Renting Vs Buying a Home: A Matter Of Wealth Accumulation or of Geographic Stability?

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Abstract
I study the housing tenure decision in the context of a life cycle model with uninsurable individual income risk, plausibly calibrated to match key features of the US housing market. I find that the relatively low ownership rate of young households is mainly explained by their high geographic mobility. Downpayment constraints have minor quantitative implications on ownership rates, except for old households. I also find that idiosyncratic earnings uncertainty has a significant impact on ownership rates. Based on these results, I argue that the long term increase in ownership rates observed over the period 1993-2009 was not necessarily due to mortgage market innovations and the relaxation of downpayment requirements, as is often argued. Instead, it was simply an implication of US demographic evolution, most notably the decline in interstate migration and, less importantly, population ageing.
1 Introduction

While there is ongoing debate on how to calculate the user cost of owner occupied housing, there exists a consensus that in the US it is lower than the rental price of housing services.\(^1\) Despite the low cost of owning relative to renting and the increasing first time home-buyer affordability index (National Association of Realtors), many young households choose to rent rather than buy a house.

A common explanation for the low ownership rates among young households is the presumed high downpayment constraint that young adults face when they buy their first homes. Although most quantitative studies on housing assume relatively high minimum downpayment requirements\(^2\) (20% or 25%), they are not very successful in matching the US life cycle ownership curve, especially for young households. It is also interesting to note that the majority of housing tenure decision models in the literature over-predict the difference in ownership rates between young and older agents (Iacoviello and Pavan 2011, Li and Yao 2006...).

According to the 2011 American Community Survey, households hold 37% of their total assets in real estate of which home equity represents 55%. Hence, understanding these issues is important for both researchers and policy makers. Indeed, a realistic characterization of tenure decision mechanisms over the life cycle is crucial to obtaining accurate analysis and assessment of applied policies, social security reforms, public programs for promoting home-ownership, and welfare impacts for different age cohorts.

Another related issue has to do with asset holdings more generally. One of the key patterns of consumption and asset holdings over the life cycle is that young agents tend to have few liquid assets and hold most of their wealth in consumer durables. Indeed, according to the Wealth and Asset Ownership survey of 2009 (United Census Bureau), average rental property equity

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\(^1\)Rosen 1979, Diaz and Luengo-Prado 2011 ...  
\(^2\)Compared to what data on downpayment reveals: 14.2% according to Us Census 2009 American Housing Survey, and 13.76% according to lendintree 2011...
seems to be less depending on age compared to home-own equity investments. Moreover, renters hold on average $135,000 in rental property equity representing 25% of the average value for owners. Hence, it is very likely that renters, who are mainly young households, hold significant real estate equity.

As mentioned earlier, many researchers have argued that this phenomenon is simply a direct consequence of two important features characterizing the housing market: A high downpayment requirement combined with a minimum housing quantity constraint. According to this hypothesis, young households, who generally have relatively low income, cannot easily afford the required downpayment to purchase a house. However, this explanation is not in line with empirical evidence and several housing market facts. First, as I already mentioned, relatively wealthy young households are very likely to rent rather than own a house despite the fact that they have enough cash to meet the downpayment requirement. Second, the high minimum downpayment requirement of 20% to 25% commonly assumed in the literature, is not consistent with US housing market financial data: While it is true that real estate experts and mortgage bankers recommend a downpayment of 20%, the effective downpayment paid by most American homeowners is much lower than that typically recommended. In fact, more than 14 million (out of a total of 71 million owner-occupied homes covered by the 2009 survey) were bought with no downpayment. Moreover, according to the 2009 American Housing Survey, the effective average downpayment was around 14.2%. According to Arslan, Guler and Taskin (2013), the average downpayment ratio during the 2001-2005 period was 21.1%. However, we should not forget that the minimum downpayment requirement should be set at lower value that the average. According to the same survey, the median is less than 10% and 77% of owner occupied homes were bought with downpayments less than 20%.

High downpayment assumptions are usually justified by existing norms on downpayment re-

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3Renters holding rental propriety investments.
quirements, such as the Qualified Residential Mortgage.\textsuperscript{4} Yet, lenders often have programs that are flexible for different types of borrowers and banks can offer loans with smaller downpayments and higher interest rates. There is also private insurance that can be purchased by borrowers in order to obtain lower downpayments.

