



Working Paper 06-54  
Economics Series (21)  
April 2006

Departamento de Economía  
Universidad Carlos III de Madrid  
Calle Madrid, 126  
28903 Getafe (Spain)  
Fax (34) 91 624 98 75

### ON THE USER COST AND HOMEOWNERSHIP\*

**Antonia Díaz**  
Universidad Carlos III

**María J. Luengo-Prado**  
Northeastern University

---

#### *Abstract*

This paper studies the determinants of housing tenure choice and the differences in the cost of housing services across households in an overlapping generations model with household-specific uninsurable earnings risk and housing prices that vary over time. We model houses as illiquid assets that provide collateral for loans. To analyze the impact of preferential housing taxation on the tenure choice, we consider a tax system that mimics that of the U.S. economy in a stylized way. We find that a mixture of idiosyncratic earnings uncertainty, house price risk, down payments and transaction costs are needed for the model to deliver life cycle patterns of homeownership and portfolio composition similar to those found in the data. Through simulations, we also show that a rental equivalence approach (relative to a user cost approach) overestimates the mean unit cost of housing by approximately 3 percent.

---

\* Corresponding author: María J. Luengo-Prado at [m.luengo@neu.edu](mailto:m.luengo@neu.edu). The authors thank the Dirección General de Universidades e Investigación de la Comunidad de Madrid, project 06/HSE/0159/2004, for financial support. They also are grateful to the participants of the 2005 MEA workshop at Mannheim University, Universidad del País Vasco and Universidad de Barcelona. Antonia Díaz thanks FEDEA for its hospitality while working on this project.

# 1 Introduction

Housing services are an important component of aggregate consumption expenditure. In the 2003 National Income and Product Accounts (NIPA) these services represent approximately 14 percent of aggregate consumption expenditures. A significant fraction of housing services—72 percent—is acquired through homeownership (the remainder is obtained in the rental market). Therefore, it is important to pay attention to the valuation of owner occupied housing services. The current practice by the Bureau of Labor Statistics is to use a *rental equivalence method* (see Verbrugge 2003 and Poole, Ptacke, and Verbrugge 2005 for a detailed description of this approach). Simply put, the Consumer Price Index is constructed assuming that the value of the services yielded by owner occupied housing is the rental market value for the home. This approach is also used in constructing NIPA. As Prescott (1997) argues, this procedure is inconsistent with the principle that the effective price of a commodity should be its cost to the household consuming it (a *user cost method*). In the absence of frictions, both procedures—by asset pricing theory—should yield the same value for owner occupied housing services. However, there are important frictions in the housing market. For example, owner occupied housing services are not taxed (whereas rents of leased homes are), and interest mortgage payments are tax deductible. Additionally, houses are illiquid assets that also serve as collateral for loans. These frictions create a wedge between the user cost of owner occupied housing services and the market rental price.

The purpose of this paper is to understand the differences between the user cost and the rental price for housing, and to give an estimate of the bias resulting from valuing owner occupied housing services using the rental price. To this end, we start by constructing a model that mimics some key features of the U.S. economy that allows us to understand the tenure choice decision.

Our model is a partial equilibrium life cycle economy where households face uninsurable idiosyncratic labor risk and house price uncertainty. Households obtain utility from the consumption of nondurables and housing services. They can save either in the form of liquid deposits or houses, which are subject to transaction costs. Houses can be partially financed minus a down payment but also serve as collateral for home equity loans. For simplicity, the only source of credit is collateralized debt. We mimic the U.S. tax system by assuming that houses are given preferential tax treatment: mortgages interest payments are fully deductible and services of owner occupied housing are not taxed.<sup>1</sup> Moreover, we assume that households are subject to idiosyncratic moving shocks that force them to sell their housing stock. This shock is meant to capture, in a stylized way, the effect of geographical mobility or changing needs due to variations in family size.

In our model and in reality, the tenure choice depends on several factors. On the one hand, buying a house insulates the consumption of housing services from variation in the rental price of housing. On the other hand, houses are illiquid assets and, hence, a very poor vehicle for shielding

---

<sup>1</sup>The preferential tax treatment on housing has been analyzed elsewhere. See, for example, Poterba (1984), Gahvari (1984), Skinner (1996) or Gervais (2002).

nondurable consumption against transitory income risk. Furthermore, homeowners' wealth is exposed to house price risk whereas renters' wealth is not. Importantly, houses serve as collateral for loans but typically cannot be fully financed. In terms of taxation, owner occupied housing services are not taxed and mortgages interest payments are deductible from the income tax base. Given the preferential tax treatment, households that are unlikely to move prefer buying to renting while younger households opt for renting because they must either accumulate a down payment or are likely to move. In order to assess the quantitative importance of each of these channels on the tenure decision, we calibrate our model to match some key features of the U.S. economy. We find that a mixture of idiosyncratic earnings uncertainty, house price risk, down payments and transactions costs are needed for the model to deliver life cycle patterns of homeownership and portfolio composition similar to those found in the data.

We investigate the role of every assumption in the model and construct alternative model economies where we change a particular feature of our baseline calibration. We find that changes in idiosyncratic risk alter the life cycle patterns of homeownership substantially. For instance, a decrease in permanent earnings risk implies a significant decrease in the homeownership rate among young households but not older households. Moreover, eliminating the mortgage interest payment deduction has a similar effect to that of an increase in the spread between the return on deposits and the mortgage interest rate, and affects mostly older households.

Finally we quantify, through simulations, the bias that results from pricing the services of owner occupied housing (for which there is not a market) using the rental price. We show that the user cost of owner occupied housing and the rental price differ because of the existence of adjustment costs, spread (i.e., the mortgage interest rate may be higher than the return to alternative liquid assets) and the deductibility of mortgage interest payments. Furthermore, because owner occupied housing services are not taxed, the bias is magnified if there are capital gains or losses. Importantly, we show that the user cost is more volatile than the rental price. Quantitatively, in our benchmark calibration, when we use the rental price (as opposed to the user cost) to value all housing services, we overestimate the average unit cost of housing by roughly 3 percent.

There is a growing literature examining tenure choice within an OLG framework. Ortalo-Magné and Rady (1999) study the relationship between financial conditions and the homeownership rate. Gervais (2002) focuses on the effects of taxation on tenure choice but abstracts from uncertainty, adjustment costs and the collateral role of housing. Ortalo-Magné and Rady (2002) demonstrate that homeownership is an effective way of isolating housing consumption against any income risk. The studies most closely related to ours are Chambers, Garriga, and Schlagenhaut (2005a), Chambers, Garriga, and Schlagenhaut (2005b), and Li and Yao (2005). Chambers, Garriga, and Schlagenhaut (2005a) study tenure choice in a general equilibrium model in which households can be renters and owners at the same time but abstract from price changes, taxation issues and home equity loans. Chambers, Garriga, and Schlagenhaut (2005b) study in detail the decision of being a landlord, a homeowner or a renter but abstract from taxes and home equity lines. Li and Yao (2005) abstract

from taxation issues and focus on the welfare effects of price appreciations.

The remainder of this paper is organized as follows. Section 2 introduces our dynamic model and presents some theoretical results on household portfolio composition and tenure choice. The calibration is presented in section 3. Section 4 studies how homeownership patterns change with the different elements of our model. In section 5, we assess the quantitative importance of the bias introduced when imputing to owner occupied housing services the rental price of housing. Conclusions are summarized on Section 6.

## 2 The Model Economy

We consider an overlapping generations economy where households derive utility from consumption of a nondurable good and housing services that can be obtained in a rental market or through homeownership. When purchasing a house, households must satisfy a down payment requirement. Also, households can use accumulated housing equity as collateral for loans. For simplicity, no other form of credit is allowed. Houses are illiquid assets subject to transaction costs. We model a tax system with preferential tax treatment on owner-occupied housing that mimics the U.S. system in a stylized way. Households face idiosyncratic uninsurable earnings risk and aggregate uncertainty arising from changes in housing prices. The specifics of the model follow.

### 2.1 Preferences, endowments and demography

Households live for up to  $T$  periods, facing an exogenous probability of dying every period. They do not value leisure. During the first  $R$  periods of life, their labor earnings are determined according to an idiosyncratic stochastic process. After period  $R$ , households retire and receive a pension. When a household dies, the household is replaced by a ‘newborn’. Households are not altruistic towards their offsprings so all bequests are accidental.

Households derive utility from the consumption of a nondurable good and from the services provided by residential capital. Housing services can be obtained by purchasing housing stock or through the rental market. We assume one unit of housing stock (either rented or owned) provides one unit of housing services. Therefore, we write the per period utility of an individual of age  $i$  at  $t$  as  $u(c_t^i, x_t f_t^i + (1 - x_t)h_t^i)$ , where  $c$  stands for nondurable consumption,  $f$  denotes the housing stock rented in the market, and  $h$  is the owned housing stock. Households cannot rent and be homeowners at the same time, so  $x_t = 1$  if the household is a renter (in period  $t$ ), and 0 if an owner.

The expected lifetime utility of a household born in period  $t$  (at  $t$ ) is:

$$E_t \sum_{i=1}^T \beta^{i-1} \zeta_{t+i}^i u(c_{t+i}^i, x_t f_{t+i}^i + (1-x_t)h_{t+i}^i), \quad (1)$$

where  $\beta \in (0, 1)$  is the time discount factor and  $\zeta^i$  is the probability of being alive at age  $i$ .

## 2.2 Market arrangements

A household of age  $i$  starts any given period  $t$  with a stock of residential assets,  $h_{t-1}^i \geq 0$ , deposits,  $d_{t-1}^i \geq 0$ , and collateral debt (mortgage debt and home equity loans),  $m_{t-1}^i \geq 0$ . Deposits earn a return  $r_t^d$ , whereas debt carries an interest payment at the rate  $r_t^m$ . Households buy the stock of houses that renders services in period  $t$  at the beginning of the period. The price of one unit of residential stock in period  $t$  (in terms of nondurable consumption) is  $q_t$ , while the rental price of one unit of housing stock is  $r_t^f$ .

When buying a house, households must satisfy a minimum down payment requirement,  $\theta$ . On the other hand, houses serve as collateral for loans (home equity loans) with a maximum loan-to-value ratio of  $(1 - \theta)$ .<sup>2</sup> For simplicity, we assume that only collateralized credit is available. This means that, in any given period, household  $i$ 's debt must satisfy:

$$m_t^i \leq (1 - \theta) q_t h_t^i. \quad (2)$$

In other words, household net worth is always non-negative, and is greater than or equal to a fraction  $\theta$  of the house. Additionally, there is a link between outstanding debt and the market value of the household's residential property. Therefore, whenever a household is not moving and there is a decline in house prices, the household is required to decrease collateral debt to equal the fraction  $(1 - \theta)$  of the house value (i.e., a margin call). On the other hand, when prices go up, households can access the additional housing equity through refinancing or a home equity loan at no additional cost. Thus, households take all the capital gains and losses associated with changes in house prices. In reality, the burden of downward property prices, and to a lesser extent the benefits of higher prices (through refinancing and closing costs), are shared between financial institutions and households.<sup>3</sup> However, this specification allows us to consider both down payment requirements and home equity loans without the need for modeling specific mortgage contracts or mortgage choice.<sup>4</sup>

---

<sup>2</sup>We abstract from income requirements when purchasing houses. Many lenders follow the rule of thumb of "3 times income" for mortgages. However, the empirical literature finds that wealth constraints are more important than income constraints when purchasing a home. See for example Linneman, Megbolugbe, Watcher, and Cho (1997) or Quercia, McCarthy, and Watcher (2000).

<sup>3</sup>This assumption simplifies the computation of the model. See Li and Yao (2005) for an alternative model with refinancing costs.

<sup>4</sup>See Campbell and Cocco (2003) for a discussion of optimal mortgage choice.

