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Low Homeownership in Germany - A Quantitative Exploration

Abstract

The homeownership rate in Germany is one of the lowest among advanced economies. To better understand this fact, we analyze the role of three specific policies which discourage homeownership in Germany: an extensive social housing sector with broad eligibility criteria, high transfer taxes when buying real estate, and no tax deductions for mortgage interest payments by owner-occupiers. We build a lifecycle model with uninsurable income risk and endogenous homeownership in order to quantify the policy effects on homeownership and welfare. We find that all three policies have sizable effects on the homeownership rate. At the same time, household welfare would be reduced by moving to a policy regime with low transfer taxes and mortgage interest tax deductions, but it would improve in the absence of social housing, in particular when coupled with housing subsidies for low-income households.

JEL-Codes: D150, E210, R210, R380.

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1 Introduction

Germany has one of the lowest homeownership rates of developed countries with only 44% of households owning their main residence in the year 2010.[1] German households face a set of policies which tilt incentives towards renting. In contrast to the U.S., for instance, Germany has a large social housing sector, high transfer taxes on buying real estate and no mortgage interest rate tax deductions for owner-occupiers. Do these policies indeed matter for Germany's low homeownership rate? And are these policies beneficial for German households, or would alternative housing policies improve the well-being of society?

To address these questions, we quantitatively investigate how moving towards U.S.-style housing policies affects homeownership, wealth accumulation and welfare of German households. We build a lifecycle model with stochastic ageing and uninsurable income risk, in which households make decisions about consumption of goods and housing services, savings and homeownership. House prices and rents are determined in equilibrium and depend on a supply technology with diminishing returns in the construction sector. Households benefit from homeownership but are constrained by a downpayment requirement for mortgages. Gains from homeownership come from the fact that the market rental rate includes a premium to cover the monitoring costs of commercial landlords.

Our quantitative model takes as inputs labor income dynamics, tax and transfer policies, and existing social housing policies in Germany. First, we non-parametrically estimate age-dependent household labor income processes from the German Socio-Economic Panel (SOEP). Second, we estimate the progressive tax and transfer functions from the same data. Third, we set various housing policy parameters, such as social housing access and subsidies, real-estate transfer taxes, mortgage rates and downpayment requirements, to represent the factual details of the existing environment. Finally, we calibrate the remaining parameters of the model to the German economy by matching the aggregate homeownership rate, the social housing stock and the average wealth of households.

The model reproduces well the empirical lifecycle profiles of homeownership and household wealth accumulation. In addition, it mimics the distribution of homeownership by wealth and income. This gives us confidence to use the model as a tool for policy analysis and evaluation.

We implement three policy experiments that potentially foster homeownership. First, we consider a reduction of the real-estate transfer tax (RETT) from its current level of 5% to

[1] According to data from the Household Finance and Consumption Survey of the European Central Bank, this is the lowest homeownership rate in the Eurozone. At the opposite extreme is Spain which has the highest homeownership rate (83% in 2010) in the Eurozone. In comparison, the U.S. stands at 67% in 2010 (U.S. Census) and the U.K. at 71% in 2004 (Andrews and Caldera, 2011).

0.33% which is the average level of this tax in the U.S. Second, we make mortgage interest payments fully tax deductible. Third, we eliminate the social housing sector. All policies are implemented in a fiscally neutral fashion by adjusting income taxes so as to balance the government budget.

We find that these policies go a long way explaining the low homeownership rate in Germany. Each policy experiment has significant positive effects on the homeownership rate, with a combined effect leading to a counterfactual homeownership rate of 62%, relatively close to the one in the U.S. where 67% of all households were homeowners in 2010. Higher homeownership does not only lead to a substitution of financial wealth by housing wealth, but it also increases average household net wealth by more than 8%.

At the same time we find diverging effects of these policy experiments in terms of household welfare. The first two tax policies, which directly incentivize homeownership, reduce welfare for all newborn households. The reason is that these policy reforms boost housing demand which leads to an increase of house prices and rental rates in general equilibrium. The reductions of tax revenues further need to be offset by higher income tax rates. Both effects hurt renter and owner households simultaneously. We further look at the changes in welfare for newborn entrants in the economy differentiated by their initial labor income. The welfare losses are lowest for high-income entrants because these are more likely to become homeowners and to extract benefits from the tax reductions. These findings provide a rationale for the existing housing tax policies.

In contrast, the abolition of social housing brings about welfare gains of about 0.5% in consumption equivalence to the average household. Without social housing, the aggregate demand for housing services is lower which reduces house prices in equilibrium. This makes homeownership more affordable and benefits in particular the wealthier and less credit-constrained households whose homeownership rates increase most strongly. Furthermore, the saved subsidies for social housing allow the government to cut income taxes which benefits all households. When differentiated by initial labor income, the biggest winners of this policy are entering households with high income. Welfare gains are still positive at the bottom end of the income distribution, even though the option of renting a social housing unit at a reduced rate is gone.

As the welfare gains of abolishing social housing are much smaller for low-income entrants than for their high-income counterparts, we further study the effects of alternative targeted housing policies. For instance, we introduce direct housing subsidies to the poor instead of social housing. This policy is associated with average welfare gains of 0.78% in terms of benchmark consumption and much larger benefits for poor entrants into the economy. In essence, direct housing subsidies for low-income households provide a better insurance device

than social housing which is itself risky (because access is rationed) and which is exclusive to renter households.

To our knowledge, this is the first quantitative macroeconomic model of the German housing market.[2] Our analysis of introducing mortgage interest tax deductions in Germany is closely related to several U.S. studies.[3] Building on earlier work of Gervais (2002) and Cho and Francis (2011), Sommer and Sullivan (2016) and Floetotto et al. (2016) analyze housing policies in models with endogenous house prices. Floetotto et al. (2016) find that homeownership rates are higher in the long-run with mortgage interest deductions but welfare is lower for most households. Sommer and Sullivan (2016) follow Chambers et al. (2009) and take into account the interaction of the deductibility of mortgage interest payments with the progressive tax system. They find that repealing mortgage deductions for owner-occupiers lead to higher homeownership and welfare. The difference between the two studies comes from a larger countervailing price effect which in part depends on how the supply side is modeled.[4]

A further contribution of this paper is the analysis of the aggregate effects of real-estate transfer taxes and social housing. The existing macroeconomic literature on such policies is limited, partly due to fact that they do not play much of a role for aggregate outcomes in the U.S. economy.[5] In a recent study, Sieg and Yoon (2017) build a dynamic equilibrium model with uninsurable income risk to study social housing policies in New York City. Households can apply for different types of subsidized housing or freely rent at the market rate, but cannot become homeowners. They find that higher availability of public housing increases welfare for all renter households.

In the U.S., as in Germany, the age profile of homeownership rates increases steeply at younger ages and then flattens out, with mild decreases for retired households. Similar to our model, borrowing constraints are the main reason for lower homeownership rates of younger households in Fernandez-Villaverde and Krueger (2011) and Yang (2009).[6] Higher

[2]See Davis and Van Nieuwerburgh (2015) and Piazzesi and Schneider (2016) for surveys of the macroeconomic housing literature which focuses mostly on the U.S.

[3]Government interventions in the mortgage market via bailout guarantees are analyzed by Jeske et al. (2013). Such policies are not relevant in the German context where downpayment requirements are higher and foreclosure rates are low.

[4]The unsettled results of the quantitative macroeconomic literature are also reflected in the empirical study of Hilber and Turner (2014) who find that mortgage interest deductibility can have positive or negative effects on homeownership, depending on the elasticity of regional housing supply. See also Gruber et al. (2017) who utilize a quasi-experimental setup for Denmark. In their study, the deductibility of mortgage interest payments only has an effect on the intensive margin of house purchases.

[5]A larger empirical literature analyzes the effects of the RETT utilizing policy regime changes. For a recent study, see Kopczuk and Munroe (2015).

[6]Halket and Vasudev (2014) show that higher mobility of younger households and house price risk are further important determinants of the age-homeownership profile. Bajari et al. (2013) and Li and Yao (2007)

homeownership late in life, in combination with collateral constraints, is also crucial to explain why many households do not dissave in retirement, as would be predicted by standard lifecycle models, see Nakajima and Telyukova (2011).

Finally, several studies examine the determinants of the homeownership rate using cross-country comparisons. In his analysis of the European household-level panel data, Hilber (2007) shows that there are significant crowding out effects of public housing for homeownership across European regions.[7] Cho (2012) utilizes a general equilibrium model and finds that mortgage markets play a dominant role in accounting for homeownership differences between the U.S. and South Korea. Kindermann and Kohls (2016) use a macroeconomic model based on distortions in the rental market to account for the negative relation between homeownership rates and wealth inequality across European countries, which is also documented in Kaas et al. (2016).

The next section gives further details of housing policies in Germany. Section 3 describes the model which is calibrated to data for Germany in Section 4. In Section 5 we conduct our counterfactual policy experiments. Welfare implications and alternative targeted policies are discussed in Section 6, and conclusions are provided in Section 7. The Appendix contains a detailed account of our data work and further quantitative results.

2 Housing policy in Germany

In this section we briefly describe important features of the German housing policies that are relevant for our quantitative model. For illustrative purposes we contrast these features with their counterparts in the U.S.[8] As we focus on a stationary environment, we do not discuss temporary rent controls that limit rental price increases in a given time period.

Social housing

Germany, as well as other European countries, entered the postwar period with a severely damaged housing stock. The massive housing shortage in combination with reduced household assets and underdeveloped capital markets in West Germany led to extensive public policies to foster reconstruction (see Rudolph, 1993). Out of the 5.2 million units that were built during the 1950s, about 63% received subsidized loans of which more than half went

are interested in the effects of house prices changes on housing demand and welfare for households in different age groups.

[7] Other empirical cross-country studies are Chiuri and Jappelli (2003) and Bicakova and Sierminska (2008).

[8] For a survey of the literature on the German housing market and how it compares to other countries, see Kirchner (2007) and Voigtländer (2009). See Olsen and Zabel (2015) for a survey of U.S. housing policies.

to the construction of social housing units. While access to subsidized housing is generally based on income, during that period more than half of the households were eligible (Kirchner, 2007). Currently, the income threshold for social housing is relatively close to the median employee income. As the quality of social housing units is relatively high, there is demand even from households close to the income threshold (see Schier and Voigtländer, 2016). Households qualifying for social housing pay a "cost based" rent regulated by law.[9] For a sample of large cities, a recent study (Deschermeier et al., 2015) estimates that the social housing rent is about 20% below the market rent for comparable units. As social housing units are usually not built by the government and are financed by subsidized loans, the duration of their social housing status is limited by the maturity of the public loan. This, together with the fact that the number of approved subsidies for new social housing has been gradually reduced, has led to rationing and a decline of the stock of social housing from 19.4% in 1968 to 7.1% of all residential housing units in 2002 (Kirchner, 2007) and a further decline thereafter.

The U.S. also has a social housing sector, with currently about 1.8% of households participating.[10] In contrast to Germany, access to social housing is strictly limited to incomes below 80% of the local median income. Renters pay on average 35% of the total costs of a unit. While social housing has insurance effects as in Germany, it is unlikely that there is a crowding-out effect on homeownership at higher income deciles.

Taxation of homeowners

The tax systems, both in Germany and in the U.S., directly affect the gains from homeownership. Germany is a peculiar case when it comes to the deductibility of mortgage interest payments. While landlords (both private households and firms) can deduct interest costs of mortgages from taxes, this is not possible for mortgages financing the residence of a homeowner. In comparison, households in the U.S. can claim mortgage interest deductions for any real estate they own.

Germany has quite a low turnover rate for houses and apartments.[11] One plausible explanation for this fact are high transaction costs. Currently, average total transaction costs are 13.7% of the purchase price, of which about five percentage points are accounted for by real-estate transfer taxes. Transaction costs are much lower in the U.S. where many states

[9] After 2002 social housing came under the jurisdiction of the German states, and some states have replaced the cost rent by a less rigid regulation based on market prices.