Based on all these facts, it seems unlikely that the low ownership rates among young households are exclusively due to high downpayments requirements, especially, if we take into consideration the flexibility of the US housing market regarding home prices. Indeed, according to the most well-known American real estate website Realtor, it is possible to buy a house for $30,000 or less. As reported in the 2009 American Housing Survey, 22% of owners have houses bought for less than 1.5 times their current income,\textsuperscript{5} and around 15% of owner-occupied houses were bought for less than the national average income. While Iacoviello and Pavan (2011) assume a minimum house price set to 1.5 times the average annual pre-tax household income\textsuperscript{6}, several other researchers have simply estimated this parameter to match data targets (Chambers Carriga and Schlagenhauf (2007), Silos (2007)...).

Besides this housing market evidence, there is also no clear conclusion about the quantitative and empirical importance of the impact of downpayment constraints on home ownership. Fisher and Gervais (2008) and Kiyotaki et all. (2007) argue that the relaxation of downpayment requirements was quantitatively small and had only modest implications

\textsuperscript{4}The Qualified Residential Mortgage (QRM) is a requirement that allows the borrower to have the best rate on the mortgage since the loan will be exempt from the the Dodd-Frank Wall Street Reform that requires financial firms to retain 5 percent of the credit risk when they sell loans to investors (skin in the game).

\textsuperscript{5}Which seems to be consistent over time: 23% according to the 2003’s AHS; and 22% according to the 1982’s AHS.

\textsuperscript{6}In their paper, they refer to the 2009 American Housing Survey which reports that only 20 percent of total owner-occupied units have a ratio to current income less than 1.5. Yet, I do not think that this information is sufficient to assume that the minimum value of a house that an agent can buy is 1.5 times the "economy average income”. On the contrary, I argue that the minimum size house is less than what was set by authors. In fact, more than 50% of households have an income lower than the average

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for the housing market. On the other hand, others researchers have found that borrowing constraints play an important role in explaining the low ownership rates among young households (Chambers et al (2005), Iacoviello and Pavan (2011) ...).

Finally, we can conclude that housing tenure decision models have not been very successful in revealing the real reasons behind the low home-ownership rates among young households nor in replicating the actual US life cycle home-ownership curve.

In this paper, I study the housing tenure decision in an equilibrium life cycle model with uninsurable individual income risk, plausibly calibrated to match key features of the US housing market, the earnings distribution and life cycle mobility rates. I explicitly distinguish owned from rented housing by modeling its collateral role and its illiquidity aspect and I allow for an endogenous housing tenure decision. I also introduce a mobility shock to capture geographical instability which can be thought as a potential explanation for the fact that many young, rich households in the US prefer to rent. As expected, the data shows that mobility rates are negatively correlated with age.7 Given that my model incorporates several potential channels through which the housing tenure decision mechanism can be affected, I investigate the different popular explanations that have been proposed to explain the relative low home ownership rate among young households. To do so, I attempt to accurately assess the role and the relative importance of financial constraints, earnings volatility and geographic mobility in explaining this apparent puzzle. I also build a simple yet rich framework in order to accurately replicate the US life cycle home-ownership curve.

I find that geographic mobility has a significant and important impact on the tenure

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7 see Figure 1
decision while the downpayment constraint has a small effect on aggregate ownership rate. More specifically, young households are almost unaffected by changes in the downpayment parameter. Only old households are impacted by the relaxation or the tightening of the downpayment constraint. I also find that the shape of the life cycle ownership curve depends strongly on the idiosyncratic earnings risk variance. Indeed, with a plausible calibration that matches key US housing market evidence and more importantly the US earnings GINI coefficient, I am able to replicate the observed life cycle home-ownership curve very closely.

Based on counter-factual experiments, I am also able to shed new light on potential factors leading to the low ownership rate among young households: The high mobility of young adults is largely the reason why they are, in general, more willing to rent a house even if they have enough wealth to meet the downpayment requirement. That being said, the limited financial resources of young households plays an important role in explaining their low aggregate ownership rate. Finally, introducing mobility shocks improves the model’s ability in matching the US ownership curve and the US housing market ratios.