We assume that selling a house is costly. A fraction of the house value is lost when sold, which may be interpreted as brokerage fees. This makes houses a less liquid asset than deposits. Furthermore, owning a house entails paying a maintenance cost equal to the fraction  $\delta^h$  of the value of the house—we assume for simplicity that if maintenance is done, the house does not depreciate. Therefore, whenever there is change in the owned housing stock (not its value) the household is selling the house and pays an adjustment cost proportional to the value of the stock,  $\chi q_t(1-\delta^h)h_{t-1}^i$ .

In our model economy, households may want to sell their houses for various reasons. First, selling the stock is the only way to realize capital gains beyond the maximum loan-to-value ratio for home equity loans. Second, households may want to increase or downsize housing consumption throughout the life cycle, or may want to take advantage of relatively cheaper rental prices. Finally, households may need to liquidate this asset to prop up nondurable consumption after depleting their deposits and ‘maxing out’ home equity loans. Additionally, we assume that working-age households are subject to an idiosyncratic moving shock that forces them to sell their house. We introduce this shock to capture unexpected ‘geographical’ mobility associated to employment or family needs.

We do not impose an age limit to credit availability. That is, households can buy a house on credit, provided that they pay the down payment, regardless of age. If a household dies, the house is liquidated, and any remaining wealth is passed on to the descendant as deposits.

### 2.3 The government

The government taxes income,  $y$ , allowing a deduction for interest payments on mortgages and home equity loans. The deduction percentage is denoted as  $\tau_m$ . The government also imposes a proportional ‘local’ tax on housing (at the rate  $\tau_h$ ). This tax is fully deductible from income taxes. Moreover, imputed housing rents for homeowners are tax-free. For an individual of age  $i$ , taxable income in period  $t$ ,  $y_t^{\tau,i}$ , is:

$$y_t^{\tau,i} = y_t^i - \tau_m r_t^m m_{t-1}^{i-1} - \tau_h q_t h_{t-1}^{i-1}. \quad (3)$$

For simplicity, we assume proportional income taxation at the rate  $\tau_y$ . Also, the entire proceeds from taxation are used to finance government expenditures that do not affect individuals at the margin.

### 2.4 The structure of uncertainty

Apart from the sources of uncertainty already discussed (uncertainty about the time of death and the moving shocks that working-age households face), households are subject to risk in labor

earnings and house prices. We discuss each in turn.

For working-age households, labor earnings,  $w$ , are the product of permanent income and a transitory shock ( $P$  and  $s$  respectively). For a household of age  $i \leq R$  in period  $t$ ,

$$w_t^i = P_t^i s_t, \quad P_t^i = P_{t-1}^{i-1} \gamma^i \epsilon_t, \quad s_t = \begin{cases} 0, & p, \\ \nu_t, & 1-p. \end{cases} \quad (4)$$

Under this specification, permanent income growth,  $\Delta \log P_t^i$ , is the sum of a non-stochastic life cycle component  $\log \gamma^i$  and a permanent shock,  $\log \epsilon \sim N\left(-\frac{\sigma_\epsilon^2}{2}, \sigma_\epsilon^2\right)$ , assumed to be specific to each household. The transitory shock, also idiosyncratic, is 0 with a small probability  $p$ —which may be interpreted as a catastrophic state as in Carroll (1997)—or  $\nu_t$ , with  $\log \nu \sim N\left(-\frac{\sigma_\nu^2}{2}, \sigma_\nu^2\right)$ . Retirees receive a pension proportional to permanent earnings in the last period of their working life:  $w_t^i = bP_{t+R-i}^R$ ,  $\forall i > R$ .<sup>5</sup>

Regarding uncertainty on housing prices, we assume, as in Li and Yao (2005), that house price appreciation follows and i.i.d. normal process:  $q_t/q_{t-1} - 1 = \varrho_t$ , with  $\varrho \sim N(\mu_\varrho, \sigma_\varrho^2)$ . The specification implies that house price shocks are permanent.<sup>6</sup>

## 2.5 The household's problem

Summarizing, the problem solved by a newborn at  $t$  is:

$$\max E_t \sum_{i=1}^T \beta^{i-1} \zeta_{t+i}^i u(c_{t+i}^i, x_t f_{t+i}^i + (1-x_t) h_{t+i}^i), \quad (5)$$

subject to

$$c_{t+i}^i + r_{t+i}^f f_{t+i}^i + d_{t+i}^i - m_{t+i}^i + q_{t+i} h_{t+i}^i + \Gamma_{t+i} q_{t+i} (1 - \delta^h) h_{t+i-1}^{i-1} \leq w_{t+i}^i + (1 + r_{t+i}^d) d_{t+i-1}^{i-1} - (1 + r_{t+i}^m) m_{t+i-1}^{i-1} + q_{t+i} (1 - \delta_h - \tau_h) h_{t+i-1}^{i-1} - \tau_y y_{t+i}^{\tau, i}, \quad (6)$$

$$y_{t+i}^{\tau, i} = w_{t+i}^i + r_{t+i}^d d_{t+i-1}^{i-1} - \tau_m r_{t+i}^m m_{t+i-1}^{i-1} - \tau_h q_{t+i} h_{t+i-1}^{i-1}, \quad (7)$$

$$m_{t+i}^i \leq (1 - \theta) q_{t+i} h_{t+i}^i, \quad (8)$$

$$q_{t+i+1} = (1 + \varrho_{t+i+1}) q_{t+i}, \quad (9)$$

$$\Gamma_{t+i} = \chi \text{ if } h_{t+i}^i \neq h_{t+i-1}^{i-1} \text{ or the moving shock realized, } x_t \in \{0, 1\}. \quad (10)$$

<sup>5</sup>This simplification is required for computational reasons and is common in the literature. See for example Gourinchas and Parker (2001).

<sup>6</sup>The assumption is common in the literature (e.g., Cocco 2005, Campbell and Cocco 2003) and greatly simplifies the computation of the model by facilitating a renormalization of the household problem with fewer state variables.

Equation (6) is the budget constraint.

## 2.6 The composition of a household's portfolio

For this model, it is possible to analytically determine under what conditions households maintain deposits and debt simultaneously. For notational simplification, let  $\widehat{r}_t^d = (1 - \tau_y) r_t^d$  denote the after-tax return to deposits, and  $\widehat{r}_t^m = (1 - \tau_m \tau_y) r_t^m$  the after-tax mortgage interest rate. Likewise,  $\widehat{\tau}_h$  is the effective property tax rate,  $\widehat{\tau}_h = (1 - \tau_y) \tau_h$ . There are two possible scenarios: *no spread and full deductibility* (of mortgage interest on income taxes), and *spread or partial deductibility*.

With no spread and full deductibility, the after-tax interest rate on deposits is the same as the after-tax mortgage interest rate. Proposition 1 in Appendix A shows that constrained households only hold debt whereas the portfolio of unconstrained households cannot be determined (unless they are in the last period of their life, in which case they have no deposits).<sup>7</sup>

Proposition 2 in Appendix A proves that with less than full deductibility or interest spread, households always prefer equity to debt financing of their houses. In other words, there is a complete segmentation of households: those who have debt do not hold deposits and *vice versa*. Obviously, some households could have neither deposits nor mortgages.

## 2.7 Determinants of the tenure decision

In order to gain some intuition on the determinants of tenure choice, we briefly examine the case without uncertainty and without adjustment costs. In principle, an individual will prefer buying to renting if the rental price is below the shadow price of owner occupied housing services. The marginal user cost of housing is:

$$uc_t^i = \frac{u_s(c_t^i, x_t f_t^i + (1 - x_t) h_t^i)}{u_c(c_t^i, x_t f_t^i + (1 - x_t) h_t^i)}, \quad (11)$$

where the subindex  $s$  denotes the first partial derivative with respect to housing services. It is easy to check that the user cost of owner occupied housing is equal to:

$$uc_t^i = \left(1 - (1 - \theta) \frac{\mu_t^i}{\lambda_t^i}\right) q_t - \frac{\lambda_{t+1}^i}{\lambda_t^i} q_{t+1} \left(1 - \delta^h - \widehat{\tau}_h\right), \quad (12)$$

where  $\lambda_t^i$  denotes marginal utility of nondurable consumption and  $\mu_t^i$  is the Lagrange multiplier associated with the liquidity constraint. Equation (12) states that the price of one unit of housing services for homeowners is the current marginal cost of purchasing the stock minus the future value of the stock net of depreciation and taxes. For a household in the last period of life, the user cost

---

<sup>7</sup>In our computation of the model, we assume that households do not hold debt and deposits simultaneously.



is just the first term  $(1 - (1 - \theta) \mu_t^i / \lambda_t^i) q_t$ . When taking its tenure decision, a household compares the shadow price of owner occupied housing services to the rental price of housing,  $r_t^f$ . Therefore, if  $r_t^f < uc_t^i$  the household strictly prefers renting to buying and *vice versa*. In the case of strict equality, the household is indifferent between buying and renting. Equating the rental price to the user cost we obtain the standard asset pricing equation,

$$\left(1 - (1 - \theta) \frac{\mu_t^i}{\lambda_t^i}\right) q_t = r_t^f + \frac{\lambda_{t+1}^i}{\lambda_t^i} q_{t+1} \left(1 - \delta^h - \widehat{\tau}_h\right). \quad (13)$$

The left hand side of equation (13) shows the marginal current cost of the asset,  $(1 - (1 - \theta) \mu_t^i / \lambda_t^i) q_t$ , taking into account that the household might be financing the home purchase. The right hand side is the asset return: the marginal return it would yield in the market,  $r_t^f$ , plus the present value of its future price net of depreciation and taxes. Next, we show how to write the user cost in the two different regimes outlined before: the no spread, full deductability scenario, and the regime where there is spread or partial deductability.

#### *No spread and full deductability*

In this case the after-tax return on deposits is equal to the after-tax mortgage interest rate. Thus, households are either constrained or their portfolio composition is irrelevant. For non-constrained individuals the user cost of owner occupied housing is given by:

$$uc_t^i = \theta q_t + \frac{[\widehat{r}_{t+1}^m q_t + (\delta^h + \widehat{\tau}_h) q_{t+1} - (q_{t+1} - q_t)] - (1 + \widehat{r}_{t+1}^m) \theta q_t}{1 + \widehat{r}_{t+1}^m}, \quad (14)$$

which shows that the user cost depends on the forgone return to capital invested in housing,  $\widehat{r}_{t+1}^m q_t$ , maintenance and property taxes,  $(\delta^h + \widehat{\tau}_h) q_{t+1}$ , and capital gains. All terms are discounted by the market interest rate.<sup>8</sup> For constrained households the expression is:

$$uc_t^i = \theta q_t + \frac{[\widehat{r}_{t+1}^m q_t + (\delta^h + \widehat{\tau}_h) q_{t+1} - (q_{t+1} - q_t)] - (1 + \widehat{r}_{t+1}^m) \theta q_t}{\lambda_t^i / \lambda_{t+1}^i}. \quad (15)$$

The constrained households' discount factor is given by the marginal rate of substitution,  $\lambda_t^i / \lambda_{t+1}^i$ , which is greater than the market discount factor  $(1 + \widehat{r}_{t+1}^m)$ . For households in the last period of life the user cost is simply  $\theta q_t$ . If the rental price is lower than the down payment, households will prefer renting to buying.

#### *Spread or partial deductability*

If there is spread or partial deductability, aside from individuals in the last period of life, there are three types of households: non-constrained with no debt, non-constrained with debt and

---

<sup>8</sup>Note that with no spread and full deductability the terms involving  $\theta$  cancel out for a non-constrained household.

constrained. For the first group, the user cost is:

$$uc_t^i = \theta q_t + \frac{[\widehat{r}_{t+1}^d q_t + (\delta^h + \widehat{\tau}_h) q_{t+1} - (q_{t+1} - q_t)] - (1 + \widehat{r}_{t+1}^d) \theta q_t}{1 + \widehat{r}_{t+1}^d}. \quad (16)$$

For households that are not constrained but hold no deposits, the user cost is given by expression (14). For constrained households the user cost is given by (15). Finally, the user cost of households in the last period of life is  $\theta q_t$ .

