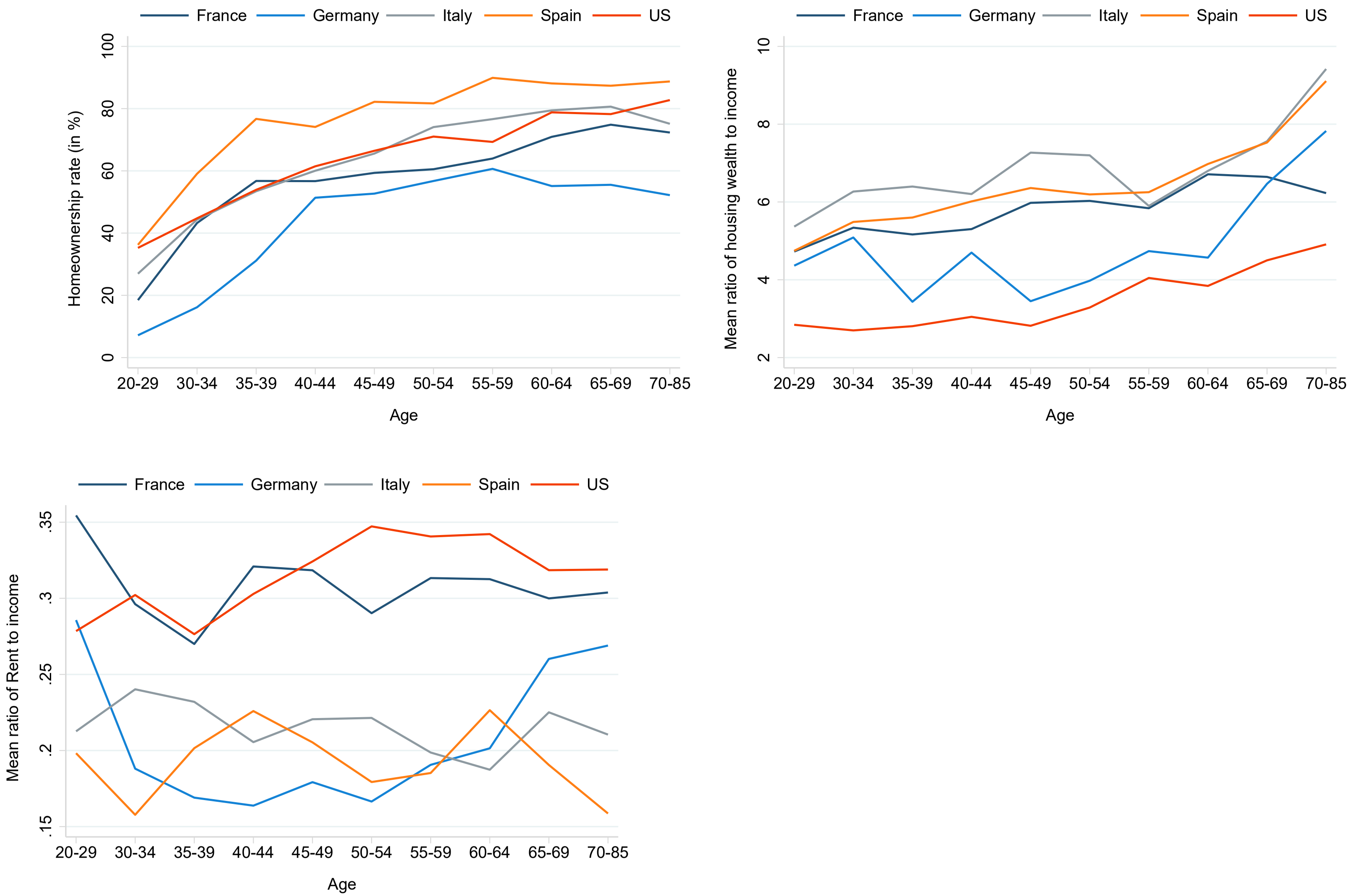
The estimated income profiles are shown in Figure 3.