According to my findings, the long run increase in the ownership rate observed over the period 1993-2009 was not necessarily due to the mortgage market innovations and the relaxation of the downpayment requirements that have characterized the US housing market over the last decades (Chambers and Garriga (2008), Ortalo-Magne and Rady (2006) ... ). Instead, it is simply an implication of the US demographic evolution, notably, the population ageing (Shrestha and J. Heisler (2009)) and the decline in interstate migration as it has been reported by Kaplan and Schulhofer-Wohl (2012). In fact, The model is able to account for the actual rise in aggregate ownership rate and to accurately replicate the transition of the ownership distribution as a function of age, between 1993 and 2009.

Although geographical instability is a straightforward and intuitive potential factor that could affect household decision regarding home-ownership, most housing tenure models in
the literature have simply ignored it. To the best of my knowledge, the most closely related work to my paper is Fisher and Gervais (2008), where they show that an increase in idiosyncratic income risk and marriage instability (delay entry into and greater exit from) are sufficient to account for most of the decline in young home ownership. My paper differs from theirs in many aspects. Firstly, in their set up, geographic instability is exclusively determined by marital status changes, while in my case, mobility is more general and implicitlly includes many other factors since it is consistent with actual data on US life cycle geographic mobility. Secondly and most importantly, it is obvious that they are tackling a different issue of the housing market dynamics.

The rest of the paper is organized as follows. In the next section, I describe the environment; Section 3 defines the household’s problem ; Section 4 characterizes the stationary equilibrium ; In section 5, I describe the model calibration in details . Sections 6 presents the results and analysis.

Figure 1: Mobility (US Census Bureau 2009 to 2010)
2 The Environment

The economy is a life cycle dynamic general equilibrium model with income uncertainty, extended to allow for housing investment, a rental market and collateralized debt. Time is discrete and there is a continuum of households of measure 1 at each date. Households are heterogenous due to their age \( a \) and cannot live more than \( T \) periods. Each household works until the retirement age, \( \hat{T} \) and subsequently receives a pension \( P \) until death. A household of age \( a \) survives from age \( a \) to age \( a + 1 \) with probability \( \alpha_a \) where \( \alpha_0 = 1 \) and \( \alpha_T = 0 \). I assume a law of large numbers so that \( \alpha_a \) is also the deterministic fraction of households of the age cohort \( a \) that will survive to age \( a + 1 \).

Every period, a measure of newborns \( \mu_1 \) enters the economy so that the total population is constant. The fraction of people who belong to the age cohort \( a \), where \( a \in \{1...T\} \), is recursively defined as \( \mu_{a+1} = \alpha_a \mu_a \), where

\[
\mu_1 = \left( 1 + \sum_{i=1}^{T-1} \prod_{j=1}^{i} \alpha_j \right)^{-1}. \tag{1}
\]

2.1 Household Preferences and Endowments

Households receive utility from consumption \( c \) and housing services \( s \). They also value leaving housing and asset equities to their heirs. The momentary utility function is:

\[
U(c, s) = \log(c) + \chi \log(\theta s), \tag{2}
\]

Above, \( \theta = 1 \) and \( s = h' \), if the household chooses to become (or remain) a home owner and buys a quantity \( h' \) of housing services. Otherwise, \( \theta < 1 \) and \( h' = 0 \) (the household rents \( s \) housing services). Hence, the household gains more utility from owning a home, as in Iacoviello and Pavan (2011), Rosen (1985) and Poterba (1992). To capture the illiquid aspect of owned housing, I impose two restrictions. Firstly and most importantly, I
assume that a homeowner has to pay a transaction cost whenever he adjusts his housing stock, \( \Lambda(h', h) = \psi \ h, \) if \( |h' - h| > 0. \) Secondly, I assume a minimum housing quantity, \( h \) such that a renter who wants to become an owner has to purchase at least \( h \) and an owner who wants to keep his tenure status unchanged, has to hold a minimum size house \( h. \) As in Gervais (2002) and Iacoviello and Pavan (2011), I do not impose such a restriction on renter units. The assumption of additively separable logarithmic preferences over consumption and housing dramatically simplifies computations. Moreover, it is consistent with the findings of Davis and Ortalo-Magne (2011), according to which, the expenditure share on housing is roughly constant, over time and across U.S cities.