Summarizing, the tenure decision depends on the difference between the rental price of housing and the user cost of owner occupied housing services. The value of the user cost depends on the forgone return of home equity, the mortgage interest rate, the preferential tax treatment on houses and the expected capital gains. The rental price and the user cost for homeowners do not need to coincide. This implies that assuming that the price of owner occupied housing is the rental price of housing, results in a bias. In section 5 we discuss this issue and try to assess quantitatively the size of this bias. But before, we must resort to calibration and simulation of the model to understand the role of uncertainty and adjustment costs in the tenure choice decision.

### 3 Calibration and simulation strategy

Our calibration is constructed to roughly match the homeownership rate for working-age individuals in the United States. According to the Survey of Consumer Finances in 1998 (SCF-98), this number is 69.6 percent. Additionally, we target two other figures from the SCF-98: The median wealth-to-earnings ratio for working-age households, 1.8, and the median ratio of house value to total wealth for working-age homeowners, 0.86. In Appendix B, we briefly review how we construct these target numbers.

#### 3.1 Calibration

##### *Preferences, endowments and demography*

For computational reasons, one period is five years. Households are born at age 20 ( $i = 1$ ) and die at the maximum age of 90 ( $i = 14$ ). The retirement age is 65 ( $i = 10$ ). Survival probabilities are taken from the U.S. Vital Statistics (for males in 1998), published by the National Center for Health Statistics. Figure 1 compares the population's age composition generated by the model and that in the SCF-98. The fraction of working-age households in the SCF-98 is 78.4 percent, while the number derived using the Vital Statistics is slightly lower 73.5.<sup>9</sup>

---

<sup>9</sup>If we use female survival probabilities instead, given that we force households to retire at age 65, the fraction of working-age households would be even lower. Therefore, we use the male probabilities.

We follow Li and Yao (2005) in our labor earnings calibration using an annual variance of the permanent shock  $\sigma_\varepsilon^2 = 0.01$ , and an annual variance of the transitory shock  $\sigma_\nu^2 = 0.073$ . These values are typical the literature (e.g., Storesletten, Telmer, and Yaron 2004). The growth rate of the non-stochastic life-cycle component is taken from Hansen (1993). The probability of the catastrophic shock,  $p$ , is set to 3 percent for workers older than 25 and 0 for newborns to guarantee non-zero income in the first period of life. For retirees, the pension is 30 percent of permanent income. This number is somewhat lower than in the literature but necessary to match the median wealth-to-earnings ratio for homeowners in the absence of a bequest motive. In our model, retirees face no income uncertainty.

For preferences over consumption of nondurable goods and housing services, we choose the non-separable utility function:

$$u(c, xf + (1 - x)h) = \frac{(c^\alpha(xf + (1 - x)h)^{1-\alpha})^{1-\sigma}}{1 - \sigma}. \quad (17)$$

The risk aversion parameter is  $\sigma = 3$ .  $\alpha$  is set to 0.43 to guarantee a match of the median ratio of house value to total wealth for homeowners.<sup>10</sup> The time discount rate is 0.016, which paired with the pension rate  $b = 0.3$ , allows us to match the median wealth-to-earnings ratio in the data.

The moving shocks (in Table 2) are calibrated to approximately match the homeownership profile for working individuals. They decrease with age and imply that, on average, individuals move 3 times over the life-cycle.

### *Market arrangements*

The down payment requirement is 25 percent—the average down payment for the period 1963-2001 according to the Federal Housing Finance Board.<sup>11</sup> The adjustment cost that matches the average homeownership rate for working-age households is 12 percent. While realtors typically charge a 6 percent commission for selling a house, households must also pay legal fees and other transaction costs. Thus, the 12 percent is justified.<sup>12</sup> Finally, we assume no spread and set  $r^m = r^d = 0.025$  in annual terms.

### *Taxes*

In terms of taxation, the income tax rate is  $\tau_y = 0.203$  to roughly match the ratio of government

---

<sup>10</sup>With a lower weight for housing services in the utility function the ratio of housing wealth to total wealth is lower. However, the analysis in Section 4 is robust to changes in this parameter value. Results are not tabulated for brevity.

<sup>11</sup>According to Federal Housing Board data, only 33 percent of households put down payments lower than 20 percent during that period. Also, since we abstract from income requirements, a higher number than the average may be justifiable.

<sup>12</sup>With a lower adjustment cost, homeownership rates are higher for younger households.

spending to GDP. Mortgage interest payments are fully deductible,  $\tau_m = 1$ , and  $\tau_h = 0$ .

### *House prices*

Housing prices are assumed to follow the process  $q_t = q_{t-1}(1 + \varrho_t)$ , where  $\varrho \sim N(\mu_\varrho, \sigma_\varrho^2)$ .  $\mu_\varrho = 0$  and  $\sigma_\varrho^2 = 0.0132$  (as in Li and Yao 2005 and within the estimates of Goetzmann and Spiegel 2000). For simplicity, we assume  $\varrho_t$  is serially uncorrelated and also uncorrelated with the income shocks. The housing depreciation and maintenance costs,  $\delta^h$ , are set to 1 percent.

An important part of our calibration is the rental price. Our model economy, being partial equilibrium, imposes no discipline on what the rental price should be. However, we can use asset pricing theory and assume that the rental price is:

$$r_t^f = \frac{q_t - E_t \left[ \frac{1}{1 + \hat{r}_{t+1}^d} q_{t+1} (1 - \delta^h - \hat{\tau}_h) \right]}{1 - \tau_y}. \quad (18)$$

Expression (18) defines the after-tax rental price for housing. The rental price varies with house prices and incorporates the fact that housing rental income is taxable income. The specification can be interpreted as the user cost for a landlord who is not liquidity constrained and who is not subject to adjustment costs. The landlord can deduct local housing taxes from income taxation but must pay income taxes on rental income. This calibration choice is also consistent with the estimates in Sinai and Souleles (2005), who find that the house price to rent ratio capitalizes expected future rents, as any other asset.

## **3.2 Simulation strategy and solution method**

In order to better understand the influence of each model feature on homeownership rates and the unit cost of housing, we alter some of the key baseline parameters in our numerical experiments (one at a time). Each experiment is conducted the same way. First, we solve the household problem to obtain the optimal policy functions for a given set of parameters. Next, we generate shocks from the assumed distributions for 10,000 individuals during 50 periods (or 250 years). Labor income shocks, moving shocks and mortality shocks are idiosyncratic, while house price shocks are common to all households. With the optimal policy functions and the generated shocks, we can compute relevant statistics (e.g., the median wealth-to-earnings ratio by age). Each experiment is repeated for 100 independent samples. The numbers we report, unless indicated, are averages of each relevant statistic across the 100 independent simulations from the last period of each simulation. In these experiments, households are linked dynastically in the sense that when one household dies, a specific newborn household inherits any remaining assets. Note, however, that we assume no intergenerational altruism so all bequests are accidental. Also, inheritances come in the form of liquid assets (i.e., houses are sold before a newborn receives the accidental bequest).

As shown in section 2.6, households do not hold debt and deposits simultaneously in our model because it is costless to borrow against accumulated home equity (if this were not the case, households may hold deposits even while holding debt). This simplification facilitates the computation of the model substantially. We must stress that our model is not intended to study household portfolio composition in the presence of housing (see Flavin and Yamashita 2002 for such a model). Rather, our purpose is to reproduce the patterns of homeownership over the life cycle in the U.S. so that we can compare the cost of housing services for renters and homeowners and determine if we are accurately measuring the cost of living. Note, also, that our deposits variable is intended to capture all financial assets (not just banking deposits), which is why we have chosen the non-spread and full deductability case as our benchmark scenario.

The former simplification along with the other assumptions of the model guarantee that the household problem can be rewritten (after normalizations) in terms of only two state variables: the house value normalized by permanent income and normalized voluntary equity (the equity held in excess of the required down payment). Our computation technique is a combination of the solution algorithms in ?) and Díaz and Luengo-Prado (2005). In particular, we solve a discretized version of the household problem. To keep the problem tractable, we use 3 points to approximate each income shock and the house price shocks. We use 140 points for the house value grid, and 180 points for the normalized voluntary equity grid.

## 4 The life cycle patterns of homeownership and wealth

In this section, we report results on several experiments that help us gain some intuition on the key determinants of homeownership, particularly for working-age households. We first focus on how the benchmark model fares compared to the data.

Figure 2 depicts the mean life-cycle profiles for earnings, nondurables, wealth and deposits. In Table 3, we show that the median wealth-to-earnings ratio ( $W/E$ ), the median house value to wealth ratio ( $H/W$ ) and the homeownership rate (all for working-age households) are in line with the corresponding values in the data. This is expected since these ratios are the targets of our calibration. In the model, as in the data, renters are concentrated amongst the relatively poor. However, the benchmark model delivers too high a wealth-to-earnings ratio for renters (0.94 vs. 0.37 in the data). Overall, the model delivers less variation in the median wealth-to-earnings ratio over the life cycle than in the data (see Figure 3). Particularly, the wealth-to-earnings ratio for younger (and relatively poorer) households is higher than in the data. This can be partially explain by the fact that in our framework, households receive their accidental bequests when they are young, whereas in the real world, most of the bequest recipients are middle-aged.<sup>13</sup> In terms

---

<sup>13</sup>Bequest could be received later in life in the model. This would require, however, careful modeling of expectations about bequests. We leave this extension for future research.

of homeownership rates, Figure 3 shows slightly higher rates for middle age households than in the data. Interestingly, the homeownership rate for retirees is lower in the model, 69 vs. 81 percent in the data. In our framework, all households must keep some required equity in their houses. For households pushing the age limit—who would prefer to run down assets—this may be particularly costly.<sup>14</sup> Introducing a true bequest motive could reverse this result.

Overall, our model delivers homeownership rates by age that are very close to those in the data. However, there are a number of factors left out from the model that may affect the tenure decision. For instance, in our calibration of the rental price, shown in equation (18), we implicitly assume away any moral hazard problem that may affect the depreciation of rental units. For instance, Chambers, Garriga, and Schlagenhauf (2005b), following Henderson and Ioannides (1983), assume that rental units depreciate at a rate twice that of owner occupied housing. Glaeser and Shapiro (1991) estimate that the difference in home maintenance between homeowners and renters is large and not attributable to other household specific factors. Assuming a larger depreciation rate for rental units would yield a larger rental price and, consequently, a higher homeownership rate. Thus, it may be argued that our model delivers too high a homeownership rate. However, there are other features of our model that may compensate for this bias. For instance, mortgages are riskier in our model than in the real world because households are forced to keep a loan-to-house-value ratio smaller than  $1 - \theta$ , where  $\theta$  is the down payment. With house price uncertainty, mortgages are subject to margin calls, which could lead to a downward bias on homeownership rates.

Finally, we report some statistics for homeowners in Figure 3. In the data, the median wealth-to-earnings ratio is about 1 for the youngest cohort. The ratio drops a bit for the next cohort and increases with age afterwards. Housing wealth as a fraction of total wealth decreases monotonically with age. In our model, the median wealth-to-earnings ratio has a much more pronounced drop for younger cohorts since all bequests are received in the first period of life. This also implies that the portfolio composition does not vary with age as much as in the data. Also, in our model economy, retirees keep a much higher fraction of their wealth as houses. This might be due to the fact that reverse mortgages are available to all retirees in our model, whereas this might not be the case in reality. Moreover, retirees in our world only face survival uncertainty whereas in reality they are exposed to other types of risk, such as health problems, which would push up the amount of desired liquid wealth.