[10] For this and the following numbers, see the U.S. Department of Housing and Urban Development (https://www.huduser.gov/portal/datasets/picture/about.html).

[11] Using data compiled by European Mortgage Federation (2016), Germany has a turnover rate which is only about half of the 2004–2015 average for a sample of 14 Western European countries.

have no RETT at all. The average RETT in the U.S. is about 0.33%.[12]

3 Model

In this section we describe the macroeconomic model of the housing market that we apply in the following sections for our quantitative experiments. We consider a small open economy in which the safe interest rate r is exogenous. Time is discrete and the period length is interpreted as a year. We describe a stationary equilibrium in which all prices and distribution measures are constant over time.

3.1 Households

Demographics

Households live through a stochastic lifecycle with five age groups $\tau = 1, \ldots, 5$. The first four groups cover the working life of the household head, and can be interpreted as 10-year age groups 25–34, 35–44, 45–54, 55–64, while $\tau = 5$ is the retirement group (ages 65+). Ignoring death before retirement, $\delta_\tau = 1/10$ is the yearly ageing probability for $\tau = 1, \ldots, 4$, and δ_5 denotes the yearly death probability in retirement. To keep the mass of households constant and normalized to unity, every period a mass $\delta_5/(1+40\delta_5)$ of new households enters the economy into age group $\tau = 1$.

Labor income

We model labor income at the household level to be composed of a component that is age-dependent, denoted M_τ, and a residual stochastic component $\varepsilon_{i,\tau}$ where $i \in \{1, \ldots, 10\}$ is the decile of residual income:

$$\log y(\tau, i) = M_\tau + \varepsilon_{i,\tau} \ .$$

The residual income decile i follows a discrete Markov process with age-specific transition matrix Ψ_τ. Residual income in decile i is denoted $\varepsilon_{i,\tau} \in E_\tau$.
Retired households receive non-stochastic pension income. That is, $\varepsilon_{i,5}$ is constant. We assume that the retiree's pension decile i is identical to the residual income decile in the year before retirement, which reflects that higher earnings lead to higher pension income.[13]

[12]The current RETT numbers by state are compiled by the National Conference of State Legislatures (http://www.ncsl.org/research/fiscal-policy/real-estate-transfer-taxes.aspx). Each state is weighted by the Census state population from 2010. For states in which there are tax schedules for different transaction prices only the lowest tax category is used.

[13]This is a crude abstraction of Germany's contribution-based pension system in which the pension

Preferences

Households maximize expected lifetime utility with time discount factor β and period utility

$$u(c, s; \tau, o) = \frac{1}{1-\gamma}\left[(c/n_\tau)^\zeta(\xi_o^\tau s/n_\tau)^{1-\zeta}\right]^{1-\gamma},$$

where γ is the degree of relative risk aversion, c is consumption of non-housing goods, s is consumption of housing services, and ζ ($1-\zeta$ resp.) is the expenditure share for goods (housing services).[14] We divide c and s by the household equivalence scale n_τ which depends on τ to reflect possible age-dependent variations in consumption and housing demand due to household size variations over the lifecycle. The shift parameter ξ_o^τ equals one for all working-age households ($\tau \leq 4$), but it can exceed one for retired homeowners ($o = 1$ and $\tau = 5$). The latter reflects the idea that retired households may enjoy own housing more than rented housing, possibly because of an additional motive of leaving a housing bequest. We do not include explicit preferences for bequests, so that all bequests are accidental and are distributed randomly to households in the first two age groups $\tau = 1, 2$.

3.2 Assets

Housing

Housing assets are denoted by $h \in \mathcal{H}$ where $\mathcal{H} = \{h_i | i = 1, \dots n\}$ is a finite grid such that $h_i = (1-\tilde{\delta})h_{i+1}$ for $i = 1, \dots, n-1$ with parameter $\tilde{\delta} \in (0, 1)$.[15] Housing is traded at the end of the period at unit price p, and it can be owned by households or by real-estate firms. The latter are risk-neutral, perfectly competitive entities who rent out housing units at rental rate ρ.

If a household owns $h > 0$ housing units, it can enjoy housing services $s \leq h$ and rent out services $h - s \geq 0$ to other households at the market rate ρ.[16] When a household buys or

depends on (capped) social-security contributions throughout the entire working lives of individuals. Proper modeling of such a system requires the inclusion of another state variable into the household problem.

[14] This Cobb-Douglas specification does not allow for complementarity between housing and non-housing consumption as in, e.g., Li et al. (2016).

[15] Housing has both a size and a quality dimension. Since our modeling abstracts from such multi-dimensionality, the housing measure should be understood to reflect both size and quality. As is common in the literature, we do not distinguish between houses and flats whose relative supply may matter for the overall homeownership rate. Indeed, Germany's share of houses (42%) among all housing units is smaller than the EU average (58%), but it is higher than in Spain (34%) where the homeownership rate is much higher than in Germany. Moreover, the cross-country correlation between homeownership rates and the share of houses is virtually zero (based on Eurostat data for 2016, distribution of population by tenure status and by degree of urbanization).

[16] This rules out that owner households rent additional space, i.e. $s \leq h$ holds if $h > 0$.

sells housing units, it needs to incur transaction costs which are fractions t^b (buyer) and t^s (seller) of the purchase price.

A renter household owns $h = 0$ and pays rent ρs for housing services s in the private market, or the lower rent $\rho^s s$ for renting a social housing unit.[17] Access to social housing is granted according to a rationing scheme which depends on household income $y(\tau, i)$ upon entry. Specifically, a renter household gains access to social housing with probability $\pi_{\tau,i}$ and it loses social housing access with probability η. This reflects that access to social housing is targeted to low-income households and that a household can live in a social housing unit for several years even when income changes.

Both owner households and real-estate firms pay maintenance cost m for every housing unit per period. A fraction δ of the aggregate housing stock depreciates at the end of a period. For housing units owned by households, depreciation shocks occur with probability π^δ in which case housing unit h_i, $i > 1$, adjusts to $h_{i-1} = (1 - \tilde{\delta})h_i$, and probability π^δ is chosen such that indeed a fraction δ of the aggregate housing stock depreciates in every period.[18] Real-estate firms need to pay monitoring costs c^m per unit of rented housing. This reflects the information asymmetry between a business owner and its renters.[19] The zero-profit condition of real-estate firms implies the following relationship between the house price p and the rental rate ρ:[20]

$$(r + \delta)p = \rho - m - c^m \ . \tag{1}$$

Next to the regular housing units which are traded on the market, there are social housing units which are operated by real-estate firms who rent them out at below-market rate $\rho^s < \rho$ to households who are granted access to these units. A distinctive feature of Germany's social housing sector is that social housing is operated by private firms who, in exchange for a subsidy to construction costs, are committed to rent control and access restrictions to low-income households for a pre-defined period (Kirchner, 2007). The commitment period of a social housing unit ends with probability Φ in which case the unit becomes a regular housing unit that can be rented out at market rate ρ. Operating social housing units also requires paying maintenance costs m as well as monitoring costs c^m. Similar to (1), the

[17] The choice of housing services s, as opposed to housing units h, is a continuous variable which reflects that arbitrarily small units (e.g. rooms of any size or quality) can be rented but not owned separately.

[18] Housing depreciation is required in our model which includes a construction sector and which has no population growth. We can think of depreciation shocks to reflect quality adjustments. Given the finite housing grid size, this makes housing a risky investment.

[19] Landlord households do not need to pay this monitoring costs because they have an informational advantage, because for instance they may live in close proximity to the rented unit.

[20] The discounted income value of a housing unit is $V = \frac{1}{1+r}[\rho - m - c^m + (1 - \delta)V]$, i.e. next period the housing unit earns income $\rho - m - c^m$ and fraction $1 - \delta$ does not depreciate. From $V = p$ follows equation (1).

zero-profit condition of real-estate firms is[21]

$$(r + \Phi + \delta)p^s = \rho^s - m - c^m + \Phi p \ , \tag{2}$$

where p^s is the market price of a social housing unit.

There is a construction sector which produces regular and social housing units. Producing I regular and I^s social housing involves costs $K(I + I^s)$, where K is an increasing and convex function. The convexity captures that marginal costs for materials and construction workers are increasing in total (regular and social) housing construction. Profit maximization of construction firms implies that

$$p = K'(I + I^s) = p^s + \varsigma \ , \tag{3}$$

where ς is the government subsidy per unit of social housing construction.[22]

Finally, let $\bar{H}$ and $\bar{H}^s$ denote the stocks of regular and social housing. Steady-state conditions are

$$\delta(\bar{H} + \bar{H}^s) = I + I^s \ , \quad (\Phi + \delta)\bar{H}^s = I^s \ . \tag{4}$$

The first equation says that the total housing stock is constant (depreciated housing equals construction). The second equation says that the stock of social housing is constant (social housing converted into regular housing or depreciated equals construction of social housing).

Financial assets

Households can save in a risk-free asset that pays the real interest rate r, and they can borrow using mortgage loans at rate r^m. Like the safe interest rate, the mortgage premium $r^m - r$ is exogenously fixed, reflecting monitoring and administrative costs of mortgage lenders which are constant per unit of borrowing.

Let a denote net financial assets of the household. Mortgage borrowing is subject to downpayment constraints

$$a \geq -(1 - \theta_\tau)ph \ ,$$

where the downpayment parameter θ_τ may depend on the household's age, and ph is the

[21] The discounted income value of a social housing unit is $V^s = \frac{1}{1+r}[\rho^s - m - c^m + (1 - \Phi - \delta)V^s + \Phi V]$, i.e. next period the housing unit earns income $\rho^s - m - c^m$, fraction $1 - \Phi$ retains social housing status and depreciates at rate δ (continuation value V^s), and fraction Φ becomes a regular housing unit with value $V = p$ (see footnote 20). From $V^s = p^s$ follows equation (2).

[22] Unlike real-estate firms, construction firms make positive profits $\Pi > 0$. In a stationary equilibrium, these firms are traded at the end of each period at price Π/r. Hence they are included in the riskless financial asset (see below), i.e. they are owned by domestic or foreign households.

value of housing units owned by the household.

3.3 The government

The government taxes households' income and real-estate transactions, it pays pensions to retirees, and it subsidizes the construction of social housing. Any excess tax revenue is spent on public goods which do not affect the households' decisions. For this reason, we leave these public goods unspecified.

We use the income tax function $T_\tau(y^t)$ which we estimate separately for the different age groups τ. In line with German tax law, taxable income y^t includes labor, capital and rental income, minus tax deductions for housing units which a landlord household rents out. These include deductions for maintenance expenses and interest payments for mortgages on the rental units.

The government taxes the transfer of real estate by collecting a fraction $\tilde{t}^b$ of the purchase price. That fraction is part of the overall buyer transaction cost, i.e. $\tilde{t}^b \leq t^b$.