C.5 Estimates of Permanent and Transitory Income Shocks

To be written [Carroll and Samwick (1997), Heathcote et al. (2010)]

D Empirical Moments

Figure 21 Homeownership Rate, Gross Housing Wealth–Income Ratio, Rent–Income Ratio



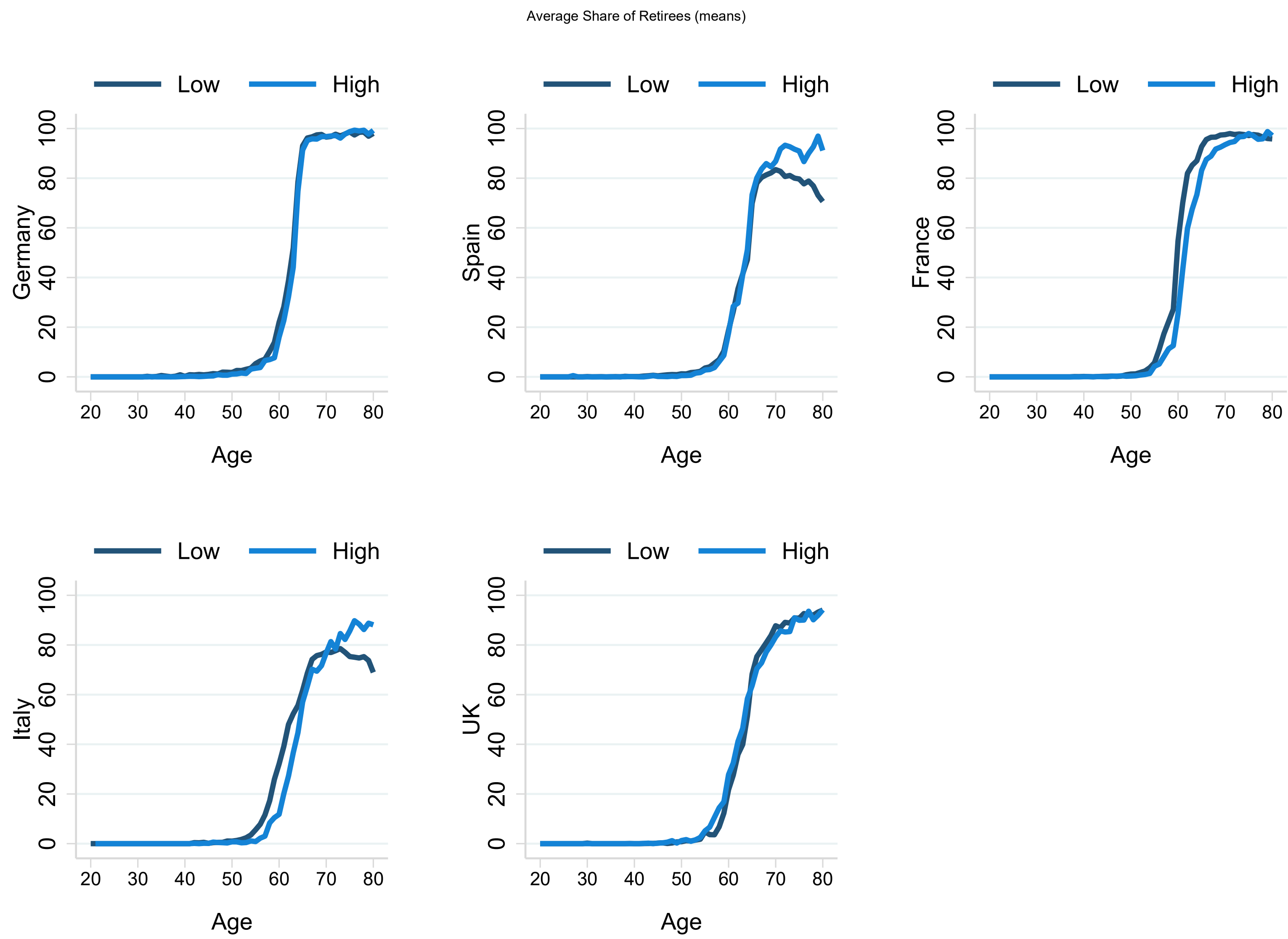
Source: Household Finance and Consumption Survey, wave 2014; Survey of Consumer Finances, 2016.
Note: The figures show the empirical moments for the five countries, used in the structural estimation.

Figure 22 Mean and Median Net Wealth–Income Ratios, Renters and Homeowners

Source: Household Finance and Consumption Survey, wave 2014; Survey of Consumer Finances, 2016.
Note: The figures show the empirical moments for the five countries, used in the structural estimation.