Although our model is somewhat stylized, it does incorporate several key features that can be ‘shut-down’ to understand their impact on homeownership. We consider different financial arrangements, different taxation scenarios, and alternative uncertainty patterns. Table 3 reports some relevant summary statistics (aggregated by cohort) from the different experiments.

---

<sup>14</sup>(Sheiner and Weil 1992) for a study on the housing wealth of the elderly.

## 4.1 Changes in financial arrangements and taxation

### *The role of illiquidity*

We first make houses a liquid asset by eliminating the transaction cost (i.e.,  $\chi = 0$ ). Figure 4, panel (a), compares this case to the benchmark scenario. In the absence of transaction costs, selling a house when hit by a bad income shock is not costly. Moreover, moving shocks—which affect working-age individuals—are not burdensome. Therefore, houses become relatively more attractive for working-age households. The homeownership rate increases substantially for this group (from 69.2 to 87.3 percent) and so does housing wealth as a fraction of total wealth (from 0.84 to 1). The effect is stronger for the youngest households. This is due to the fact that the median wealth-to-earnings ratio increases for all ages (because no wealth is lost in transactions), lessening the effects of the wealth constraint required when purchasing a house. Homeownership, however, decreases for the group of retirees. This result suggests that, in the benchmark case, a significant fraction of retirees keep their houses to avoid paying the transaction cost.<sup>15</sup>

### *Spread*

Next, we introduce ‘spread’ in the model by setting  $r^m = 0.035$ , 1 percent higher than the rate for deposits,  $r^d$ —Figure 4, panel (b). The existence of spread significantly reduces the homeownership rate because the unit cost of housing for homeowners increases. With spread, individuals are no longer indifferent about their portfolio composition. In fact, they always prefer equity to debt financing of their houses. Keeping a mortgage is costly, and the more so the larger the mortgage. As a result, the homeownership rate falls for all cohorts. The drop is particularly large for retirees. These households do not face income uncertainty, hence their tenure decision depends primarily on the relative price of renting versus owning. For our parametrization, they prefer to face rental price risk to owning. The existence of adjustment costs intensifies the effect. Older working-age cohorts know that, when retired, they would rather rent, so some households do not buy houses in the first place to avoid paying transaction costs.<sup>16</sup>

### *The mortgage interest deduction*

In Figure 4, panel (c), we see that eliminating the mortgage interest payment deduction has a similar effect to the introduction of spread: it increases the unit cost of housing for homeowners. For the same reasons, this policy change decreases the homeownership rate of older households proportionally more. Glaeser and Shapiro (1991) find that mortgage interest payment deductions

---

<sup>15</sup>One possible implication of this result is that a differential adjustment cost for retirees, possibly non monetary, could help explain why retirees do not sell their houses.

<sup>16</sup>Results are different if the rental price is based on the mortgage interest rate instead of the deposits rate. In this case, given our parameter values, the increase in the rental price is significant enough that homeownership becomes a much more attractive option for all age cohorts, pushing the overall homeownership rate to 90 percent.



benefit mostly the wealthy. In our model the wealthiest households are concentrated within the older cohorts. Thus, our results are consistent with theirs.

### *Down payments*

Next, we consider a case with a lower down payment,  $\theta = 0.1$ . Recall that a smaller  $\theta$  implies a higher loan-to-value ratio for home equity loans. In Table 3, we report that the median wealth-to-earnings ratio for the entire population is slightly lower (2.05 vs. 2.13 in the benchmark scenario) but the overall homeownership is higher (75.1 percent versus 69 percent). Figure 5, panel (a) shows that there is, however, an asymmetric effect on the homeownership rate across cohorts. Although homeownership increases slightly for the youngest cohort, there is an overall decrease in homeownership for working-age households (the homeownership rate falls from 69.17 to 67.85). However, homeownership increases dramatically for retirees (the fraction of homeowners goes from 68.68 to 94.97 percent).

The interaction of transaction costs with the lower down payment, as well as a change in the size of bequests accounts for the result. In order to see this, let us first analyze an alternative model economy without transaction costs or bequests depicted in Figure 5, panel (b). We consider two different down payments—25 percent and 10 percent. Bequests are taxed away entirely to minimize differences in initial wealth conditions in the two cases. Furthermore, we assume that houses are liquid assets by setting the adjustment cost parameter  $\chi = 0$ . In this case, the results are fairly intuitive. A lower down payment increases the homeownership rate for the cohorts more likely to be liquidity constrained—the younger households and the retirees—leaving other cohorts unaffected.

With transaction costs and accidental bequests, the interpretation is slightly more complicated. The lower down payment in combination with the adjustment cost changes the timing of home purchases for some households. In particular, there seems to be a delay effect on homeownership for certain households. For retirees, who do not face moving shocks or income uncertainty, owning a house is particularly attractive given the preferential tax treatment of owner occupied housing and the fact that ownership offers protection against rental price risk. However, owning a house also entails keeping a certain amount of housing equity,  $\theta q_t h_t^i$ . In the absence of bequest motives, older individuals want to run down assets and at some point, it is rational to free the housing equity to prop up nondurable consumption, even if acquiring housing services in the rental market is relatively more expensive. With the lower down payment, this requirement is lessened and owning becomes a more attractive option.<sup>17</sup> Relatively poorer working-age households, who with a lower down payment would like to own during retirement, prefer to wait until uncertainty is reduced, keep a more liquid portfolio during their working life, and buy a house more suitable for their retirement needs. This accounts for part of the decline in homeownership amongst older

---

<sup>17</sup>In fact, given the parametrization,  $\theta = 0.1$  and  $\chi = 0.12$ , most retirees keep their houses till the end to avoid paying the adjustment cost.



working-age households and the sharp increase in homeownership for the eldest working-age cohort.

Also, there is a reduction in the amount of accidental bequests left by retirees for two different reasons. First, with lower down payments, houses give further access to collateralized credit, so saving is overall lower. Second, retired homeowners only face survival risk and no longer the rental price risk. Thus, precautionary saving falls and accidental bequests decrease accordingly. This affects the youngest cohorts. Although liquidity constraints should be lessened by the lower down payment, accidental bequests are on average lower, which results in a very modest increase in homeownership for the youngest cohort.<sup>18</sup>

Our finding is different from other results in the literature. For instance, Chambers, Garriga, and Schlagenauf (2005a) find that easing financial conditions increases homeownership significantly for the younger cohorts. The authors use a general equilibrium model economy with no house price risk, no rental price risk, no collateral credit, or mortality risk (and therefore without accidental bequests). Moreover, they calibrate a smaller transaction cost, 6 percent. In a very different framework, Ortalo-Magné and Rady (1999) also find that an easing of financial conditions increases the homeownership rate for the younger cohorts. They assume that houses come only in two sizes, and that there are no accidental bequests. They, however, do not consider any type of idiosyncratic risk. We cannot assess the importance of the general equilibrium effect but our previous work, (Díaz and Luengo-Prado 2005), suggests that the interest rate should rise in response to a lower down payment. This, in turn, increases the rental price of housing but it also makes mortgage payments more burdensome. Thus, the overall effect on the life cycle pattern of homeownership is unclear. Nevertheless, we think that our finding highlights the importance of home equity loans (or reverse mortgages) during retirement.

Summarizing, we find that reducing the down payment increases the homeownership rate in the economy but that it may have asymmetrical effects on the life cycle pattern of homeownership rates. If reverse mortgages are available to all, the delay effect described before may produce a reduction of homeownership rates for some working-age cohorts. The aggregate effect, however, is an increase in the total homeownership rate.

## 4.2 Changes in risk

### *No moving shocks*

Shutting down the exogenous moving shocks has a similar effect to the elimination of transaction costs—Figure 5, panel (a). The moving shock forces working-age individuals to sell their houses and pay the adjustment cost. Consequently, the cost of acquiring housing services through purchases of the stock decreases and homeownership increases without these shocks. This result is consistent

---

<sup>18</sup>Note that Figures 4-7 depict the end-of-period wealth-to-earnings ratio. Therefore, the figures alone cannot be used to determine the median size of accidental bequests.

with Ortalo-Magné and Rady (2002) and Sinai and Souleles (2005) who find that homeownership is higher for households with longer horizons in their residences.

Note that the median wealth-to-earnings ratio increases for every cohort but the youngest one. Since moving shocks do not affect retirees, the bulk of accidental bequests remains pretty much the same and the median wealth-to-earnings ratio for the youngest cohort does not change significantly. For the other cohorts, the median wealth-to-earnings ratio increases because the adjustment cost is paid less frequently.<sup>19</sup>

#### *No house price risk*

Figure 6, panel (b) depicts the case with no house price uncertainty,  $\sigma_p^2 = 0$ . Note the median wealth-to-earnings ratio decreases for all cohorts and the pattern of homeownership over the life cycle is strikingly different: there are no homeowners before age 55 and no renters after age 60.

One of the reasons why households buy houses is to shield their consumption of housing services from any variation in prices. In our model, no house price uncertainty implies no rental price uncertainty, closing down this motive. Without variation in the price of housing services, working-age households turn to the rental market to avoid paying adjustment costs when experiencing a moving shock or a bad income realization. In other words, for working-age individuals, the expected unit cost of owner occupied housing is higher than the rental price. Once income uncertainty is lessened and an exogenous moving shock is less likely, the preferential tax treatment of owner occupied housing reverses the relationship between the expected user cost of housing and the rental price, and households turn to homeownership. The adjustment cost prevents retirees from selling their houses once they have them. Interestingly, the median house size without price uncertainty is 48 percent smaller than the median house size in our benchmark economy.

In order to more clearly see these effects, we eliminate the adjustment cost along with house price uncertainty in Figure 6, panel (c). Without adjustment cost, it is evident that the effect of the preferential tax treatment on owner occupied housing is strong enough for households of all ages to prefer buying to renting. In fact, the homeownership rate is 100 percent for all households except those who reach 85 years of age, for whom it is 0. The eldest households know with certainty that they will die at the end of the period and sell their houses to free the down payment for current consumption, acquiring housing services in the rental market instead.<sup>20</sup>

#### *Changes in permanent uncertainty*

Panel (a) in Figure 7 shows a case with no permanent income uncertainty,  $\sigma_\epsilon^2 = 0$ . Shutting

---

<sup>19</sup>In fact, while in our benchmark economy the median household owns three different houses, without moving shocks the median household owns only one house.

<sup>20</sup>This is not apparent in the figure since all cohorts of retirees are aggregated into one.

down permanent variation in earnings decreases the homeownership rate of the younger cohorts. All earnings variation is transitory so holding illiquid residential assets is a poor way of shielding consumption against variations in earnings in the presence of adjustment costs. Note also that the median wealth-to-earnings ratio falls for all cohorts—with CRRA preferences consumers are prudent and lower uncertainty leads to lower wealth accumulation. As a result, the wealth constraint imposed by the down payment requirement is more likely to bind for the poorer younger households. Consistently with this, older cohorts, which are also less likely to be hit by movings shocks and have accumulated more wealth, do not vary their tenure decision as much.

#### *Changes in transitory uncertainty*

Panel (b) in Figure 7 depicts an experiment where we shut down transitory variation in earnings other than the catastrophic shock (i.e.,  $\sigma_\nu = 0$  but  $p = 0.03$ ). The change has an asymmetric effect across cohorts in terms of homeownership (it decreases for the younger cohorts and increases for the older ones) but leads to lower wealth accumulation at all ages.

With less transitory variation in earnings, households need fewer liquid assets. With constant wealth this should lead to higher homeownership rates. In our simulations, older working-age households indeed increase their residential stock and decrease their holdings of liquid assets. However, since there is less uncertainty, households accumulate less wealth. Overall, they leave less accidental bequests which lowers homeownership among the youngest cohorts. Moreover, since a larger fraction of the idiosyncratic risk is permanent, younger households prefer to buy later in life, when earnings are sufficiently high, spreading out the accumulation of the down payment over several periods.