3.4 Value functions and household decisions

The state vector of a household at the beginning of a period is (τ, i, σ, a, h). The first two components, age and income decile, are exogenous to the household's problem. $\sigma \in \{0, 1\}$ is an indicator for social housing access for a renter household. Financial and housing assets a and h are the outcomes of past savings decisions. Let $V(\tau, i, \sigma, a, h)$ be the household's value function which solves the recursive problem

$$V(\tau, i, \sigma, a, h) = \max_{c,s,a',\tilde{h}'} u(c, s; \tau, \mathbb{I}_{h>0}) + \beta \mathbb{E} V(\tau', i', \sigma', a' + b', h') \ , \tag{5}$$

subject to

$$\begin{aligned} c + a' + p\tilde{h}' = {} & y(\tau, i) + [1 + r\mathbb{I}_{a>0} + r^m \mathbb{I}_{a<0}]a + ph + \max(\rho(h - s), 0) - \tilde{\rho} s \mathbb{I}_{h=0} \\ & - mh - T_\tau(y^t) - \mathbb{I}_{\tilde{h}' \neq h}(t^b p\tilde{h}' + t^s ph) \ , \end{aligned} \tag{6}$$

$$\tilde{h}' \in \mathcal{H} \cup \{0\}, \ s \geq 0, \ s \leq h \text{ if } h > 0 \ , \tag{7}$$

$$a' \geq -p\tilde{h}'(1 - \theta_\tau) \ , \tag{8}$$

$$h' = \begin{cases} (1 - \tilde{\delta})\tilde{h}' & , \text{ with prob. } \pi^\delta \text{ if } \tilde{h}' > h_1, \\ \tilde{h}' & , \text{ otherwise,} \end{cases} \tag{9}$$

$$\tilde{\rho} = \begin{cases} \rho^s & , \text{ if } \sigma = 1, \\ \rho & , \text{ otherwise,} \end{cases} \tag{10}$$

$$\sigma' = \begin{cases} 1 & , \begin{cases} \text{with prob. } \pi_{\tau',i'} \text{ if } \sigma = 0 \text{ and } h' = 0, \\ \text{with prob. } 1-\eta \text{ if } \sigma = 1 \text{ and } h' = 0, \end{cases} \\ 0 & , \text{ otherwise,} \end{cases} \tag{11}$$

$$\begin{aligned} y^t = y(\tau, i) &+ r \max[a, 0] + (\rho - m) \max(0, h - s) \\ &- r^m \min \left\{ \max[-a, 0], \max[p(h-s)(1-\theta_\tau), 0] \right\} , \end{aligned} \tag{12}$$

$$b' \sim B(.) \text{ with prob. } \pi^I \text{ if } \tau \in \{1, 2\}, \text{ and } b' = 0 \text{ otherwise.} \tag{13}$$

Equation (6) is the budget constraint which says that expenditures on consumption, financial and housing assets must be equal to labor (or pension) income y, financial and housing assets plus interest (negative, if there is mortgage debt), rental income or rent payments, minus expenditures on maintenance, taxes and transaction costs for buying and/or selling. (7) include constraints on housing units and the requirement that homeowners do not rent additional space. (8) is the borrowing constraint. Equation (9) says that housing unit $\tilde{h}' > h_1$ depreciates with probability π^δ at the end of the period. Equation (10) specifies the rent which equals the social housing rent conditional on $\sigma = 1$. (11) says how the social housing status evolves over time: renter households ($h' = 0$) can enter social housing with probability $\pi_{\tau,i}$ and they retain social housing status with probability $1-\eta$. Taxable income is specified in (12): it includes labor or pension income, capital income, rental income with deductions for maintenance expenditures, and deductions for interest payments for mortgages on housing units that a landlord household rents out. Regarding the latter, we assume that the household can attribute up to the lendable fraction $(1 - \theta_\tau)$ of the value of rented housing $p(h - s)$ to the deductible mortgage. Lastly, (13) says that a household in the first or second age group receives random bequests b' with probability π^I drawn from the bequest distribution $B(.)$. The expectations operator in (5) is with respect to the realization of the depreciation and social housing shocks specified in (9) and (11), bequests (13), as well as income and ageing shocks.

The solution of this problem specifies policy functions for consumption $C(.)$, housing consumption $S(.)$, and financial and housing assets taken to the next period, $A(.)$ and $H(.)$. These policy functions depend on the household's state (τ, i, σ, a, h). For notational convenience, $H(.)$ denotes the housing policy $\tilde{h}$ *before* a depreciation shock hits the household at the end of the period with probability π^δ.

Simplifying notation, we denote the death event by $\tau' = 6$ in which case the continuation utility is $V(6, i', \sigma', a', h') = 0$. New households who enter age group $\tau = 1$ have value $V(1, i, 1, 0, 0)$ with probability $\pi_{1,i}$ (access to social housing) or $V(1, i, 0, 0, 0)$ with probability $1 - \pi_{1,i}$ (no access to social housing), where residual income decile i is drawn uniformly from $\{1, \ldots, 10\}$.

3.5 Equilibrium

The equilibrium specifies value and policy functions for households, housing supply and market prices for housing and rental units, given government policy. We assume that the government fixes the social housing rent ρ^s as well as the entry and exit probabilities into social housing, $\pi_{\tau,i}$ and η, and that it adjusts the supply of social housing, and therefore the construction subsidy ς, accordingly.[23] Formally, a stationary equilibrium is described by the household value function $V(.)$ and policy functions for goods consumption $C(.)$, housing consumption $S(.)$, financial and housing assets for the next period, $A(.)$ and $H(.)$, a stationary distribution μ of households over states (τ, i, σ, a, h), bequest distribution $B(.)$, house prices p, p^s, rental rate ρ, construction I, I^s, and housing stocks $\bar{H}$ and $\bar{H}^s$ for regular and social housing, and a social housing subsidy ς, such that:[24]

1. Value and policy functions, V and (C, S, A, H), solve the household's problem as specified in (5)–(13).

2. Real-estate firms maximize profits which implies (1) and (2).

3. Construction firms maximize profits which implies (3).

4. Housing market equilibrium (all housing units are occupied):

$$\bar{H} + \bar{H}^s = \int S(\tau, i, \sigma, a, h) \; d\mu(\tau, i, \sigma, a, h) \; .$$

5. Social housing units are occupied by renters with social housing access:

$$\bar{H}^s = \int S(\tau, i, \sigma, a, h) \mathbb{I}_{\sigma=1} \; d\mu(\tau, i, \sigma, a, h) \; .$$

6. μ is a stationary distribution, i.e. it is invariant regarding the exogenous Markov processes for τ and i, the evolution of social housing status (11) and policy functions for a and h.

[23] Alternatively, one may assume that the government fixes the supply of social housing whereas access probabilities into social housing adjust proportionately in equilibrium. Our counterfactual experiments do not change much under this alternative specification.

[24] We only consider equilibria where real-estate firms own a positive fraction of the housing stock. Depending on the parameterization, it is conceivable that all rented housing units are owned by landlord households in which case the price-to-rent ratio is too high for real-estate firms to be active in equilibrium. Given that firms (corporations and limited liability partnerships) own a significant fraction of the housing stock, this seems to be a reasonable restriction.

7. The distribution of bequests $B(.)$ is identical to the distribution of $a' + p(1 - t^s)h'$ for households in age group $\tau = 5$.

8. Housing stocks $\bar{H}$ and $\bar{H}^s$ are stationary, conditions (4).

Given a stationary equilibrium, the stock of owner-occupied housing is

$$\bar{H}^{ho} = \int \min\Big(H(\tau, i, \sigma, a, h), S(\tau, i, \sigma, a, h)\Big)\ d\mu(\tau, i, \sigma, a, h)\ ,$$

and the stock of rented housing owned by landlord households is

$$\bar{H}^{hr} = \int \max\Big(0, H(\tau, i, \sigma, a, h) - S(\tau, i, \sigma, a, h)\Big)\ d\mu(\tau, i, \sigma, a, h)\ .$$

Adding the two gives the total housing stock owned by households,

$$\bar{H}^h = \bar{H}^{ho} + \bar{H}^{hr} = \int H(\tau, i, \sigma, a, h)\ d\mu(\tau, i, \sigma, a, h)\ .$$

The stock of regular housing owned by real-estate firms is the residual

$$\bar{H}^{re} = \bar{H} - \bar{H}^h\ .$$

Government budget balance says that expenditures on public goods, pensions, and subsidies for social housing construction equal revenues from income taxes and real-estate transfer taxes:

$$G + \int y(5, i)\ d\mu(5, i, \sigma, a, h) + \varsigma I^s = \int T_\tau(y^t(\tau, i, \sigma, a, h))\ d\mu(\tau, i, \sigma, a, h)$$

$$+\tilde{t}^b p \int H(\tau, i, \sigma, a, h)\mathbb{I}_{H(\tau,i,\sigma,a,h)\neq h}\ d\mu(\tau, i, \sigma, a, h)\ .$$

4 Calibration

We choose parameter values to match key features of the German economy. All income and wealth numbers are expressed in thousand euros at 2006 prices. Several parameters are calibrated outside the model, while others are calibrated such that the model matches selected data targets.

4.1 Externally calibrated parameters

Labor income and pensions

The labor income process is described by age-specific constants M_τ, deciles for residual income E_τ, as well as transition matrices Ψ_τ. We estimate these parameters using household labor income data from the German Socio-Economic Panel (SOEP) for the years 1995–2015. The dynamics of residual labor income are estimated non-parametrically, using a similar strategy as in De Nardi et al. (2016). For details about this procedure see Appendix A.
Regarding pension income, we apply the following simple strategy. According to OECD (2013), the gross replacement rate (i.e. gross pension income divided by pre-retirement earnings) in Germany is 42%. To match this number, we first calculate average income across all working-age phases $\tau = 1, 2, 3, 4$ in each decile. We then set pension income to 42% of this value for each pension decile. The top and the bottom deciles are capped at 32,000 euros and 6,000 euros respectively, which are measures for the maximum and minimum annual pensions of the public retirement system (see Appendix A).

Taxes and bequests

We specify the income tax function as $T_\tau(y^t) = y^t - \lambda_\tau(y^t)^{1-\phi_\tau}$, where λ_τ and ϕ_τ are age-specific parameters that capture the level and progressivity of the income tax system (see e.g. Benabou, 2002; Guner et al., 2014; Heathcote et al., 2017). Age-dependence reflects possible factors not captured by the model, such as the number of children or labor market participants in the household. We estimate these functions based on all households except landlords,[25] separately for all age groups τ, for which gross and net income information is available. For details and parameter estimates, see Appendix A.

[25]Therefore, the households in the data sample cannot use the deductions due to homeownership that apply to landlord households.

Further parameters

Table 1 shows the additional parameters that are calibrated externally. The first four rows refer to demographics. Household size is estimated from the SOEP sample, using the modified OECD equivalence scale. The choices for δ_τ reflect the average durations in working-age groups $\tau = 1, \ldots, 4$ and in retirement $\tau = 5$. Since there are twenty households in age groups $\tau = 1, 2$ per dying household, the probability to receive a random bequest is $\pi^I = 1/20$.

Table 1: Externally calibrated parameters.

Parameter		Value	Explanation/Target
Household size	$(n_1, \ldots, n_5)$	(1.41,1.74,1.70,1.44,1.39)	OECD equivalence scale
Ageing probabilities	$\delta_1, \delta_2, \delta_3, \delta_4$	0.1	10-year age groups
Death probability	δ_5	0.05	20-year retirement
Inheritance rate	π^I	0.05	Random bequests for ages $\tau = 1, 2$
Risk aversion	γ	2	Standard parameter
Expenditure share	ζ	0.717	Consumption shares
Maintenance cost	m	0.0032	1.2% of consumption
Real interest rate	r	0.0255	Average 1991–2014
Real mortgage rate	r^m	0.0374	Average 1991–2014
Downpayment req.	$\theta_1, \theta_2, \theta_3$	0.20	Chiuri and Jappelli (2003)
Downpayment req.	(θ_4, θ_5)	(0.60,1.0)	No mortgage in retirement
Transaction costs	$(t^b, \tilde{t}^b, t^s)$	(0.108,0.052,0.029)	see text
Depreciation rate	δ	0.01	100-year housing lifespan
Social rent discount	ρ^s/ρ	0.80	Deschermeier et al. (2015)
Access probabilities	$\pi_{\tau,i}$	0.001–0.018	see Appendix A
Transformation rate	Φ	0.04	Schier and Voigtländer (2016)
Supply elasticity	φ	2.34	Caldera and Johansson (2013)

Regarding preference parameters, we choose a standard value for relative risk aversion, and we set the expenditure share for non-housing goods ζ so that housing consumption equals 28.3% which is the housing share of consumption expenditures of German households in 2014 (Statistisches Bundesamt, 2016). From the same data source, households spend 1.2% of total consumption on maintenance which gives rise to the parameter value for m.
The real interest rate and the real mortgage rate are averages over the period 1991–2014.[26] We set the downpayment requirements to 20% of the housing value for all households below age 55 (cf. Figure 14 in Andrews et al., 2011, and Table 1 in Chiuri and Jappelli, 2003). We further impose that mortgages must be repaid in retirement. To avoid extreme mortgage adjustments at age transitions, we set the downpayment requirement for the oldest working-age group to 60%.