Individuals are endowed with one unit of time in each period which they supply inelastically in the labor market at a wage rate \( w. \) The labor productivity of an individual of age \( a \) is \( \epsilon_a z, \) where \( \{\epsilon_a\}_{a=1}^T \) is the deterministic age specific component, and \( z \) is a labor efficiency shock following a Markov process: \( z \in \{z_1, z_2, \ldots, z_N\} \) with transition probabilities \( \pi(z'|z) \) and a stationary distribution \( \Pi(z). \)

Pension are fully financed by governments revenues from lump-sum taxes \( \tau \) collected from workers. I assume that a household starts his life with initial endowments of capital and housing \( k_0 = h_0 = 0. \)

Accidental bequests are assumed to be uniformly distributed among all households currently alive. \( B^k \) and \( B^h \) denote, respectively, transfers of accidental bequests of capital and housing stock from deceased households in the last period. I assume that households receive the housing bequest transfers at no cost.

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8 We assume that only home owners are responsible for paying transaction costs. However, in reality, both buyer and seller are supposed to pay a part of the total transaction costs. Having said this, in practice, those costs are negotiable and usually handled as a matter of local tradition. Overall, sellers cover an important part of the closing costs that buyer is responsible for (known as seller concessions or seller contributions).

9 When I numerically solve the model, I also impose a minimum housing adjustment quantity. Indeed, \( h' \) is not treated as a continuous variable that can take any value, it is more a discrete variable: a small grid.

10 For instance, renters can share housing units. Overall, the rental housing supply is very flexible.
**Mobility shock:**

I assume that homeowners are subject to taste shocks that force them to leave their houses and rent for at least one period, otherwise their utility will be driven to $-\infty$. This taste shock could be interpreted as a mobility shock that forces a household to leave the city where he lives to a new one. Since my model is a one city representative framework, I cannot model the mobility shocks in an explicit manner. However, in an environment with multiple cities, one could assume that a household is not allowed to have access to a housing market more than once in each period. Then, if a homeowner experiences a mobility shock, he will be deprived from purchasing housing during the first period in the new city. Obviously, renters will not be affected by these shocks since they will able to buy a house if they want. Let $\lambda_a$ be the probability of experiencing the mobility shock for a household of age $a$.

### 2.2 Production

The production sector is relatively standard. The goods market is competitive and characterized by a constant returns to scale production function:

$$Y = AK^\alpha L^{1-\alpha},$$  \hspace{1cm} (3)

Where $K$ and $L$ are aggregate inputs of capital and labor, respectively. The final good can be either consumed or costlessly transformed into new residential and non-residential capital. Given that the production technology is a constant returns to scale function, the number of firms in the equilibrium is indeterminate. Hence, without loss of generality, I assume that there is a single representative firm that minimizes its costs, $qK + wL$, subject to (3).

In equilibrium, free entry implies that goods prices adjust so that profits are zero. We assume that the price of the final good is normalized to 1. Thus, in a competitive equilibrium, the prices of all goods are all equal to one and the capital rent, $q$, and the labor wage, $w$ are
defined as:

\[ q = \alpha A \left( \frac{K}{L} \right)^{\alpha - 1} \]

\[ w = (1 - \alpha) A \left( \frac{K}{L} \right)^{\alpha} \]

### 2.3 Intermediate Financial and Housing Markets

There are two intermediate zero-profit markets:

- **Competitive financial sector**: A representative financial agency collects deposits from households (investors) and uses these funds to make loans to firms and households (borrowers). In competitive equilibrium, the interest rate \( r = q - \delta_k \), where \( \delta_k \) is the depreciation rate of physical capital \( k \).

- **Competitive housing rental market**: A representative real estate firm buys some of the final good, converts it into rental housing capital at no cost and rents it to tenants at the rental price \( p \). The no arbitrage condition implies that \( p = \frac{r + \delta_h}{1 + r} \),\(^{11}\) where \( \delta_h \) is the depreciation rate of housing \( h \).