#### *No catastrophic income shock*

In our model, the catastrophic income shock affects working-age individuals exclusively. Younger homeowners, who have accumulated less wealth, are more likely to have to sell their houses when faced with such a shock. Figure 7 panel (c) shows that eliminating the shock increases homeownership significantly for the younger cohorts. Now, working-age individuals do not need to save as much in the form of liquid assets and buy more houses. Thus, the homeownership rate increases. Note the median wealth-to-earnings ratio changes only slightly, indicating that this shock affects mainly the composition of a household’s portfolio.

## **5 The rental price vs. the user cost**

We now return to the discussion outlined in section 2.7 regarding the cost of housing services for homeowners. Our objective is to assess the size of the bias introduced when using the rental price

to value owner occupied housing services. First, we discuss how the user cost of owner occupied housing and the rental price differ in the presence of adjustment costs. Then, we compute the bias resulting from using a rental price approach to value housing services (compared to a user cost approach) in our model.

### 5.1 An average user cost of owner occupied housing with capital gains and adjustment costs

Owner occupied housing services are not traded in the market and, therefore, there is no price for them. The standard procedure to compute the value of owner occupied housing services is to use the rental price to value them. As noted in the introduction, this procedure is inconsistent with the principle that the effective price of a commodity should be the cost of the commodity to the household consuming it. In principle, we can use the rental price of capital theory, as in Hall and Jorgenson (1967), and use the marginal user cost shown in section 2.7 to value these services. For instance, for a liquidity constrained household the marginal user cost shown in expression (15) can be written as:

$$uc_t^i = \frac{\theta (\lambda_t^i/\lambda_{t+1}^i - 1) q_t + (1 - \theta)\widehat{r}_{t+1}^m q_t + (\delta^h + \widehat{\tau}_h) q_{t+1} - (q_{t+1} - q_t)}{\lambda_t^i/\lambda_{t+1}^i}. \quad (19)$$

Expression (19) shows that the user cost is the sum of several components. The first term captures the forgone return of home equity,  $\theta (\lambda_t^i/\lambda_{t+1}^i - 1) q_t$ , where  $\lambda_t^i/\lambda_{t+1}^i$  is the marginal rate of substitution. The second term represents the marginal cost of the mortgage,  $(1 - \theta)\widehat{r}_{t+1}^m q_t$ , the third term is the sum of maintenance costs and property taxes, and the last term is the capital gain.

In the presence of adjustment costs, the marginal user cost is not well defined. Nevertheless, applying the principle of effective cost per unit of consumed services, we can define an *ex-post average user cost* as follows:

$$\overline{uc}_t = \frac{(1 - \mathcal{M}_t) q_t \widehat{r}_{t+1}^d + \mathcal{M}_t q_t \widehat{r}_{t+1}^m + q_{t+1} (\delta^h + \chi_{t+1} L_{t+1} + \widehat{\tau}^h) - (q_{t+1} - q_t)}{1 + \widehat{r}_{t+1}^d}, \quad (20)$$

where  $\mathcal{M}_t$  denotes the mortgage loan-to-value ratio, and  $L_{t+1}$  is an indicator equal to 1 if the household moves at the beginning of period  $t + 1$ , and 0 otherwise. Note the correspondence between the marginal user cost and this average user cost. The first component— $(1 - \mathcal{M}_t) \widehat{r}_{t+1}^d q_t$ —represents the forgone return of home equity. The second component,  $\mathcal{M}_t q_t \widehat{r}_{t+1}^m$ , measures the cost of the mortgage. The third term reflects maintenance costs, adjustment costs and property taxes (net of deductions). The final component is the accrued capital gain, which decreases the cost of owner occupied housing when positive. All terms are discounted by the after-tax interest rate. Comparing this expression to the definition of the rental price in equation (18), we see that the difference between both measures depends on the interest rate spread, the distortion imposed by

the fact that owner occupied housing services are not being taxed, the existence of adjustment costs and the divergence between expected and actual capital gains/losses.

As argued by Prescott (1997), Verbrugge (2003) and Poole, Ptacke, and Verbrugge (2005), among others, adding capital gains to the definition of the user cost violates the tradition of NIPA. However, since the rental price includes expected capital gains, we believe it is appropriate to incorporate them in the user cost definition as well. Nevertheless, since owner occupied housing services are not taxed, the divergence between the rental price and the user cost is magnified by the inclusion of capital gains. We have, however, an exact measure of the importance of the capital gains channel. In fact, the divergence between the rental price and the user cost can be decomposed as follows:

$$r_t^f - \overline{uc}_t = \frac{q_t [\tau_y \widehat{r}_{t+1}^d - (1 - \tau_y) \mathcal{M}_t (\widehat{r}_{t+1}^m - \widehat{r}_{t+1}^d)]}{(1 - \tau_y) (1 + \widehat{r}_{t+1}^d)} + \frac{(\delta^h + \widehat{\tau}_h) [E_t(q_{t+1}) - (1 - \tau_y) q_{t+1}]}{(1 - \tau_y) (1 + \widehat{r}_{t+1}^d)} - \frac{(1 - \tau_y) q_{t+1} \chi_{t+1} L_{t+1}}{(1 - \tau_y) (1 + \widehat{r}_{t+1}^d)} - \frac{E_t(q_{t+1}) - q_{t+1}}{(1 - \tau_y) (1 + \widehat{r}_{t+1}^d)} - \frac{\tau_y (q_{t+1} - q_t)}{(1 - \tau_y) (1 + \widehat{r}_{t+1}^d)}. \quad (21)$$

The last component measures the effect of including capital gains in the definition of the user cost.

## 5.2 The rental price vs. the user cost in our model

Table 4 compares the rental price to the average user cost for homeowners in our benchmark case. As described in section 3.2, we run a series of independent simulations (with 10,000 households each and for 50 periods).<sup>21</sup> The reported numbers refer to the unit cost of housing for the penultimate period of each simulation. We report the (across simulations) mean price of housing (column 1), the mean rental price (column 2), and the mean user cost for homeowners (column 3a). Note that within a given simulation, all households share the same realization of the house price shock. Moreover, in the benchmark case, the after-tax interest rates on deposits and mortgages are identical so the mortgage loan-to-value ratio does not affect the user cost. Therefore, within a simulation, all variation in the user cost comes from differences in the adjustment cost. Across simulations, different capital gain/loss realizations also add to the variance of the measure (the rental price only varies across simulations). Since differences in the price level of housing across simulations may obscure our comparisons, we also report means for the rental price and the user cost that have been normalized by the housing price level.

The user cost for homeowners is lower than the rental price (0.127 vs. 0.247), but it is also more volatile (the respective coefficients of variations for these means across simulations are 4.26 and 2.84 respectively). Note that these are the unit costs of housing for one simulation period

---

<sup>21</sup>We use 81 out of our 100 simulations to construct Table 4. For computational reasons, the process for the house price shock,  $\varrho$ , is discretized and takes three different values. We exclude some simulations randomly, to guarantee that we have an equal number of simulations with each possible price shock. Adding more simulations or more people to each simulation did not change the results significantly.

which represents 5 years. Looking at the normalized numbers, we see the same story: the user cost for homeowners is lower than the rental price (0.169 vs. 0.175), but the user cost is more volatile. Figure 8 depicts the distribution of the normalized user cost for homeowners in the benchmark case pooling data for all simulations together. Because the user cost does not depend on the loan to value ratio in this scenario and there are only 3 possible i.i.d. price shocks, there are only 6 distinct values for the user cost of homeowners. The highest value for the user cost, 0.45, is for households that must move in a period of falling house prices. The lowest user cost is for a household that is not moving in a period of house price appreciation,  $-0.10$ .

Our objective is to assess the size of the bias introduced when using the rental price to value owner occupied housing services. We calculate the implied bias two different ways—referred to as the ‘non-weighted bias’ and the ‘weighted bias’—as follows. Let  $\overline{uc}_j$  be the mean user cost for homeowners in a given simulation  $j$  and  $r_j^f$  be the rental price. Let  $O_j$  be the proportion of homeowners in the simulation,  $H_j$  the stock of owner occupied houses, and  $F_j$  the stock of rental residential stock. The non-weighted/weighted biases are:

$$\text{Non-Weighted Bias} = \frac{[\overline{uc}_j \times O_j + r_j^f \times (1 - O_j)] - r_j^f}{r_j^f}, \quad (22)$$

$$\text{Weighted Bias} = \frac{[\overline{uc}_j \times H_j + r_j^f \times F_j] - r_j^f \times (H_j + F_j)}{r_j^f \times (H_j + F_j)}. \quad (23)$$

For a given average user cost and a rental price, the bias is larger the greater the fraction of homeowners using the first method, and the larger the fraction of owner occupied housing services relative total housing services using the second method.<sup>22</sup>

In Table 4, we report mean biases across simulations. The non-weighted bias is  $-2.66$  percent, while the weighted bias is  $-2.91$  percent. That is, the rental equivalence approach overestimates the unit cost of housing in the benchmark case.

We also calculate an average user cost without capital gains (column 3b), one without adjustment costs (column 3c), and one without capital gains or adjustment costs (column 3d). Looking at the normalized figures, we see that ignoring capital gains in the computation of the user cost substantially lowers the volatility of the measure but does not change the mean, the reason being that the price appreciation process has been calibrated to have mean 0. Without the transaction cost, the user cost is significantly lower, 0.139. In short, if we ignore capital gains we underestimate the volatility of the mean unit cost of housing, while if we ignore adjustment costs, we also create a significant downward bias (the larger the greater the adjustment cost).

A word of caution: although the computed biases are small in our benchmark case, it is impor-

---

<sup>22</sup>The average homeownership rate across simulation is about 69 percent, while the average fraction of owner occupied housing services is 76.5 percent. Note that we assume that one unit of housing stock (rented or owned) delivers one unit of housing services.

tant to understand that when using real data, the bias will tend to be large in periods when values of price appreciation/depreciation are significantly higher than average; i.e., the user cost is much more volatile than the rental price.

For completeness, we also report the mean user cost and the mean biases for alternative parameter specifications in Table 5. The non-weighted bias varies from  $-16.9$  percent (for the case with no adjustment cost) to  $9.87$  percent (for the case with spread). However, these numbers must be taken with caution because this mean bias depends on the proportion of homeowners and these parameterizations do not deliver a homeownership rate close to that in the data.

## 6 Concluding Remarks

In this paper, we build a partial equilibrium life cycle model economy to help us better understand tenure decision choices as well as quantify possible biases when using a rental equivalence approach to compute the cost of housing for both homeowners and renters.

We find that a mixture of idiosyncratic earnings uncertainty, house price risk, down payments and transactions costs are needed for the model to deliver life cycle patterns of homeownership and portfolio composition similar to those found in the data. Also, we show that the bias resulting from pricing services of owner occupied housing (for which there is no market) using the rental market is about 3 percent. Furthermore, we show that a user cost approach delivers a much more volatile measure of the unit cost of housing, the more so the higher the volatility of house price shocks. We believe that our findings are informative for the debate on how to accurately measure the housing component of the cost of living.

For computational reasons, the model has been simplified along several dimensions that should be addressed in future research. For example, the normalization needed to solve the household problem prevents us from analyzing the case of a progressive tax system. We also believe it is important to further study the role of bequests. As we demonstrate, with simple accidental bequests, changes in the housing market have important effects on the intergenerational transmission of wealth.