[26]The safe interest rate is the yield on 10-year government bonds, and the mortgage rate is the effective rate on 10-year fixed rate mortgages reported by the Bundesbank. Nominal rates are converted into real rates with CPI inflation.

To measure transaction costs, we attribute the real-estate transfer tax (which varies by German state) and solicitor fees to the buyer. Brokerage fees (which also vary by state), are attributed to both buyers and sellers, and we apply population weights to obtain the numbers for t^b, $\tilde{t}^b$ and t^s in the table.

We normalize the price per unit of housing to $p = 1$, and we set the depreciation rate such that the average life span of a housing unit is 100 years. Regarding social housing, we set the social rent at 20% below the market rent, that is we set ρ^s to equal 80 percent of the market rent ρ (see Section 2). Access to social housing is granted to renter households depending on their income $y(\tau, i)$. We estimate transition rates into social housing by income decile using SOEP data to obtain social housing access probabilities $\pi_{\tau,i}$ (see Appendix A for details). Social housing units (whose private construction is subsidized) can be converted into regular private housing units (for rental or for sale) after a commitment period of 25 years (Schier and Voigtländer, 2016), which implies $\Phi = 0.04$.

For the construction technology we use $K(I + I^s) = \frac{k_0}{1+\varphi}(I + I^s)^{1+\varphi}$ so that $K'(I + I^s) = k_0(I + I^s)^{\varphi}$. Caldera and Johansson (2013, Table 2) estimate the long-run price elasticity of new housing supply in Germany at 0.428 which leads to $\varphi = 2.34$.[27] Parameter k_0 is set internally using the equilibrium conditions (3) and (4) to ensure the normalization $p = 1$.

We choose a housing grid $\mathcal{H} = (h_i)$ with fifteen values ranging from $h_1 = 80,000$ to $h_{15} = 700,000$. The minimum housing size corresponds to a value just below the 10th percentile of the housing wealth distribution in the SOEP sample, and h_{15} is large enough such that all households choose to own a unit below the maximum size. The probability of a depreciation shock is set to $\pi^{\delta} = 0.0651$ which ensures that the aggregate depreciation rate is indeed $\delta = 0.01$.

4.2 Internally calibrated parameters

Table 2 shows further parameters which are calibrated internally. Average household wealth identifies the discount factor β to match the data target that we obtain from the SOEP sample. From the same data, we obtain homeownership rates for the total population as well as for retired households. These data targets identify the value of monitoring costs c^m which implicitly controls the price-to-rent ratio, as well as the preference shift parameter ξ_1^5 for retired homeowner households. Note that the price-to-rent ratio in the benchmark

[27] This compares to a much higher elasticity of 2.014 in the U.S. which is likely due to a more elastic supply of land (cf. Sommer and Sullivan, 2016, who estimate a price elasticity of 0.9, and Floetotto et al., 2016, who use the number 2.5). Therefore, if we used the U.S. value of the housing supply elasticity in our calibration, we would obtain *smaller* price responses in general equilibrium. In other words, our results would be closer to the partial equilibrium responses that we report below next to the general-equilibrium results.

model equals 19.5 which is reasonably close to the 2004–2008 average of 21.6 reported by the Bundesbank.[28] The social housing exit probability η is set internally to make sure that social housing is 7.1% of the total housing stock which is the share in 2002 (Kirchner, 2007).

Table 2: Internally calibrated parameters.

Parameter		Value	Target	Model	Data
Discount factor	β	0.949	Average wealth	129.5	128.7
Monitoring cost (%)	c^m	0.0127	Homeownership rate (%)	42.3	42.2
Utility weight owner 65+	ξ_1^5	1.485	Homeownership rate 65+ (%)	47.0	47.6
Construction cost	k_0	0.2515	Normalization $p = 1$	–	–
Social housing exit rate	η	0.031	Social housing share	0.071	0.071

4.3 Model fit

Figure 1 shows the model-generated age profiles of homeownership, net wealth, housing and financial wealth. Note that we target the homeownership rate of households in all age groups pooled together which is 42.2% as well as homeownership in retirement. Our model captures rather well the increase of the homeownership rate during the first four age stages, as well as the slight decline in retirement.

Regarding wealth, our model generates hump-shaped patterns of net wealth and its components, although it overpredicts the accumulation of net wealth during working life and the decumulation in retirement. As the bottom left graph shows, this is due to retirees owning too small housing units in the model. Our model generates a wealth Gini coefficient of around 0.5 which is too low compared to the one in our data (0.61). This is a well-known feature of incomplete-markets models using income processes estimated from household survey data (cf. De Nardi and Fella, 2017, for a recent survey).

The top graphs in Figure 2 show that our model captures rather well the hump-shaped age profiles of average gross and net income over the lifecycle. Note again that only the age profile of labor income is calibrated, whereas capital and rental incomes are endogenous, as are the tax deductions of landlord households. The bottom graphs in this figure show that our model generates relatively well the variations of the homeownership rate by income and wealth deciles. Both in the data and in the model, the homeownership rate for the bottom four wealth deciles is below ten percent, and it is above 88 percent for the top three wealth deciles. In other words, the homeownership status varies most between the fifth and

[28] See the series "Purchase price/annual rent ratio of freehold apartments in Germany (administrative districts)" available at https://www.bundesbank.de/Navigation/EN/Statistics/statistics.html.

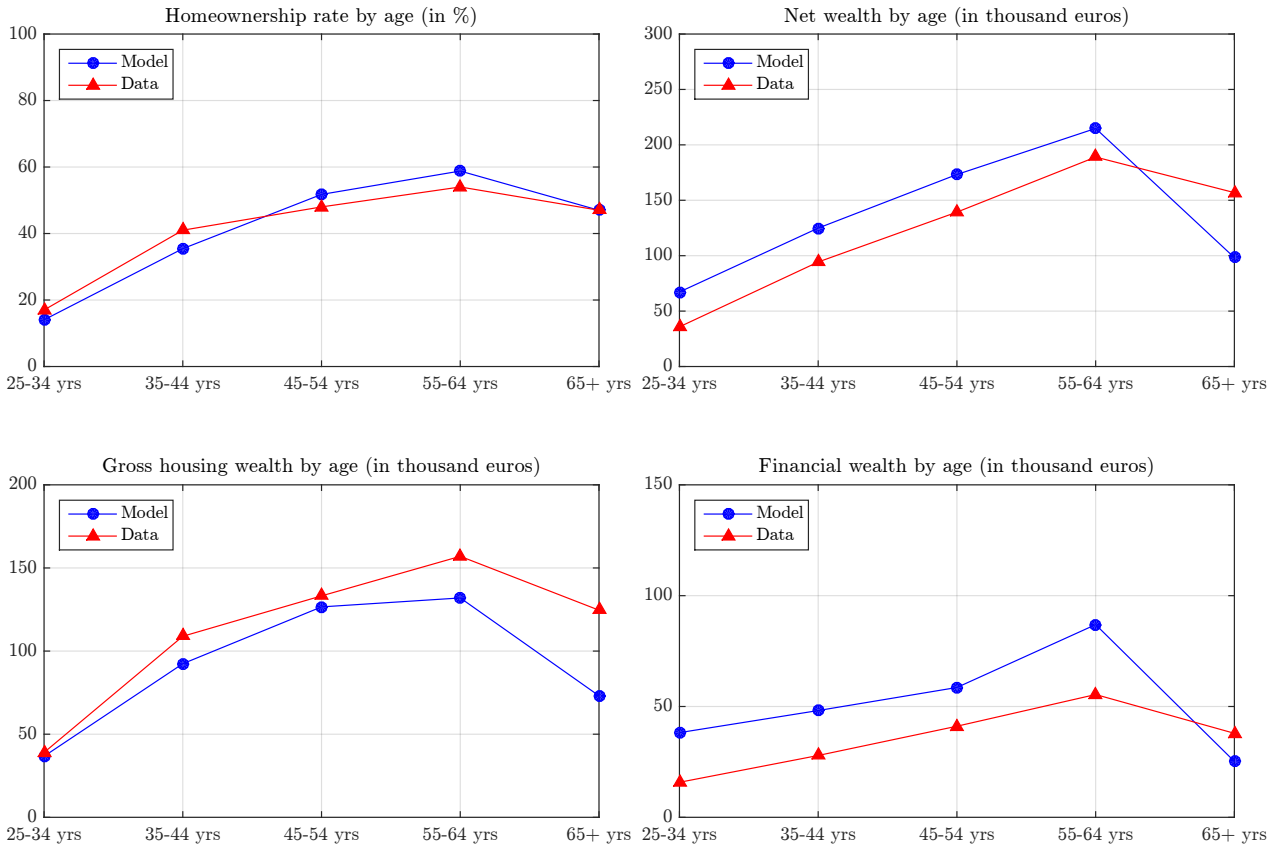

Figure 1: Model fit

seventh wealth deciles. Regarding income variation, the model accounts for a difference of 30 percentage points between homeownership rates in the top and bottom deciles which is somewhat smaller than in the data.

5 Accounting for low homeownership

The good fit of our model to non-targeted moments, and in particular to the homeownership rate profiles by age, wealth and income, lends support for its use as a tool for counterfactual policy evaluation. In this section, we aim at quantifying the importance of different institutional factors for homeownership and wealth accumulation. To this end, we conduct a series of counterfactual experiments in our general equilibrium framework, where our focus is on steady-state comparisons. In particular, we explore the following four counterfactuals C1-C4 which move the German housing policies closer to those applied in the United States:

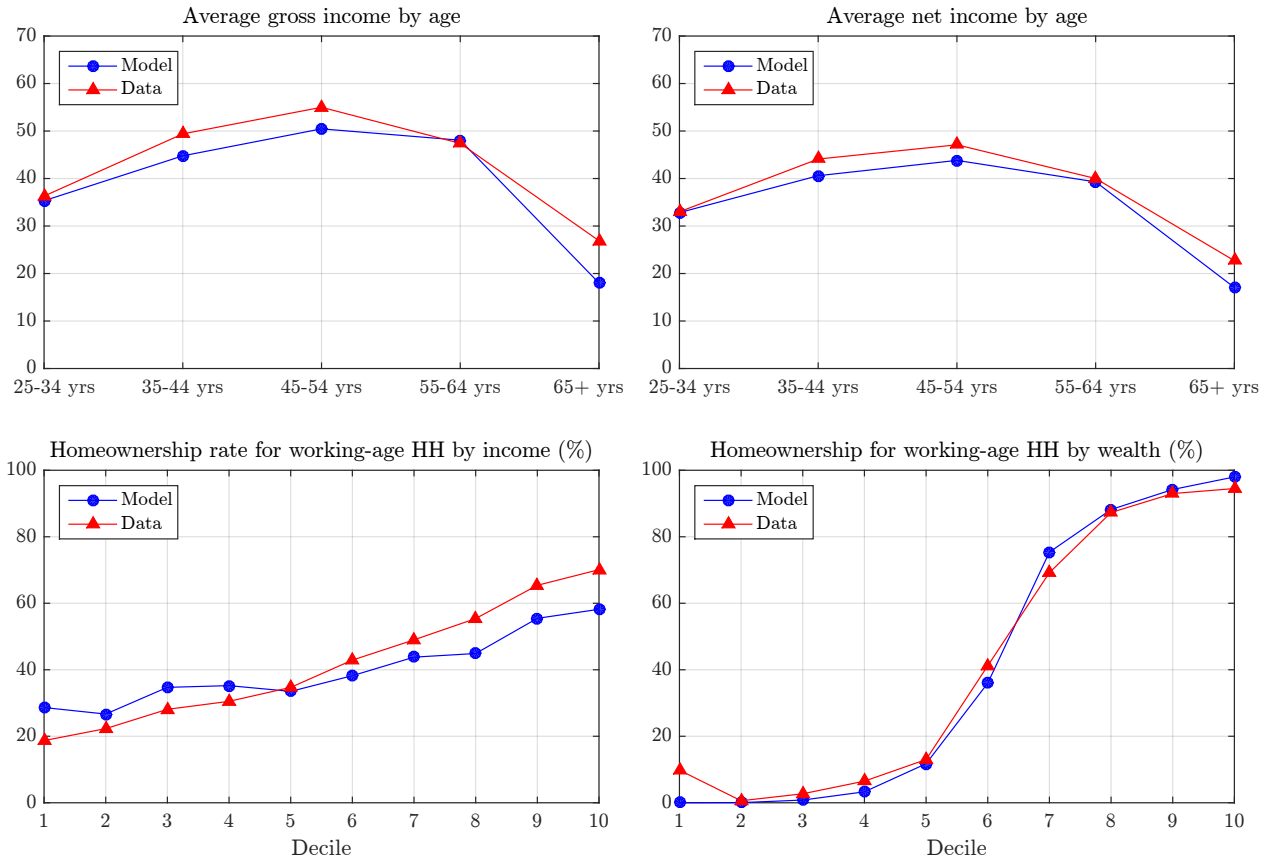

Figure 2: Model fit

C1: The real-estate transfer tax (RETT) is set to a value comparable to the U.S., $\tilde{t}^b = 0.33\%$.

C2: Mortgage interest payments are fully tax deductible.

C3: There is no social housing, i.e. access probabilities are set to zero:[29] $\pi_{\tau,i} = 0$.

C4: Full combination of C1-C3.

Throughout all experiments, we let house prices, rental rates and housing construction adjust to clear the housing market. For counterfactuals C1 and C2, we further fix social housing access probabilities at the benchmark level (adjusting the social housing construction subsidy accordingly), and we keep the social rent at the same level as in the benchmark. We further impose for all experiments revenue neutrality for the government. To achieve this, we increase/decrease the scale parameters of the tax functions λ_τ by the same proportion for all

[29] Although social housing exists in the U.S., its scale is much smaller and access is means-tested to ensure that only the poorest households can benefit from it.

age groups to balance the government budget. We then contrast our experiments with those in partial equilibrium where house prices and taxes do not adjust in order to understand the impact of the various policies on housing demand in isolation.

Homeownership rates by age

Figure 3 plots the age profiles of homeownership for our counterfactual experiments. As can be seen, the lifecycle profiles of homeownership rates lie higher for any individual counterfactual scenario than in the baseline economy. The effects are quite significant for C1 (elimination of RETT) while being slightly more moderate under C2 (mortgage interest deduction) or C3 (no social housing). This suggests that all channels contribute prominently to explaining low homeownership rates in Germany.

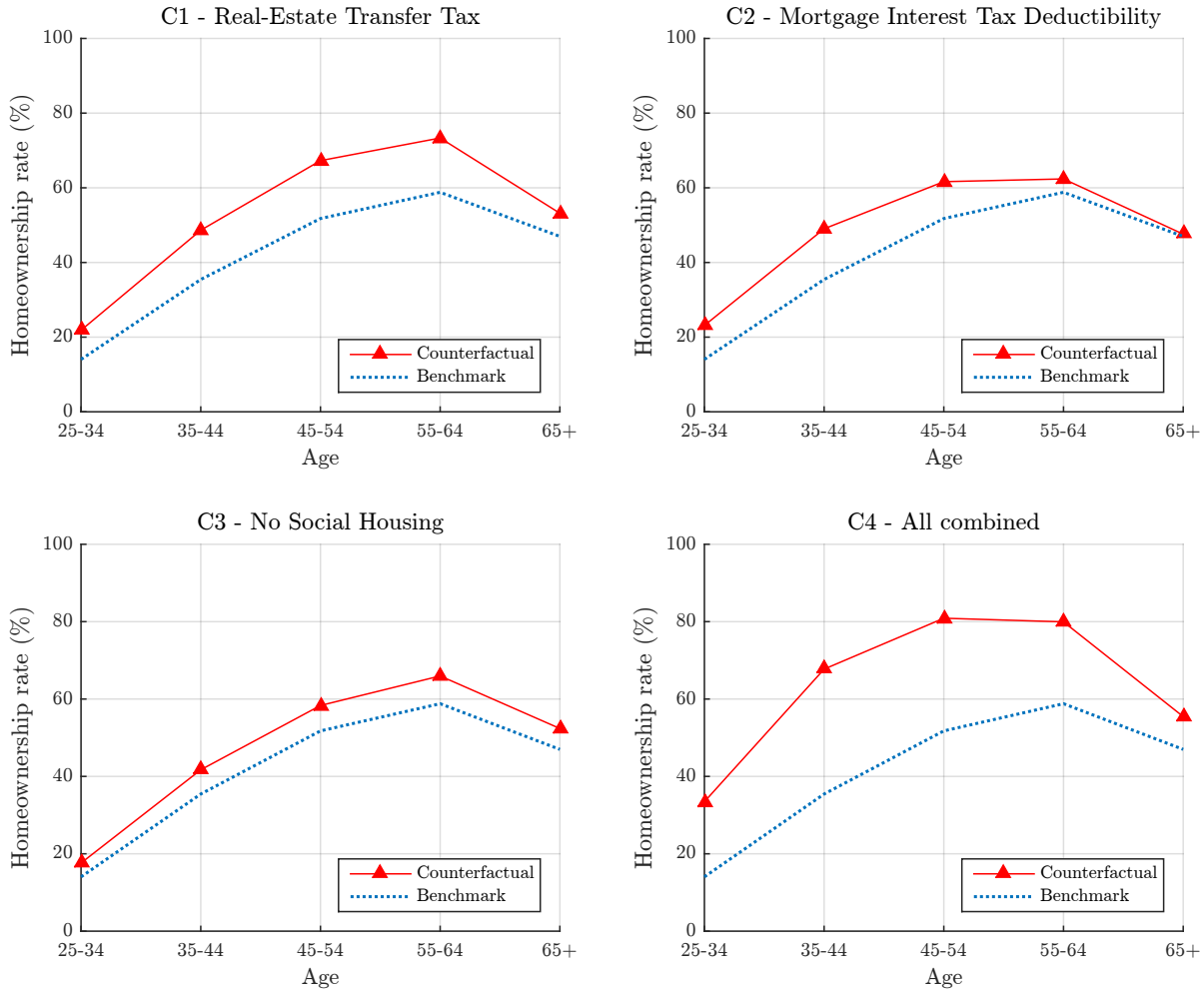

Figure 3: Homeownership rate by age for counterfactual experiments

Quantitatively, the most important policy factor is the real-estate transfer tax (RETT). Our

results suggest that cutting the RETT would shift the homeownership profile upwards by 6-16 percentage points across all age groups. The quantitative impact of RETT in our model is largely consistent with empirical findings: Petkova and Weichenrieder (2017) estimate a -0.23 elasticity of RETT on transactions of single-family homes. In our model, 1.66% of households buy an owner-occupied housing unit each year, and under policy C1 (reducing the RETT), this share increases to 2.57% in general equilibrium (with price and tax adjustment) or to 2.52% (without tax adjustments), suggesting an elasticity of -0.45 or -0.42 respectively.[30]
Without social housing, the lifecycle profile would shift upwards by 6-7 percentage points for the middle- and older-age groups and by a bit less for the youngest age group. Finally, our results suggest that making mortgage interest payments fully tax deductible has a positive 9-14 percentage points effect on homeownership for the younger age groups, but it is quantitatively much weaker for older workers and retirees.
The combined effect is depicted in the bottom right panel of Figure 3. We find that homeownership rates would be as high as 68% in the second age group, and around 80% for the middle- and older-age groups if all policy channels were adjusted simultaneously. The overall homeownership rate under the combined scenario increases to 62.2% which is only a few percentage points below the homeownership rate in the U.S.

Homeownership, wealth accumulation and house prices

To shed more light on these findings, Table 5 reports a selection of aggregate statistics. Our results suggest that lower transaction costs or no social housing lead to a more pronounced wealth accumulation together with higher homeownership. Mortgage interest deductibility also fosters housing investments, but higher indebtedness nearly offsets the impact on total wealth. Under any policy change, households would invest a larger share of their portfolio in housing wealth, while assets invested in financial wealth would decrease even in absolute terms.
Interestingly, although all three policies C1–C3 promote homeownership, they have quite distinct implications for house prices as well as for the price-to-rent ratio. The house price falls when social housing is abolished (C3), but the reverse is true when the RETT is cut (C1) or when mortgage interest can be deducted (C2). These results are intuitive: without the option of subsidized housing overall demand for housing services goes down, so that house prices as well as the price-to-rent ratio fall; conversely, with the lower RETT, housing demand goes up, especially at the lower-income groups, which increases the price-to-rent

[30] A potential reason for the higher elasticity in our model could be that we consider all housing units, and that transactions of smaller units (apartments) are more sensitive to changes in transaction costs than transactions of single-family homes.

Table 3: **Counterfactuals: General equilibrium and revenue neutrality**

	Benchmark	RETT C1	Mort Ded C2	No Social H C3	Combination C4
Homeownership (%)	42.3	52.9	48.6	48.1	62.2
– 25-34 yrs	14.0	21.8	23.1	17.6	33.5
– 35-44 yrs	35.4	48.6	49.0	41.7	67.7
– 45-54 yrs	51.8	67.3	61.6	58.3	80.9
– 55-64 yrs	58.8	73.3	62.4	66.0	79.9
– 65+ yrs	47.0	53.2	47.6	52.4	55.5
Total wealth	129.5	138.4	131.8	133.6	140.5
– Housing	89.0	114.9	107.0	99.3	139.9
– Financial	47.1	35.1	40.2	42.2	26.1
– Mortgage	-6.6	-11.7	-15.4	-8.0	-25.5
House price	1.000	1.010	1.011	0.981	1.018
Price-to-rent ratio	19.46	19.51	19.52	19.34	19.56
ΔGov't BC (per HH)	–	0	0	0	0
–ΔRETT Rev	–	-0.245	0.037	0.035	-0.241
–ΔIncTax Rev	–	0.227	-0.047	-0.121	0.156
–ΔSocHous Subs	–	-0.019	-0.009	-0.085	-0.085
ΔDemand (in %)	–	0.44	0.45	-0.75	0.76
–Income Q1	–	1.71	-0.23	-0.32	-0.33
–Income Q2	–	1.20	1.31	-0.28	2.57
–Income Q3	–	0.62	1.14	-0.37	1.55
–Income Q4	–	-0.53	0.38	-1.16	-0.37
–Income Q5	–	0.00	-0.29	-1.21	0.41

NOTE: All monetary values in thousand euros.

ratio. Similarly, the effect of tax deductibility of mortgage interest raises the price-to-rent ratio and the house price, this time through a rising housing demand of middle-income households. Finally, in the combination of all counterfactuals (C4) the house price and the price-to-rent ratio are higher than at the benchmark level. Again this is induced by a surge of housing demand in the lower- and middle-income groups.

The adjustment of prices in general equilibrium is attenuated by the adjustment of income taxes. If taxes were fixed at the benchmark level, the cut of RETT would lead to an even stronger increase of housing demand which induces a twice as large increase of the house price, hence mitigating the policy impact (see Table 11 in Appendix B).