Note that the present net cost of consuming one unit of housing services during a period via a housing purchase is \( 1 - \frac{1 - \delta_h}{1 + r} = \frac{r + \delta_h}{1 + r} \), which is exactly the same net cost of consuming one unit of housing services during a period via the rental market.\(^{12}\)

However, renters can adjust their housing consumptions without paying transaction costs. Moreover, relatively poor households can rent small units since there is no minimum size for rental units. On the other hand, owning has several advantages over renting. First, owning provides more satisfaction to the household than renting (\( \theta < 1 \)). Second, housing can be

\(^{11}\)The present value of investing one unit of capital in the rental housing market, \( p + \frac{1 - \delta_h}{1 + r} \), should be equal to the present value of investing one unit of capital in financial market which is \( \frac{1}{1 + r} = 1 \).

\(^{12}\)However, if we consider the fact that a household can die next period with a probability \( \alpha_{\alpha + 1} \), the present net cost of owning one unit of housing will be slightly higher than the cost of renting: \( p + \frac{(1 - \alpha_{\alpha + 1})(1 - \delta_h)}{1 + r} \).
used as collateral to borrow money (collateral value). Hence, both rental and purchasing housing demands can be non negative.
3 Household’s Problem

Given the absence of any aggregate uncertainty, I focus on a stationary equilibria in which prices, wages and interest rate are constant across time. The state variables of the model are: capital holdings $k$, housing wealth, $h$, productivity, $z$ and the mobility shock, $m$. Letting $x = \{k, h, z, m\}$ denote the state vector, the problem of a household of age $a$ can be written recursively as:

$$W_a(x) = (1 - m) \cdot \left\{ \max_{D \in \{0, 1\}} \{ D \cdot W^o_a(x) + (1 - D)W^r_a(x) \} \right\} + m \cdot W^r_a(x), \quad (4)$$

where $W^o_a$ and $W^r_a$ denote the value functions when the household of age $a$ owns and rents, respectively.

The indicator $m$ takes the value 1 when the owner experiences a mobility shock requiring him to move to another city and takes the value 0 otherwise. For renters, $m$ is always 0.\textsuperscript{13} Hence, when $m=1$, the household (homeowner) is forced to sell his housing stock and rent for the current period.

The variable $D$ is a choice variable that takes the value 1 when the household chooses to become (remain) a homeowner and 0 otherwise.

The net income of an agent of age $a$ is defined as $y_a = w \epsilon_a z - \tau$, for $a < \hat{T}$ and $y_a = P$, for $a \geq \hat{T}$.

I also assume that agents cannot borrow when they reach the age $T$ so that $k' = 0$ for $a = T$.

Households receive utility from discounted bequeathing wealth $Q_w$, where $\phi$ controls the strength of the bequest motive, $1 - \alpha_a$ is the probability that the household dies the next period and $\beta$, represents the time discount factor. The bequest motive is introduced in order\textsuperscript{13}

\textsuperscript{13}for $h=0$, $m$ is automatically set to 0.
to avoid a sharp decline in home-ownership late in life, which could represent a potential source of bias.

- **Value of being a homeowner**: The problem of a homeowner consists of choosing consumption, house size and savings position.

\[
W_a^{o}(x) = \max_{c,k',h'} \left\{ U(c,h') + \beta \left( 1 - \alpha_a \right) \phi \log(Q_w) + \beta \alpha_a \sum_{z'} \pi(z' | z) \left\{ (1 - \lambda_{a+1}) W_{a+1}(k',h',z',0) + \lambda_{a+1} W_{a+1}(k',h',z',1) \right\} \right\}
\]

\[Q_w = (1 - \delta_h) h' + (1 - \delta_k) k',\]

\[c + k' + h' + \Lambda(h', h) = y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h)\]

\[k' \geq -(1 - \kappa)h', \quad c \geq 0 \quad \text{and} \quad h' \geq h\]

A household can borrow up to a percentage \((1 - \kappa)\) of the value of his new housing stock, where \(0 \leq \kappa \leq 1\). Hence, this constraint can also be interpreted as a downpayment constraint for housing purchases which is equivalent to a fraction \(\kappa\) of the value of the home being purchased.