## References

- Budria, S., J. Díaz-Giménez, V. Quadrini, and J.-V. Ríos-Rull (2002). New facts on the distribution of earnings, income and wealth in the U.S. *Federal Reserve Bank of Minneapolis Quarterly Review* 21, 2–35.
- Campbell, J. and J. F. Cocco (2003). Household risk management and optimal mortgage choice. *Quarterly Journal of Economics* 118, 1149–1194.
- Carroll, C. D. (1997). Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis. *Quarterly Journal of Economics* 112, 1–55.
- Chambers, M., C. Garriga, and D. E. Schlagenhauf (2005a). Accounting for changes in the homeownership rate. Mimeo, Florida State University.
- Chambers, M., C. Garriga, and D. E. Schlagenhauf (2005b). Housing tenure and investment decisions. Mimeo, Florida State University.
- Cocco, J. F. (2005). Portfolio choice in the presence of housing. *Review of Financial Studies* 18, 535–567.
- Díaz, A. and M. J. Luengo-Prado (2005). Precautionary savings and wealth distribution with durable goods. Mimeo, Universidad Carlos III.
- Flavin, M. and T. Yamashita (2002). Owner-occupied housing and the composition of the household portfolio over the life cycle. *American Economic Review* 92, 345–362.
- Gahvari, F. (1984). Incidence and efficiency aspects of differential taxation of industrial and residential capital in a growing economy. *Journal of Public Economics* 25.
- Gervais, M. (2002). Housing taxation and capital accumulation. *Journal of Monetary Economics* 49, 1461–1489.
- Glaeser, E. L. and J. M. Shapiro (1991). The benefits of the home mortgage interest deduction. NBER Working Paper # 9284.
- Goetzmann, W. N. and M. I. Spiegel (2000). The policy implications of portfolio choice in underserved mortgage markets. Mimeo, Yale ICF Working Paper No. 00-18.
- Gourinchas, P.-O. and J. Parker (2001). Consumption over the life cycle. *Econometrica* 70, 47–91.
- Hall, R. E. and D. W. Jorgenson (1967). *American Economic Review* 57(3), 391–414.
- Hansen, G. D. (1993, January-March). The cyclical and secular behaviour of the labor input: Comparing efficiency units and hours worked. *Journal of Applied Econometrics* 8(1), 71–80.
- Henderson, V. and Y. Ioannides (1983). A model of housing tenure choice. *American Economic Review* 73, 98–113.
- Li, W. and R. Yao (2005). The life-cycle effects of house price changes. Mimeo, Federal Reserve Bank of Philadelphia, WP. 05-7.
- Linneman, P., I. F. Megbolugbe, S. F. Watcher, and M. Cho (1997). Do borrowing constraints change U.S. homeownership rates? *Journal of Housing Economics*, 318–333.
- Ortalo-Magné, F. and S. Rady (1999). Boom in, bust out: Young households and the housing price cycle. *European Economic Review* 43(4), 755–766.
- Ortalo-Magné, F. and S. Rady (2002). Tenure choice and the riskiness of non-housing consumption. *Journal of Housing Economics* 11(3), 266–279.



- Poole, R., F. Ptacke, and R. Verbrugge (2005). Treatment of owner-occupied housing in the cpi. Mimeo, BLS.
- Poterba, J. M. (1984). Tax subsidies to owner-occupied housing: An asset market approach. *Quarterly Journal of Economics*, 729–752.
- Prescott, E. C. (1997). On defining real consumption. Federal Reserve Bank of St. Louis Review, May/June 1997.
- Quercia, R. G., G. W. McCarthy, and S. F. Watcher (2000). The impacts of affordable lending efforts on homeownership rates. Manuscript, Federal Home Loan Mortgage Corporation.
- Sheiner, L. and D. N. Weil (1992). The housing wealth of the aged. NBER Working Paper No. 4115.
- Sinai, T. and N. S. Souleles (2005). Owner-occupied housing as a hedge against rent risk. *Quarterly Journal of Economics* 120(2), 763–789.
- Skinner, J. (1996). The dynamic efficiency cost of not taxing housing. *Journal of Public Economics* 59.
- Storesletten, K., C. Telmer, and A. Yaron (2004). Consumption and risk sharing over the life cycle. *Journal of Monetary Economics* 51, 609–633.
- Verbrugge, R. (2003). The puzzling divergence of aggregate rents and user costs, 1978-2001. Mimeo, PINR, BLS.

## A The composition of household's portfolio

If we solve the household's problem shown in section 2.5 we obtain the following first order conditions,

$$c_{t+i}^i : \beta^i u_c(c_{t+i}^i, f_{t+i}^i + h_{t+i}^i) - \lambda_{t+i}^i = 0, \text{ for all } i \leq T, \quad (24)$$

$$c_{t+i}^i : -\lambda_t^i = 0, \text{ for all } i \geq T, \quad (25)$$

$$d_{t+i}^i : -\lambda_{t+i}^i + E_{t+i} \left\{ \lambda_{t+i+1}^{i+1} \left( 1 + \widehat{r}_{t+i+1}^d \right) \right\} + \varphi_{t+i}^{d,i} = 0, \text{ for all } i, \quad (26)$$

$$m_{t+i}^i : \lambda_{t+i}^i - E_{t+i} \left\{ \lambda_{t+i+1}^{i+1} \left( 1 + \widehat{r}_{t+i+1}^m \right) \right\} + \varphi_{t+i}^{m,i} - \mu_{t+i}^i = 0, \text{ for all } i. \quad (27)$$

where  $\lambda_{t+i}^i$  is the multiplier of the budget constraint,  $\varphi_{t+i}^{d,i}$  and  $\varphi_{t+i}^{m,i}$  are the multipliers of the non-negativity constraints for deposits and mortgages, respectively, and  $\mu_{t+i}^i$  is the multiplier associated to the borrowing constraint shown in (2).

**Lemma App. 1.** *The borrowing constraint and the non negativity constraint on mortgages cannot bind simultaneously.*

### A.1 No spread and full deductability

**Lemma App. 2.** *The non negativity constraint on deposits and mortgages cannot bind simultaneously.*

*Proof.* We prove it by contradiction. Let us assume that  $\varphi_{t+i}^{d,i} > 0$  and  $\varphi_{t+i}^{m,i} > 0$ . If  $\varphi_{t+i}^{d,i} > 0$ , then by (26) we have that  $-\lambda_{t+i}^i + E_{t+i} \left\{ \lambda_{t+i+1}^{i+1} [1 + \widehat{r}_{t+i+1}^d] \right\} < 0$ . In (27) it implies that  $\mu_{t+i}^i > 0$ , violating Lemma 1. Therefore, both non negativity constraints cannot bind at the same time.  $\square$

**Lemma App. 3.** *The non negativity constraint on mortgages is never binding,  $\varphi_{t+i}^{m,i} = 0$ .*

*Proof.* If  $\varphi_{t+i}^{d,i} > 0$  then Lemma 2 ensures that  $\varphi_{t+i}^{m,i} = 0$ . If  $\varphi_{t+i}^{d,i} = 0$ , then we have that  $\varphi_{t+i}^{m,i} = \mu_{t+i}^i$ . If  $\varphi_{t+i}^{m,i} > 0$  this implies that  $\mu_{t+i}^i > 0$ , which contradicts Lemma 1.  $\square$

**Proposition 1.** *Assume that there is no spread between the return on deposits and the mortgage rate and that mortgage interest payments are fully deductible (i.e.,  $r_t^d = r_t^m \forall t$ , and  $\tau_m = 1$ ). Then, households in their last period life hold no deposits. All other households can be divided in two groups. Those who are liquidity constrained hold no deposits. Those who are not liquidity constrained are only concerned with their net position  $d_t^i - m_t^i, \forall t$  and  $\forall i < T$ .*

*Proof.* Adding expressions (26) and (27) we obtain  $\varphi_{t+i}^{d,i} + \varphi_{t+i}^{m,i} - \mu_{t+i}^i = 0$ . By Lemma App. 3 this expression becomes  $\varphi_{t+i}^{d,i} = \mu_{t+i}^i$ . Thus, if the borrowing constraint is binding the household

holds no deposits and  $m_{t+i}^i = (1 - \theta) q_{t+i} h_{t+i}^i$ . If the borrowing constraint is not binding only the difference  $d_{t+i}^i - m_{t+i}^i$  matters.  $\square$

## A.2 Spread or partial deductability

**Proposition 2.** *Assume that there is spread between the return on deposits and the mortgage rate or that mortgage interest payments are not fully deductible (i.e.,  $r_t^d < r_t^m$  or  $\tau_m < 1$ ). Then, households do not simultaneously hold deposits and debt. In particular, households in the last period of life hold no deposits.*

*Proof.* Adding expressions (26) and (27) we obtain:

$$E_{t+i} \lambda_{t+i+1}^{i+1} \left[ \widehat{r}_{t+i+1}^d - \widehat{r}_{t+i+1}^m \right] + \varphi_{t+i}^{d,i} + \varphi_{t+i}^{m,i} - \mu_{t+i}^i = 0.$$

Since the expression inside the brackets is negative then  $\varphi_{t+i}^{d,i} + \varphi_{t+i}^{m,i} - \mu_{t+i}^i > 0$ , which implies that  $\varphi_{t+i}^{d,i} + \varphi_{t+i}^{m,i} > 0$ . Thus, households do not hold simultaneously positive amounts of deposits and debt. Specifically, borrowing constrained households do not hold deposits.  $\square$

## B The Data

Our data comes from the 1998 Survey of Consumer Finances (SCF) elaborated by the Federal Reserve Board. Our definition of earnings is taken from Budria, Díaz-Giménez, Quadrini, and Ríos-Rull (2002). Given this definition, some households in the sample have negative earnings. Since our model cannot account for those cases, we have restricted our sample to those households with non negative earnings. Moreover, since in our model households' net worth cannot be negative, we have further restricted our sample to those households with non negative wealth. The definition of household's net worth is the one used in the SCF: total assets minus total liabilities. The variable housing comprises the items called primary and secondary residence in the SCF and its value is gross of any collateralized debt. That is, the value of housing  $H$  is the full value of the house, not home equity. Households that report no housing stock are assumed to be renters.

Table 1: DATA FROM THE 1998 SURVEY OF CONSUMER FINANCES

Cohort	Median ratios					Homeownership rate
	Total	Homeowners		Renters	$W/E$	
	$W/E$	$W/E$	$H/E$	$H/W$		
20-25	0.40	1.14	2.20	1.98	0.31	23.28
25-30	0.62	0.93	1.67	1.57	0.37	44.97
30-35	1.00	1.51	1.99	1.26	0.23	62.16
35-40	1.59	2.09	2.04	0.91	0.45	70.85
40-45	1.89	2.37	1.91	0.87	0.45	77.29
45-50	2.34	2.81	2.01	0.76	0.56	80.78
50-55	3.34	3.72	2.33	0.70	0.50	80.33
55-60	4.19	4.45	2.96	0.66	0.21	86.23
60-65	4.84	5.38	2.86	0.66	0.73	80.05
65+	-	-	-	0.65	-	81.23
Working age	1.80	2.60	2.15	0.86	0.37	69.55
Total	2.99	3.75	2.92	0.79	0.38	72.07

Notes:  $W/E$  denotes the wealth-to-earnings ratio.  $H/E$  is the house value-to-earnings ratio and  $H/W$  is the house value-to-wealth ratio.