Housing demand

To better understand the impact of different policies on housing demand, we present in Table 4 the model implications under the scenario where the house price, and hence the rental rate, are fixed and where taxes do not adjust to balance the government budget. That is, we ignore the reaction of housing supply and tax policy to the different policy changes. A first observation is that the effect of the reduction of RETT on homeownership and wealth is a bit stronger than in the benchmark scenario: because the house price does not increase, it becomes even more attractive for households to invest in housing, both for their own consumption as well as for investment purposes. For a similar reason, the introduction of mortgage interest deductibility has a larger effect on housing investment and wealth when prices are fixed. Indeed, under both C1 or C2, housing demand increases substantially for all income groups. Tax deductibility has a particularly strong impact on the demand of middle-income groups whose decision to take up a mortgage in order to finance a home is most responsive to the policy change.

On the other hand, the effect of the removal of social housing is weaker when house prices and rents are fixed. Compared to the benchmark scenario, the homeownership rate increases to 46.6%, which is due to the fact that the option value of entering a subsidized unit is gone. However, overall housing demand falls because both renters and homeowners want to live in smaller units than before. In general equilibrium, this decline in housing demand leads to a fall of house prices (and less housing construction) which pushes up the homeownership rate to 48.1%. Without this price decline, the increase of homeownership is weaker.

Table 4 further presents the impact on the government budget in partial equilibrium (without price or tax adjustments). For instance, cutting the RETT imposes a cost on the government of 330 euros per household, while no subsidies to social housing implies a revenue increase of 75 euros per household. When price changes in general equilibrium are taken into account, these numbers change only little (see Table 11 in Appendix B).

Homeownership rates by wealth decile

Differences in homeownership rates across European countries are largely accounted for by the bottom and middle deciles of the wealth distribution (see Kaas et al., 2016). In Figure 4 we show how the four counterfactual experiments affect the homeownership rate across deciles of the wealth distribution. None of the policy changes has a sizeable effect on homeownership rates in the bottom two deciles of the wealth distribution, but quite significant effects for households in the middle deciles. In particular, the combined effect of all four scenarios raises the homeownership rates in the middle deciles by more than 55 percentage points.

Table 4: **Counterfactuals: Partial equilibrium with fixed taxes and house prices**

	Benchmark	RETT C1	Mort Ded C2	No Social H C3	Combination C4
Homeownership (%)	42.3	53.4	49.0	46.6	62.3
– 25-34 yrs	14.0	22.2	22.4	16.6	32.4
– 35-44 yrs	35.4	48.9	49.4	40.9	66.4
– 45-54 yrs	51.8	67.7	61.7	57.6	80.5
– 55-64 yrs	58.8	73.6	62.7	64.4	80.5
– 65+ yrs	47.0	54.0	48.8	50.0	57.1
Total wealth	129.5	140.0	133.2	132.3	144.3
– Housing	89.0	116.8	108.4	97.2	143.0
– Financial	47.1	35.2	40.3	42.9	27.0
– Mortgage	-6.6	-12.0	-15.5	-7.8	-25.7
House price	1.000	1.000	1.000	1.000	1.000
Price-to-rent ratio	19.46	19.46	19.46	19.46	19.46
ΔGov't BC (per HH)	–	-0.330	-0.220	+0.075	-0.670
–ΔRETT Rev	–	-0.245	0.040	0.028	-0.241
–ΔIncTax Rev	–	-0.106	-0.271	-0.038	-0.514
–ΔSocHous Subs	–	-0.022	-0.012	-0.085	-0.085
ΔDemand (in %)	–	2.05	1.96	-2.36	4.19
–Income Q1	–	3.06	0.98	-1.81	2.51
–Income Q2	–	3.00	2.88	-1.88	5.88
–Income Q3	–	2.27	2.61	-2.19	5.07
–Income Q4	–	1.12	1.73	-2.52	3.23
–Income Q5	–	1.53	1.51	-2.94	3.98

NOTE: All monetary values in thousand euros.

6 Welfare and policy

In this section we *(i)* discuss the welfare consequences of the three housing policies we consider in the previous section, and, *(ii)* introduce alternative housing market policies which are targeted to low-income households.

6.1 Welfare effects

We compute welfare in terms of percentage consumption equivalence to the benchmark economy of a newborn after drawing the first income realization. In this way, we can discuss

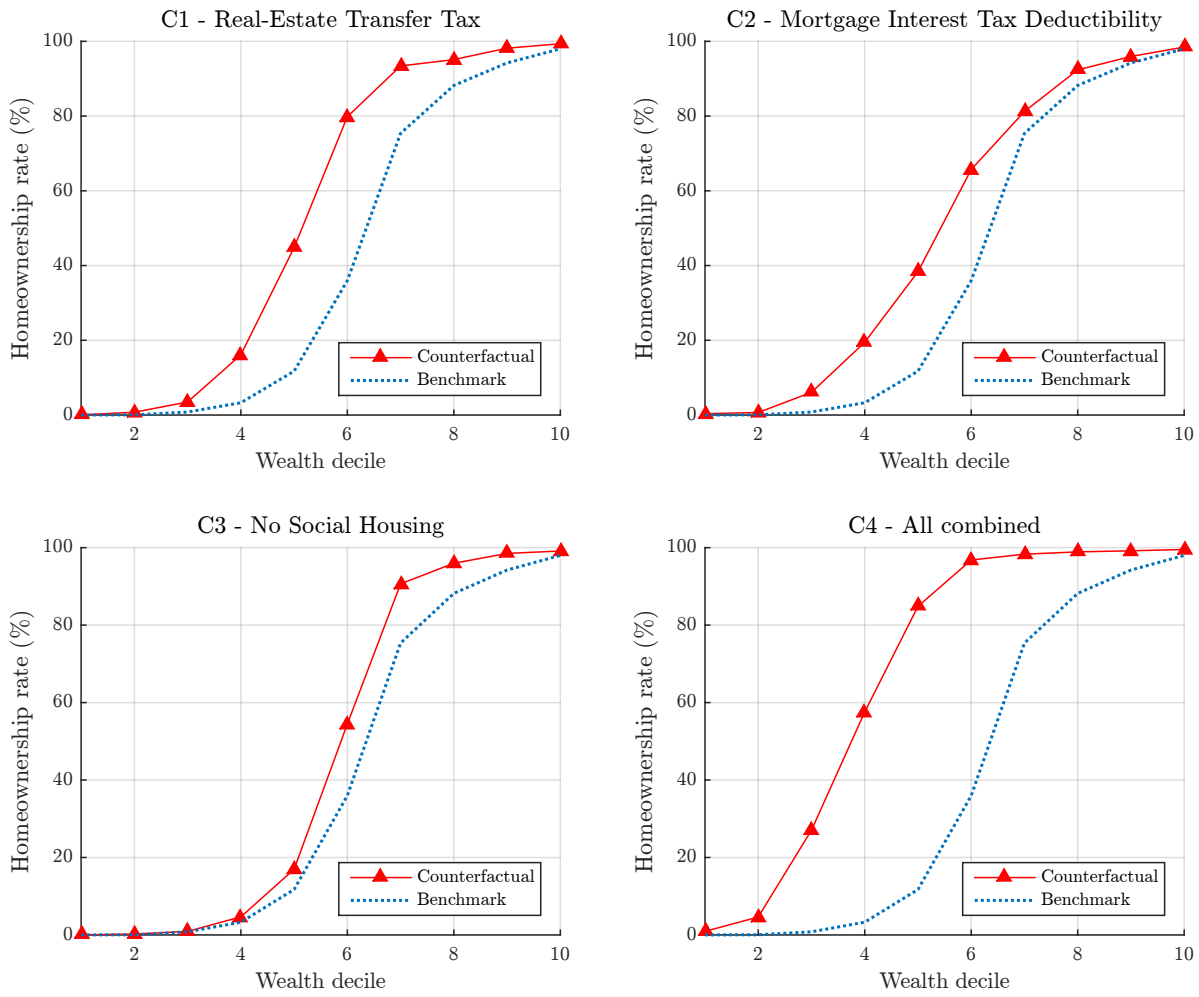

Figure 4: Homeownership rate by wealth decile in counterfactual experiments (for working-age households).

the welfare consequences of the housing policies for households entering the economy in different segments of the income distribution.[31] In each of the four cases C1–C4, we look at several versions of the counterfactual economies. First, we compute the welfare results for the partial equilibrium with fixed prices and the same taxes as in the benchmark. Second, we allow for house prices and rents to adjust in equilibrium, keeping taxes fixed. Finally, we look at fiscally neutral versions of the experiments where prices *and* taxes adjust. The results are presented in Figure 5.

Reducing the RETT to U.S. levels (C1) without adjusting prices and taxes leads to an

[31]The emphasis of our welfare analysis is on long-term outcomes shaped by housing policy. Therefore we focus on the well-being of a newborn household born into the stationary environment induced by the reforms. Furthermore, our model does not feature positive externalities of homeownership that are sometimes discussed in the literature (e.g. Green and White, 1997, and Dietz and Haurin, 2003) which may additionally affect welfare.

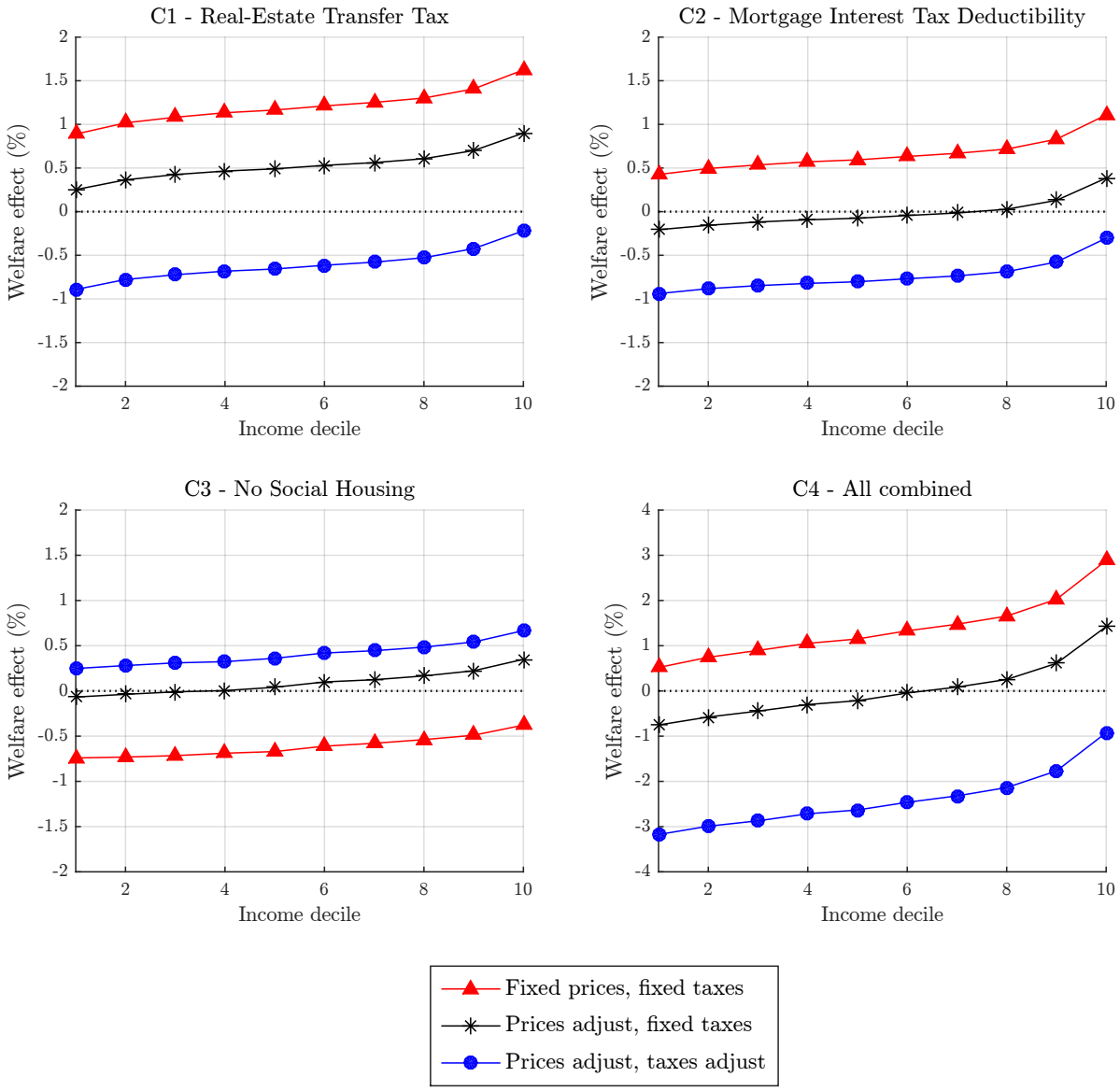

Figure 5: Welfare effects by income decile for counterfactual experiments (in consumption equivalent variations)

immediate increase in welfare of around 1-1.5% across all incoming income groups because households face lower transaction costs related to buying a home. When the house price and rents are allowed to increase in equilibrium, this positive effect is diminished. Once taxes adjust to account for the lost revenue, the welfare consequences from reducing the transfer tax become negative for newborn households in all income groups.