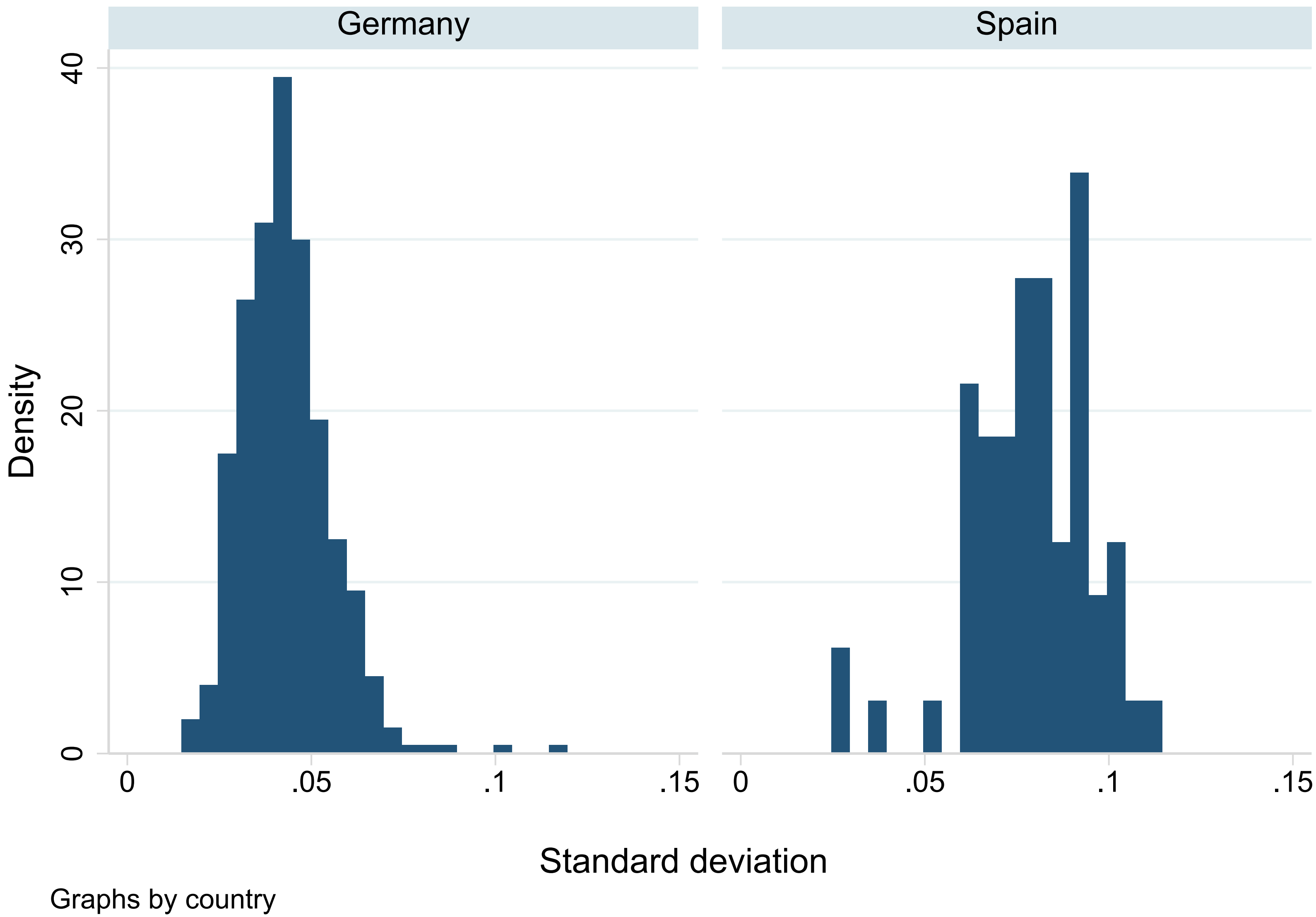
E Additional Figures

Figure 23 Share of Retirees by Age



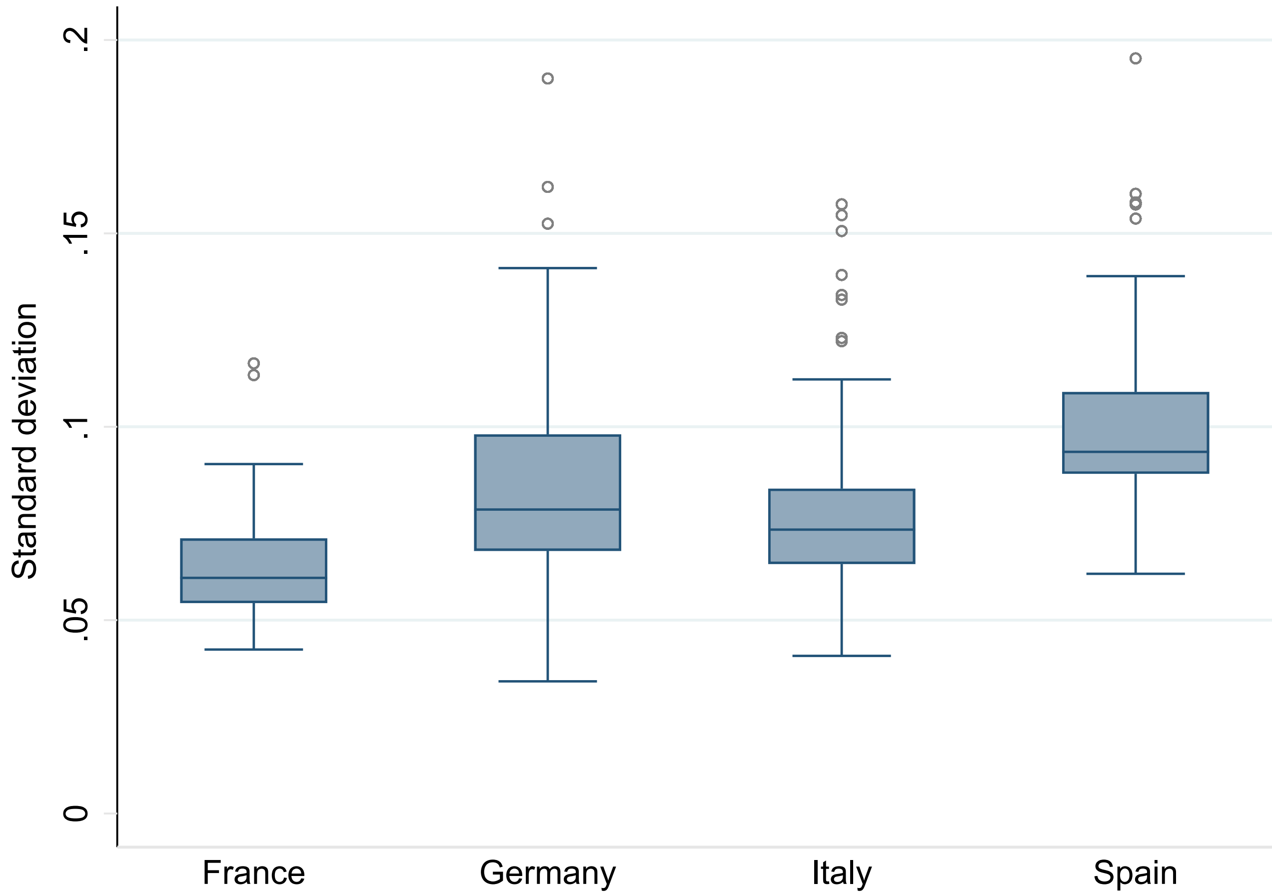
Source: EU Statistics on Income and Living Conditions, 2009–2019.
Note: The figures show at what age people gradually retire, for each country and level of education.

Figure 24 Standard Deviation of Growth Rates of Regional House Prices, Germany, Spain



Source: Spain: Ministerio de Fomento; Germany: bulwiengesa AG.
Note: The left panel shows standard deviation of annual growth rates of house prices across 401 regions (Kreise) in Germany, 2004–2017. The right panel shows standard deviation of growth rates of house prices across 63 regions in Spain, 1995–2018.

Figure 25 Standard Deviation of Growth Rates of Regional House Prices, France, Germany, Italy, Spain



Source: European DataWarehouse, `https://www.eurodw.eu/`.
Note: The figure shows a box and whisker plot of the distribution of standard deviations of annual house price growth rates across regions in large European countries, 1999–2019. The box plot shows the lower adjacent value, the 25th percentile, the median, the 75th percentile and the upper adjacent value. The adjacent values are the 25th percentile − 1.5×interquartile range and the 75th percentile + 1.5×interquartile range. The number of regions ranges between 52 in Spain and 96 in France.