Table 2: BENCHMARK CALIBRATION PARAMETERS

Age	Moving Shocks	Survival Probability	Non-stochastic income growth
20-24	0.355	0.992	0.000
25-29	0.355	0.991	0.278
30-34	0.355	0.988	0.152
35-39	0.355	0.985	0.113
40-44	0.355	0.981	0.068
45-49	0.345	0.975	0.016
50-54	0.345	0.964	0.000
55-59	0.340	0.946	-0.047
60-64	0.320	0.915	-0.082
65-69	0	0.875	0.000
70-74	0	0.816	0.000
75-79	0	0.737	0.000
80-84	0	0.612	0.000
85-89	0	0	0.000

Earnings:  $\sigma_\epsilon^2=0.01$ ,  $\sigma_v^2=0.073$ ,  $p = 0.03$ ,  $b = 0.3$   
Preferences:  $\beta=0.984$ ,  $\sigma = 3$ ,  $\alpha = 0.43$   
Taxation:  $\tau_y = 0.203$ ,  $\tau_m = 1$ ,  $\tau_h = 0$   
Market Arrangements:  $r^d = r^m = 0.025$ ,  $\theta = 0.25$ ,  $\chi = 0.12$   
Housing Prices:  $\delta^h = 0.01$ ,  $\mu_\rho = 0$ ,  $\sigma_\rho^2 = 0.0132$

Table 3: MEDIAN RATIOS: MODEL VS. DATA

Cohort		Total	Homeowners			Renters	Homeownership
		$W/E$	$W/E$	$H/E$	$H/W$	$W/E$	rate
Working-age	Benchmark	1.81	2.42	1.98	0.84	0.94	69.17
	No adj. cost	2.14	2.47	2.49	1.00	0.79	87.27
	Spread	1.70	2.48	1.98	0.82	1.09	57.26
	No deduction	1.76	2.47	1.98	0.82	1.04	61.92
	Lower down payment	1.82	2.41	1.98	0.85	1.09	67.85
	No moving shocks	2.13	2.51	2.28	0.91	0.85	83.18
	No price uncertainty	1.42	2.67	2.60	0.96	1.26	13.51
	No perm. income uncertainty	1.25	1.93	1.79	0.95	0.76	55.18
	No trans. income uncertainty	1.59	2.03	1.81	0.92	0.82	68.98
	No catastrophic shock	1.83	2.14	2.04	0.91	0.29	83.01
	Data	<i>1.80</i>	<i>2.60</i>	<i>2.15</i>	<i>0.86</i>	<i>0.37</i>	<i>69.55</i>
65+	Benchmark	-	-	-	1.08	-	68.68
	No adj. cost	-	-	-	1.01	-	51.87
	Spread	-	-	-	0.99	-	34.15
	No deduction	-	-	-	1.00	-	44.92
	Lower down payment	-	-	-	1.28	-	94.97
	No moving shocks	-	-	-	1.09	-	65.36
	No price uncertainty	-	-	-	1.61	-	99.99
	No perm. income uncertainty	-	-	-	1.11	-	69.73
	No trans. income uncertainty	-	-	-	1.08	-	72.05
	No catastrophic shock	-	-	-	1.08	-	68.84
	Data	-	-	-	<i>0.65</i>	-	<i>81.23</i>
Total	Benchmark	2.13	2.81	2.48	0.88	0.79	69.04
	No adj. cost	2.36	2.88	2.86	0.99	0.63	77.90
	Spread	1.92	2.93	2.47	0.84	0.96	51.15
	No deduction	1.99	2.91	2.47	0.85	0.88	57.42
	Lower down payment	2.05	2.52	2.42	0.96	0.92	75.14
	No moving shocks	2.44	2.90	2.71	0.93	0.68	78.46
	No price uncertainty	1.65	1.94	2.76	1.42	1.50	36.39
	No perm. income uncertainty	1.56	2.30	2.27	0.98	0.57	59.03
	No trans. income uncertainty	1.77	2.26	2.18	0.96	0.81	69.79
	no catastrophic shock	2.02	2.42	2.32	0.96	0.29	79.26
	Data	<i>2.99</i>	<i>3.75</i>	<i>2.92</i>	<i>0.79</i>	<i>0.38</i>	<i>72.07</i>

$W/E$  denotes the wealth-to-earnings ratio.  $H/E$  is the house value to earnings ratio and  $H/W$  is the house value to wealth ratio.

Table 4: RENTAL VS. USER COST. THE BENCHMARK CASE

	MEAN UNIT COST OF HOUSING					
	Price	Rental	User Cost ( homeowners only)			
	(1)	(2)	(3a)	(3b)	(3c)	(3d)
Mean across simulations	1.523	0.243	0.127	0.247	0.080	0.199
Across simulation coeff. variation	(3.00)	(2.84)	(4.26)	(2.91)	(6.68)	(2.89)
Mean within simulation s.d.	[0.00]	[0.00]	[0.07]	[0.07]	[0.00]	[0.00]
	NORMALIZED BY THE PRICE LEVEL					
Mean	1.000	0.175	0.169	0.169	0.139	0.139
Across simulation coeff. variation	(0.00)	(0.00)	(1.13)	(0.10)	(1.43)	(0.07)
Mean within simulation s.d.	(0.00)	[0.00]	[0.05]	[0.05]	[0.00]	[0.00]
	BIAS %					
Non-weighted bias						
Mean	–	–	–2.66	–2.24	–14.67	–14.26
Across simulation coeff. variation	–	–	(28.94)	(3.12)	(5.44)	(0.29)
Weighted bias						
Mean	–	–	–2.91	–2.44	–15.98	–15.51
Across simulation coeff. variation	–	–	(28.83)	(3.13)	(5.44)	(0.29)

Notes: The numbers are constructed from 81 independent simulations with 10,000 individuals each. One simulation period corresponds to 5 years. (3a) The ex-post user cost defined in equation (20). (3b) The ex-post user cost without capital gains. (3c) The ex-post user cost without adjustment costs. (3d) The ex-post user cost without capital gains or adjustment costs.

Table 5: (NORMALIZED) RENTAL VS. USER COST

	Mean Unit Cost of Housing					Mean Bias %	
	Rental	User Cost (for homeowners only)				Method 1	Method 2
	(1)	(2)	(3)	(4)	(5)		
Benchmark	0.175	0.169 (0.191) [0.047]	0.169 (0.017) [0.047]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-2.66 (76.95)	-2.91 (83.76)
No adj. cost	0.175	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-16.77 (92.87)	-17.45 (98.05)
Spread	0.175	0.209 (0.192) [0.049]	0.209 (0.018) [0.049]	0.176 (0.200) [0.014]	0.176 (0.010) [0.014]	9.87 (57.12)	10.57 (61.64)
No deduction	0.175	0.188 (0.187) [0.047]	0.188 (0.018) [0.047]	0.156 (0.194) [0.007]	0.156 (0.010) [0.007]	3.79 (62.36)	4.13 (67.65)
Lower down payment	0.175	0.162 (0.193) [0.043]	0.162 (0.016) [0.043]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-5.62 (78.96)	-6.16 (86.43)
No moving shocks	0.175	0.147 (0.196) [0.026]	0.147 (0.014) [0.026]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-13.15 (91.25)	-14.05 (97.90)
No price uncertainty	0.175	0.143 (0.001) [0.019]	0.143 (0.001) [0.019]	0.139 (0.000) [0.000]	0.139 (0.000) [0.000]	-6.00 (0.15)	-7.22 (0.17)
No perm. income uncertainty	0.175	0.167 (0.192) [0.046]	0.167 (0.016) [0.046]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-3.04 (65.70)	-3.42 (74.09)
No trans. income uncertainty	0.175	0.169 (0.192) [0.047]	0.169 (0.017) [0.047]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-3.04 (77.44)	-3.30 (80.84)
No catastrophic shock	0.175	0.170 (0.191) [0.047]	0.170 (0.018) [0.047]	0.139 (0.198) [0.000]	0.139 (0.010) [0.000]	-2.50 (89.03)	-2.64 (92.71)

Notes:

(2) The ex-post user cost defined in equation (20). (3) Ex-post user cost without capital gains. (4) Ex-post user cost without adjustment costs. (5) Ex-post user cost without capital gains or adjustment costs. The figure in parentheses is the standard deviation of the mean unit cost of housing (or bias) across the independent simulations. The amount in squared brackets is the mean (across simulations) of the within simulation standard deviation of the user cost.