The full deduction of mortgage interest payments (C2) has very similar welfare consequences to C1. In this case though, the welfare gains in partial equilibrium are completely offset when prices are allowed to adjust. Fiscal neutrality, in addition, leads to a loss in terms of benchmark equivalent consumption of around 0.5-1.0%. Note that in both experiments

C1 and C2, households who enter the economy with lower incomes lose more than their richer counterparts. The explanation is that lower-income young households are less likely to become homeowners later in life and hence benefit less from the removal of RETT or from the introduction of mortgage interest tax deductions.
The welfare effects of abolishing social housing (C3) are quite different. The partial equilibrium results with fixed prices and taxes are negative for all entering income groups. Once the house price is allowed to decrease in equilibrium, entrants with above-median income start to benefit. Further, the reduction of income taxes due to the saved social housing subsidies make all newborn households winners of this policy with an average welfare gain of 0.41%. The gains are larger for households entering the economy in higher income deciles who are more likely to become homeowners (and thus to buy at a lower house price) and less likely to benefit from social housing subsidies.
The combination of all three policies (C4) decreases welfare when house prices and taxes are adjusted in equilibrium. Households entering the economy at the bottom end of the income distribution face a consumption reduction of around 3%, while richer entrants lose around 1%.

6.2 Targeted housing policies

Our results show that conventional policies of low transaction taxes and mortgage interest tax deductions would raise the homeownership rate in Germany, but would not bring about efficiency gains for households, especially at the bottom end of the income distribution. On the other hand, abolishing social housing improves welfare for all newborns, with the largest welfare gains accruing to high-income households. In the following we therefore propose and evaluate three policy alternatives that specifically target low-income households:

P1: (Targeted social housing) Restrict access to social housing (move-in probabilities) to households in the lowest two deciles of the aggregate income distribution. We assume equal access probabilities for all eligible households. Furthermore, we set the social housing rent and the probability of social housing exit to their benchmark levels. The production subsidy on social housing is set to generate the same government spending on social housing as in the benchmark.

P2: (Housing subsidy) Abolish social housing and substitute it with targeted housing subsidies. In particular, all households (both owners and renters) in the lowest two deciles receive a housing subsidy, proportional to the (imputed) rental expenditures. The percentage rate of the subsidy is set so that government spending on this subsidy

is equal to social housing spending in the benchmark.[32]

P3: (Subsidizing young buyers) Provide proportional subsidies to households in the first age group 25-34 when they buy a home. The eligibility criterion is that household labor income is below the median labor income in the economy. We set the subsidy to 10% of the house price, which is half of the downpayment requirement or twice the RETT.

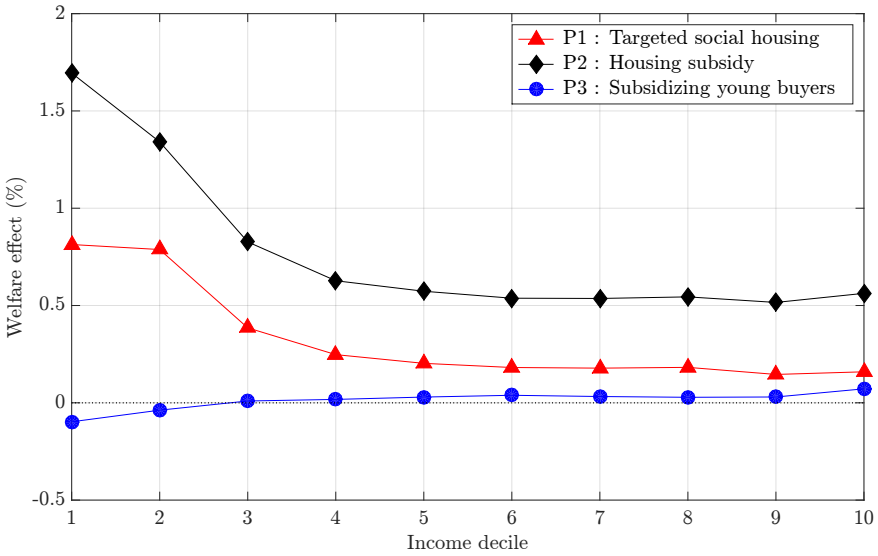

Figure 6: Welfare effects by income decile for targeted housing policies

We look at fiscally neutral versions of the experiments with fully adjusted house prices. Detailed results of the counterfactual experiments are presented in Table 5 and welfare results are shown in Figure 6, again differentiated by the income decile of households upon entering the economy. Targeted social housing (P1) leads to a rise (fall) in housing demand for poor (rich) households. Aggregate housing demand, and hence the house price and the price-to-rent ratio, barely change so that the homeownership rate stays the same as in the benchmark economy. The policy is associated with an average welfare improvement for all households of around 0.33%. Entrants in the bottom two deciles benefit more from targeted social housing, with average welfare gains of 0.8%. Therefore, the targeted version of the

[32]Germany already operates a social program of housing subsidies (*Wohngeld*). The entitlement to the program depends on income and household size. In 2004, around 9% of German households benefited from the program, but thereafter recipients of social benefits (Hartz IV) were excluded from this program, so that *Wohngeld* spending dropped by more than two thirds. This program enters implicitly in the estimated tax functions that we use in the model. With our policy experiment, we propose a substantial expansion of the existing housing subsidy programs.

social housing policy dominates the existing policy, but it delivers smaller *average* welfare gains compared to the proposed elimination of social housing (C3). However, welfare gains for poorer entrant households are larger under program P1.

Table 5: **Targeted housing policies**

	Benchmark	Targeted SH P1	Housing subs P2	Young buyers P3
Homeownership (%)	42.3	42.3	47.0	47.1
– 25-34 yrs	14.0	14.2	16.7	23.8
– 35-44 yrs	35.4	35.1	40.6	43.0
– 45-54 yrs	51.8	51.7	57.5	57.0
– 55-64 yrs	58.8	59.0	64.6	61.9
– 65+ yrs	47.0	47.1	51.3	48.3
Total wealth	129.5	129.9	132.4	134.2
– Housing	89.0	89.2	97.7	100.1
– Financial	47.1	47.1	42.5	44.3
– Mortgage	-6.6	-6.5	-7.8	-10.3
House price	1.000	1.002	0.988	1.003
Price-to-rent ratio	19.46	19.46	19.38	19.47
ΔGov't BC (per HH)	–	0	0	0
–ΔRETT Rev	–	0.002	0.029	0.026
–ΔIncTax Rev	–	-0.002	-0.029	0.086
–ΔSocHous Subs	–	0.000	-0.085	-0.012
ΔDemand (in %)	–	0.06	-0.54	0.11
–Income Q1	–	1.35	4.34	0.80
–Income Q2	–	0.28	-0.80	0.69
–Income Q3	–	-0.12	-1.00	0.30
–Income Q4	–	-0.20	-1.59	-0.38
–Income Q5	–	-0.36	-1.66	-0.36

NOTE: All monetary values in thousand euros.

Providing housing subsidies to poor households instead of social housing (P2) leads to a homeownership rate of 47%. This increase relative to the benchmark is driven by a decline of the house price which is induced by lower housing demand from middle- and higher-income households, accompanied by a sharp increase of housing demand of poorer households. More housing transactions further bring about an increase of RETT revenues which allows the government to cut income taxes. The policy delivers average welfare gains of around 0.78% in terms of consumption equivalence. Welfare gains are particularly large (1.3-1.7%) for house-

holds entering the economy in the lowest two deciles. Direct housing subsidies provide better insurance against income risk than the provision of targeted social housing (P1) because of two reasons: First, the subsidies are given both to homeowners and to renters; second, access to social housing is uncertain, while subsidies are paid to every eligible household. Interestingly, targeted housing subsidies even benefit households who enter the economy in the upper deciles. These households are essentially indifferent between the policy of targeted housing subsidies (P2) and the abolition of social housing (C3), see Figures 5 and 6. Even though C3 brings about larger tax cuts and lower house prices, rich entrants value the additional insurance of P2 because of the income mobility they face.

Finally, subsidizing young buyers (P3) leads to a disproportionate rise in homeownership in the first age group, so that the aggregate homeownership rate goes up to 47.1%. Aggregate housing demand barely increases, however, as does the house price. Interestingly, this policy does not provide any change in average welfare. The average household holds more housing wealth and larger mortgages relative to the benchmark because homeownership is explicitly incentivized. However, the incentive is given to young households who are subject to income shocks and may benefit more from holding a larger share of their portfolio in terms of liquid assets.

7 Conclusions

In this paper, we examine the institutional reasons behind Germany's low homeownership rate. For this purpose we build a quantitative macroeconomic model with overlapping generations who face uninsurable income risk and who decide about consumption of goods and housing services and about savings in terms of liquid financial assets and illiquid housing wealth. German tax policies which disadvantages homeowners, such as real-estate transfer taxes and an income tax law without mortgage-interest deductions, explain a large fraction of the homeownership rate gap to countries like the U.S. where the homeownership rate is about 20 percentage points higher. Changing these tax policies does not lead to welfare gains, however. This is because higher income taxes are required to balance the government budget and because the house price increases in response to stronger housing demand.

A further important determinant of low homeownership is the provision of social housing to households who are more likely to enter such housing units when they have low income but who may continue to pay a subsidized rent even when income goes up. The abolition of social housing not only raises the homeownership rate, but also brings about long-run welfare gains for all households entering the economy in different income deciles. We argue that welfare gains are even larger, and especially more targeted towards lower-income households, when

social housing is replaced by housing subsidies paid to lower-income households.

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Appendix A: Data

Data

The empirical facts about homeownership, income and wealth are derived from the German Socio-Economic Panel (SOEP). Detailed household wealth information is not collected every year. We use the wealth modules of the SOEP collected in years 2002, 2007 and 2012. The data is restricted to households whose head is of age 25 or older. Household labor income of household heads of age below 65 is restricted to be positive. We also exclude business owners to be consistent with our quantitative model which does not feature entrepreneurship. The resulting pooled dataset consists of 24,595 households. Homeownership is defined as owning the primary household residence. Household net wealth is defined as the value of all real and financial assets net of liabilities.