Figure 1: Composition of the Population

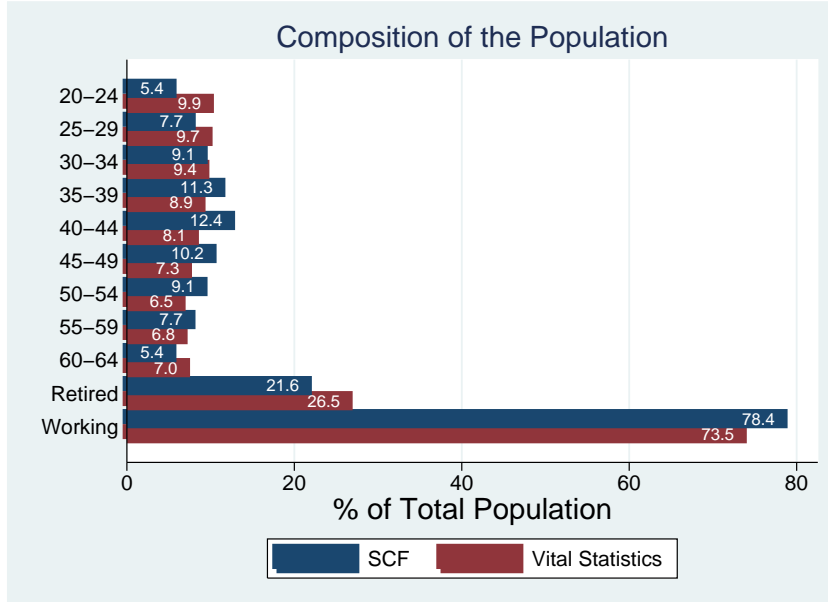


Figure 2: Life-Cycle Profiles for the Benchmark Case

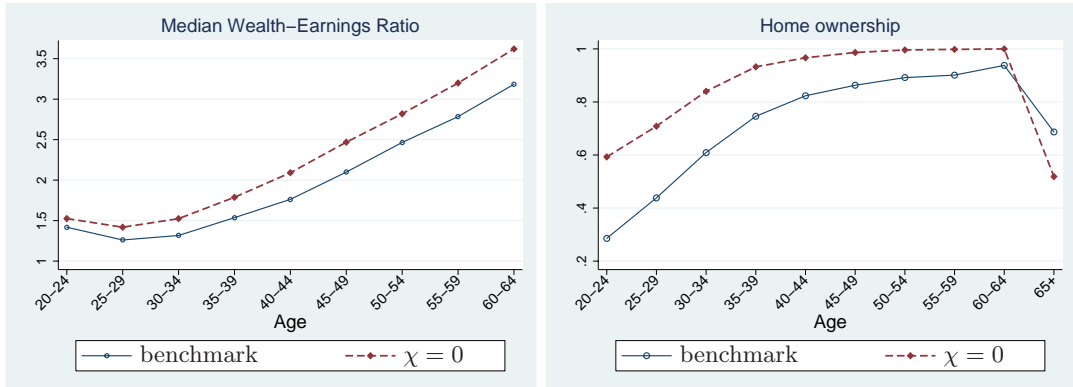




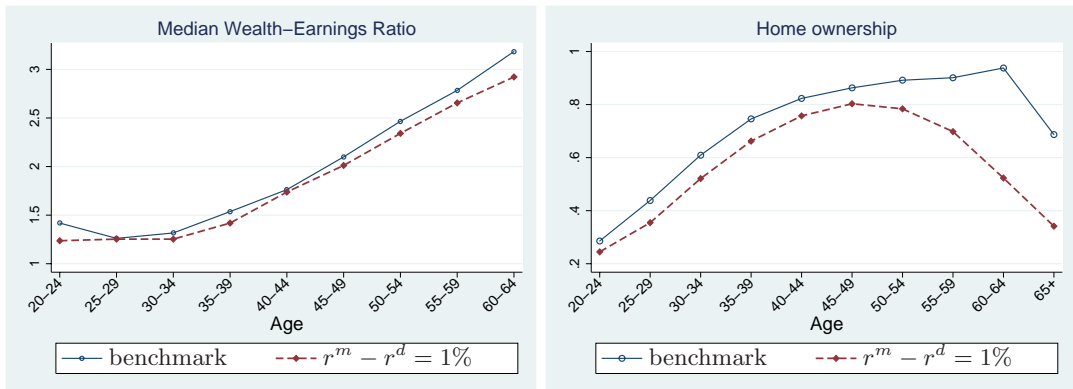
Figure 3: Benchmark vs. Data



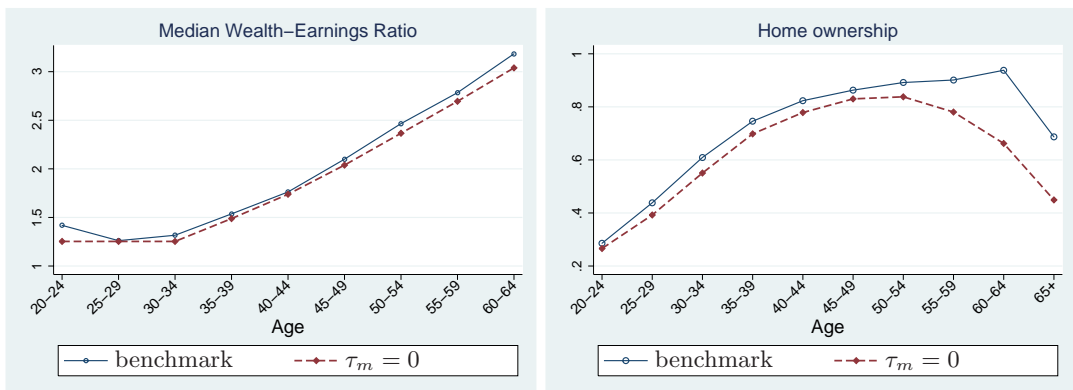
Figure 4: Comparison with Benchmark II



(a) No Adjustment Cost

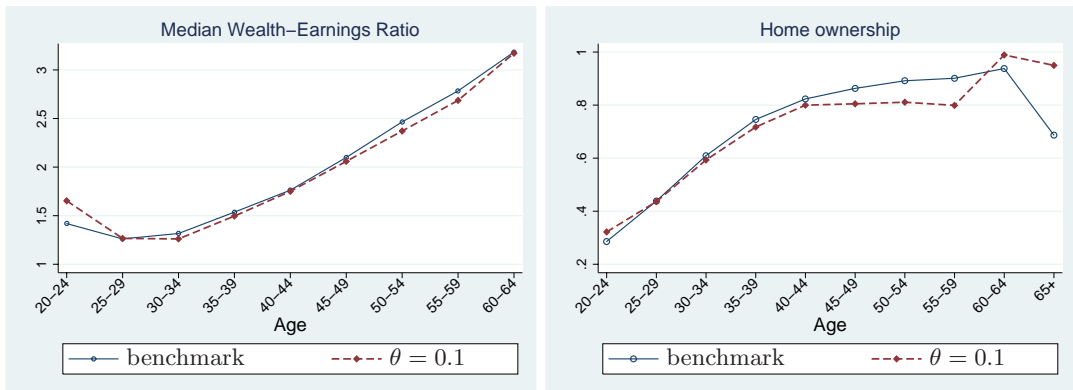


(b) Spread

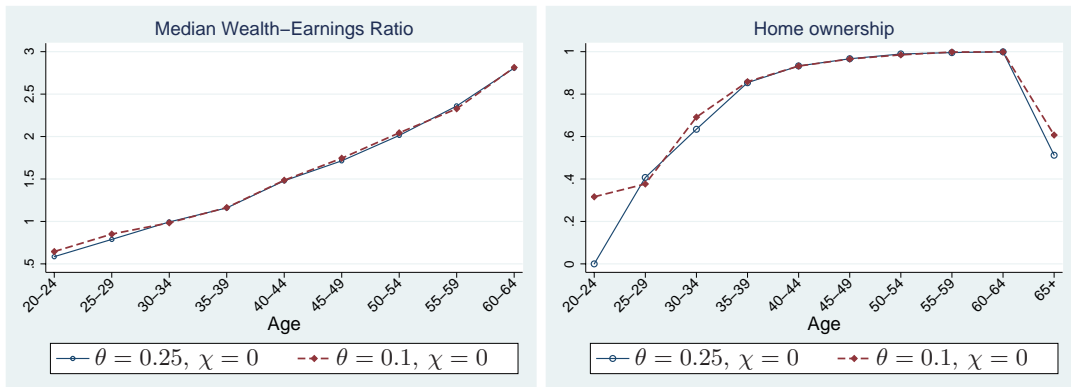


(c) No deduction

Figure 5: Comparison with Benchmark II

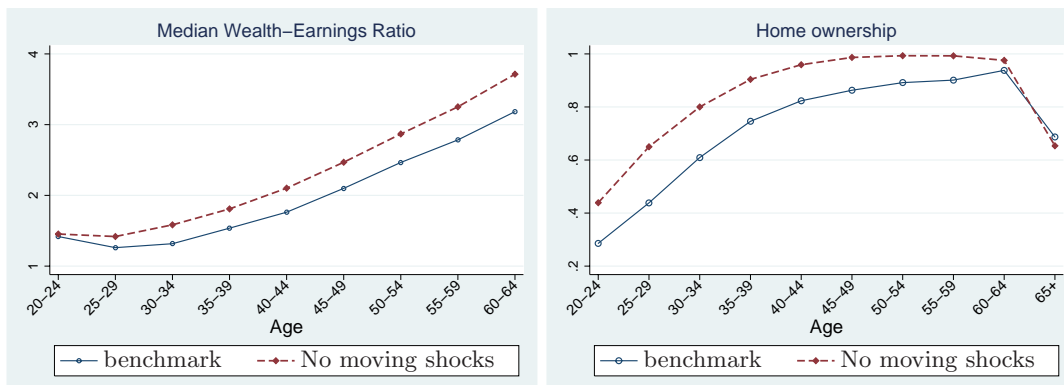


(a) Lower down payment



(b) Lower down payment, no adjustment cost and no bequest

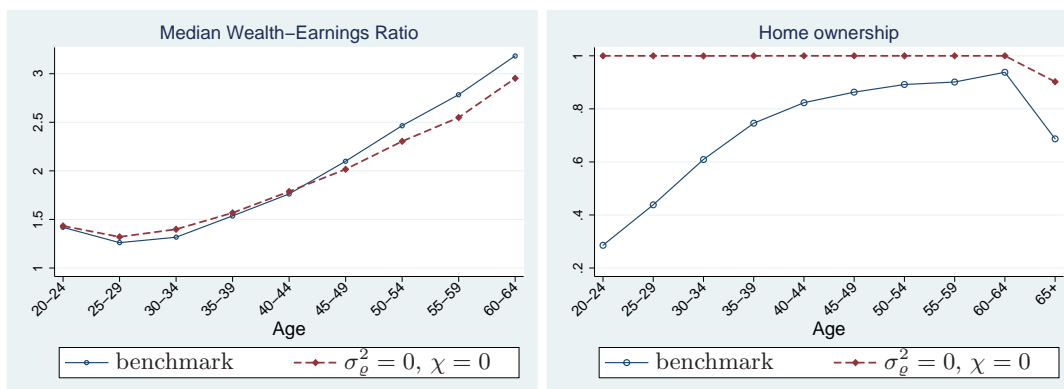
Figure 6: Comparison with Benchmark III



(a) No moving shocks

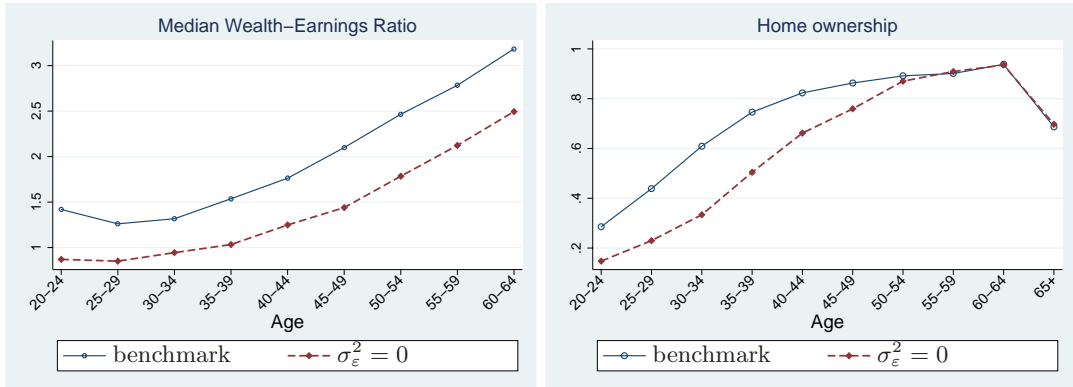


(b) No price uncertainty

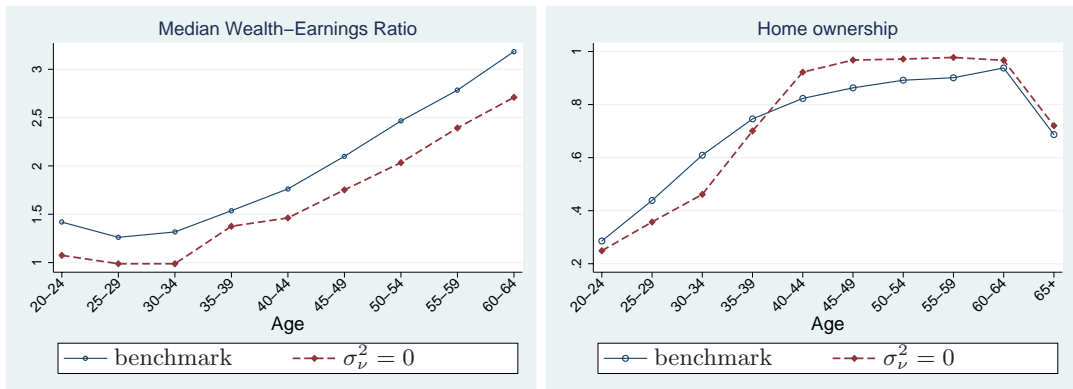


(c) No price uncertainty or adjustment cost

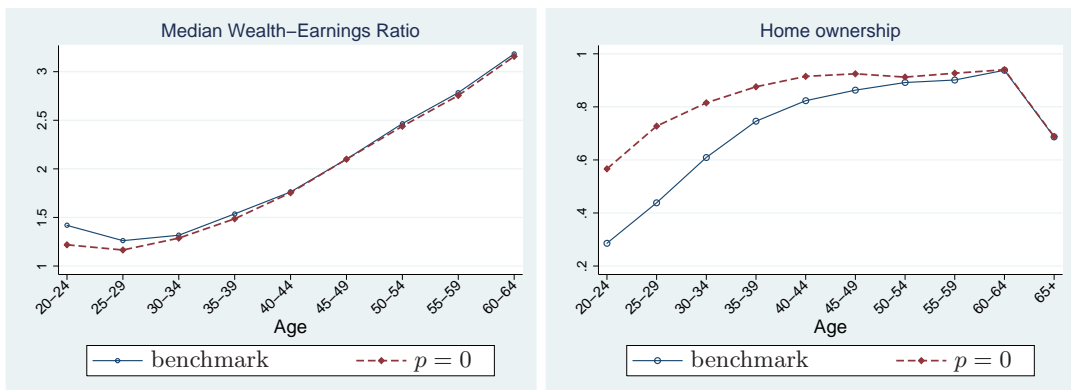
Figure 7: Comparison with Benchmark IV



(a) No permanent income uncertainty



(b) No transitory income uncertainty



(c) No catastrophic shock

Figure 8: User Cost Distribution