The data used in the estimations of the household labor income processes, tax functions and social housing move-in probabilities by income deciles also come from the SOEP. We use all yearly waves between 1995 and 2014. The data restrictions are on the age of the household head (25-64 years) and household labor income (positive values). The derived sample consists of 130,686 observations. The income variables utilized in the estimation of the income tax functions are gross household and net household income. The data sample for the estimation of income-tax functions excludes landlord households since mortgage interest on rental units can be deducted (see the main text). Therefore, the sample size for this estimation is reduced to 112,467 observations. All monetary values are CPI-deflated and are expressed in terms of 2006 euros.

Estimating household labor income processes

The household labor income processes are estimated non-parametrically following a strategy related to De Nardi et al. (2016).[33] We construct first-order discrete Markov processes for residual labor income directly from the SOEP data as input for each of the working-age groups in our economic environment. We refer to "household age" when we mean the age of the household head. The procedure can be summarized as follows. Working-age stages $\tau = 1, 2, 3, 4$ in the model correspond to 10-year age groups in the data, namely 25-34, 35-44, 45-54, and 55-64 years of age. For each of these age stages of the lifecycle, we pose the

[33]They argue that non-parametric estimates of the labor earnings process have significant advantages over the more traditional approaches of estimating a parametric linear Markov process for the stochastic component of earnings and discretizing it. In particular, the non-parametric method performs better when used in quantitative work in terms of matching the lifecycle patterns of consumption and savings.

following specification for household labor income:

$$\log y_{j,t}^{\tau} = \alpha_0^{\tau} + \alpha_{1,t}^{\tau} D_t + \alpha_2^{\tau} a_{j,t}^{\tau} + \alpha_3^{\tau} (a_{j,t}^{\tau})^2 + \varepsilon_{j,t}^{\tau} \ , \tag{14}$$

where D_t is year-t dummy variable and $a_{j,t}^{\tau}$ is the actual age of household j in year t within the age stage τ. For instance, if $\tau = 1$, then the age of the households observed in this stage would be between 25 and 34. The term $\varepsilon_{j,t}^{\tau}$ reflects the stochastic component of household labor income. Several clarifications are in order. First, we control for time and age effects and extract the residual stochastic income which is used in the construction of the Markov chains describing labor income dynamics. Second, by estimating (14) for each age group τ separately, we allow these time and age effects to be different over the lifecycle.
The estimated coefficients in regressions (14) are used to construct the age-specific deterministic income levels M_{τ}. We use the estimated residuals from the four regressions (14) to construct the age-specific discrete Markov processes for income dynamics. For this purpose, we assume that $\varepsilon_{j,t}^{\tau}$ is i.i.d. distributed across households. Then, we pose that $\varepsilon_{j,t}^{\tau}$ follows a discrete Markov chain of order one with an age-dependent state space

$$E_{\tau} = \left\{ e_1^{\tau}, ..., e_I^{\tau} \right\} \ ,$$

for $\tau = 1, ..., 4$ and an age-dependent transition matrix $\Psi_{\tau}(i'|i)$ of size $I \times I$. Note that the age-dependent state space is of constant size I but the residual income realizations and the transition matrices are age-specific. In estimating these processes we proceed as follows:

1. We fix the number of bins, $I = \{1, \ldots, 10\}$. Each discrete level of residual income can be interpreted as a decile of the age-specific residual income distribution. For each age τ, we order the estimated $\varepsilon_{j,t}^{\tau}$ in ascending order and divide them in ten bins of equal size.

2. Each point in the state space E_{τ} is picked to be the mean in bin i at age τ.

3. The elements $\psi_{i,i'}^{\tau}$ of the transition matrix $\Psi_{\tau}(i'|i)$ are set to the observed average proportions of households in bin i in year t that are in bin i' in year $t+1$ for $t = 1995, \ldots, 2013$.

The estimated values for the annual labor income deciles vary from 3,038 euros (lowest decile) to 81,185 euros (highest decile) for age 25-34 and from 5,058 euros (lowest decile) to 120,053 euros (highest decile) for age 45-54. The transition matrices are normalized to doubly

stochastic matrices with the help of the Sinkhorn-Knopp algorithm (Sinkhorn, 1964).[34] The estimated transition matrices exhibit significant persistence which increases with age.

Pension income

As mentioned in the main text, we set pension income at 42% of average earnings in the respective decile at which a household moves into retirement, and we apply caps at 32,000 euros and 6,000 euros.[35] As a result we obtain the deciles of pension incomes shown in Table 6.

Table 6: Pension income

$y(5,1)$	$y(5,2)$	$y(5,3)$	$y(5,4)$	$y(5,5)$	$y(5,6)$	$y(5,7)$	$y(5,8)$	$y(5,9)$	$y(5,10)$
6,000	6,468	9,814	12,434	14,806	17,224	20,025	23,713	29,272	32,000

Estimating tax functions

The income tax function $T_\tau(y)$ which describes the tax and transfer policies in place is specified as

$$T_\tau(y) = y - \lambda_\tau y^{1-\phi_\tau} \ , \tag{15}$$

where $T_\tau(y)$ are net taxes (i.e. income taxes and social security contributions net of public transfers) at taxable household income y for a household of age τ. This specification has long tradition in economics and has been used by Benabou (2002), and more recently by Guner et al. (2014) and Heathcote et al. (2017) among others. The parameter ϕ_τ influences the progressivity of the tax and transfer system. When $\phi_\tau > 0$, marginal tax rates are always greater than average tax rates, which is the usual way to define a progressive tax system. On the other hand, if $\phi_\tau = 0$, then households in the economy face a flat tax rate $1 - \lambda_\tau$. Negative values of the parameter give rise to a regressive tax system. The parameter λ_τ, on the other hand, determines the net tax revenue and reflects the average level of taxation. Specification (15) implies that if the tax system is progressive, the average tax rate below income $\lambda_\tau^{1/\phi_\tau}$ is negative, that is, households with such income receive net transfers from the government.

[34] A doubly stochastic transition matrix delivers a uniform stationary distribution. The normalization is necessary as the income distribution is uniform across decile groups by construction.

[35] Precisely, contributions to the public retirement system are capped if income exceeds a threshold level. The upper limit is based on the assumption that a worker has paid these maximum contributions throughout the entire working life. The lower bound is based on basic old-age security (4,800 for singles and 8,800 for couples).

Tax function (15) implies the following relation between taxable income y and net income $\tilde{y}$,

$$\tilde{y} = \lambda_\tau y^{1-\phi_\tau}. \tag{16}$$

We log this equation and estimate it via OLS for the pooled data sample, separately for each age group τ. The latter reflects the idea that household size, in particular the number of children, varies with age and hence implies different tax deductions which are not taken into account.

Table 7: Tax functions

Age (τ)	25-34	35-44	45-54	55-64	25-64
λ_τ	50.634***	58.405***	46.842***	20.329***	37.560***
	(1.142)	(1.028)	(0.827)	(0.512)	(0.380)
ϕ_τ	0.377***	0.385***	0.364***	0.293***	0.346***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
R^2	0.801	0.797	0.834	0.836	0.821
N	23,023	37,420	32,342	19,682	112,467

NOTE: Standard errors (in parentheses). The delta method is used to compute the standard errors from the OLS estimation of the logged version of equation (16). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The results from the estimation are presented in Table 7. The fit of the regression model is reasonably good. The estimates for ϕ_τ point out that the German tax and transfer system has a strong redistributive component. A similar estimation exercise for the United States (Heathcote et al., 2017) delivers a value of 0.181 for the progressivity parameter ϕ.

Estimating social housing move-in probabilities by income

The structural model takes as inputs the annual probabilities of moving in social housing rental units for each decile of household labor income. First, the ten deciles of household labor income are calculated for the full working-age population. Second, the probabilities of having access to social housing are calculated based on the sample of households who do not live in social housing rental unit in year t but report to be living in social housing in year $t+1$. The results are presented in Table 8. The move-in probabilities are diminishing with income. In the first decile of labor income, around 2% of renters move in social housing. In the tenth decile, only 0.01% move in.

Table 8: Social housing move-in probabilities

$Prob$(Social housing | income decile)									
1	2	3	4	5	6	7	8	9	10
0.0181	0.0122	0.0129	0.0130	0.0077	0.0069	0.0043	0.0055	0.0023	0.0012

Empirical facts

Based on the wealth modules of the SOEP for the years 2002, 2007 and 2012, homeowners comprise around 44% of all households in Germany with household heads older than 24 years.[36] Table 9 shows the age profiles of the homeownership rate, net wealth, gross housing wealth and financial wealth positions of households. The difference between the sum of gross housing wealth and financial wealth, and the net wealth position equals the average mortgage liability.

Table 9: Homeownership and wealth by age

Age (τ)	25-34	35-44	45-54	55-64	65+
Homeownership rate (in %)	17.07	40.86	48.23	54.03	46.56
Net wealth (in thousand euros)	35.79	94.32	139.26	188.97	156.91
Gross housing wealth (in thousand euros)	38.98	108.87	133.19	156.97	124.63
Financial wealth (in thousand euros)	15.81	27.95	41.07	55.41	37.90

Table 10 shows the homeownership rates by deciles of the household income and wealth distributions for working-age households.

Table 10: Homeownership rates by income and wealth

Homeownership rate (in %) for working-age households										
Decile	1	2	3	4	5	6	7	8	9	10
Income	18.73	22.27	28.11	30.52	34.74	42.94	48.99	55.38	65.41	70.11
Wealth	9.82	0.61	2.68	6.46	13.04	41.19	69.20	87.27	92.97	94.48

[36] In the model calibration procedure we target a homeownership rate of 42.2% which is the result of the age-specific homeownership rates aggregated according to the population shares of each age group in the model.

Appendix B: Further results

Table 11 presents results of the different experiments under the assumption that the government does not adjust taxes to restore budget balance. House prices and rents are fully flexible. If the RETT is cut or mortgage interest payments become tax deductible, the increase of the homeownership rate is weaker when taxes are fixed compared to the case where taxes are increased to balance the budget. This is because of a stronger effect on housing demand which increases the house price, hence mitigating the positive impact of the policy. When social housing is abolished, the homeownership rate increases slightly more compared to the case of revenue neutrality where the government cuts taxes. In the combined scenario we find that the increase of the homeownership rate is two percentage points smaller with fixed taxes than under revenue neutrality.

Table 11: **Counterfactuals: General equilibrium with fixed taxes**

	Benchmark	RETT C1	Mort Ded C2	No Social H C3	Combination C4
Homeownership (%)	42.3	51.9	47.3	48.2	60.3
– 25-34 yrs	14.0	21.0	22.6	17.6	32.7
– 35-44 yrs	35.4	48.0	47.8	41.7	65.5
– 45-54 yrs	51.8	66.4	60.2	58.7	79.3
– 55-64 yrs	58.8	72.1	61.3	66.2	78.7
– 65+ yrs	47.0	51.8	46.1	52.4	52.8
Total wealth	129.5	138.8	131.8	133.3	142.0
– Housing	89.0	114.4	105.7	99.3	139.8
– Financial	47.1	36.0	41.3	42.0	27.5
– Mortgage	-6.6	-11.7	-15.2	-8.0	-25.4
House price	1.000	1.019	1.018	0.980	1.032
Price-to-rent ratio	19.46	19.57	19.56	19.33	19.64
ΔGov't BC (per HH)	–	-0.332	-0.223	+0.077	-0.666
–ΔRETT Rev	–	-0.246	0.034	0.035	-0.241
–ΔIncTax Rev	–	-0.100	-0.261	-0.044	-0.510
–ΔSocHous Subs	–	-0.014	-0.004	-0.085	-0.085
ΔDemand (in %)	–	0.78	0.75	-0.86	1.42
–Income Q1	–	1.55	-0.26	-0.38	-0.46
–Income Q2	–	1.46	1.58	-0.37	3.03
–Income Q3	–	0.93	1.29	-0.49	2.25
–Income Q4	–	0.01	0.65	-1.21	0.64
–Income Q5	–	0.49	0.32	-1.41	1.23

NOTE: All monetary values in thousand euros.