- **Value of renting**: The problem of a renter consists of choosing consumption, rental housing services and savings position.

\[
W_a^{r}(x) = \max_{c,k',s} \left\{ U(c,s) + \beta \left( 1 - \alpha_a \right) \phi \log(Q_w) + \beta \alpha_a \sum_{z'} \pi(z' | z) \left\{ W_{a+1}(k',0,z',0) \right\} \right\}
\]
\[ c + k' + p s + \Lambda(0, h) = y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h) \]

\[ k' \geq 0, \quad c \geq 0 \quad s \geq 0 \quad \text{and} \quad h' = 0. \]

A renter has no collateral to obtain loans \((k' > 0)\). However, he will not be affected by mobility shocks next period and can potentially own a home, unlike a current owner who can find himself forced to rent the next period with probability \(\lambda_{a+1}\).
4 Stationary Equilibrium

Given that there is no aggregate uncertainty in the economy, I focus on a stationary equilibrium in which prices, wages, and interest rate are constant through time.

At the beginning of each period a household is characterized by his capital holding $k$, his housing stock $h$, his age $a$, labor productivity $z$ and his owning taste shock (mobility shock) $m$. In the stationary equilibrium, $\Phi(k, h, a, z, m)$, the measure of agents of type $(k, h, a, z, m)$, is constant.

**Definition**

A stationary equilibrium consists of a collection of value functions $\{W_a(x), W_o^a(x), W_r^a(x)\}$, policy functions $(c, k', h', s, D)$, aggregate quantities $L$, $K$, $H$, $H^o$ and $H^r$, taxes $\tau$, pensions $P$, accidental bequest transfers $\{B^k, B^h\}$, prices $\{w, q, r, p\}$ and a law of motion $\Gamma$ such that:

- All economic actors optimize their profits and utilities subject to the following factor and rental prices:
  \[
  q = \alpha A \left( \frac{K}{L} \right)^{\alpha-1}, \\
  w = (1 - \alpha) A \left( \frac{K}{L} \right)^\alpha, \\
  r = q - \delta_k, \\
  p = \frac{r + \delta_h}{1 + r},
  \]

- Markets clear:
  \[
  \int \epsilon a z \, d\Phi = L, \\
  \int k'(x, a) \, d\Phi = K, \\
  \int c(x, a) \, d\Phi + \delta_k \int k'(x, a) \, d\Phi + \delta_h \int h'(x, a) + p \int s(x, a) \, d\Phi + d\Phi + \int \Lambda(h'(x, a), h) \, d\Phi = AK^\alpha L^{1-\alpha}, \\
  H = H^o + H^r = \int D(x, a)h'(x, a) \, d\Phi + \int [1-D(x, a)]s(x, a) \, d\Phi,
  \]
• Accidental bequest transfers satisfy:

\[ B^k = \int [k'(x, a) - k] \, d\Phi, \]
\[ B^h = \int [h'(x, a) - h] \, d\Phi, \]

In the stationary equilibrium, the accidental bequest is simply the difference between the total capital at the last period and the total capital at the beginning of the current period.

• Government budget balances:

\[ \sum_{a=1}^{\tilde{a}} \varpi_a \tau = \sum_{a=\tilde{a}+1}^{T} \varpi_a P, \]
where

\[ \varpi_{\tilde{a}} = \int d\Phi(k, h, a = \tilde{a}, z, m). \]

• The measure \( \Phi \) follows: \( \Phi = \Gamma(\Phi) \), where \( \Gamma \) is the law of motion generated by policy functions \( h' \) and \( k' \), the transition probabilities \( \pi(z'|z) \) and the age dependent mobility probabilities \( \{\lambda_a\}_{a=1}^{T} \).

I compute the stationary equilibrium of the model using a standard backward induction method of solving overlapping generations models. However, I proceed with a new method on how to define the capital grid that allows households to borrow up to the limit \( (1 - \kappa)h' \) when buying a house, without being forced to use a huge grid (See Appendix A for more details).
5 Calibration

I calibrate the baseline model to match some long-run averages of the US economy as well as several demographic features. It is not trivial to precisely match all these targets at the same time. However, after performing a sensitivity analysis, I was able to identify which parameter(s) should be used to target each ratio.

5.1 Demographics

The unit of time is one year and households become economically active at the age of 20 and die no later than age 100. The deterministic age profile of the unconditional mean of labor efficiency for males aged 21-65 is taken from Hansen (1993) (see Figure 2). Population numbers and survival probabilities are from Faber (1982)(see Figure 3).

5.2 Macroeconomics evidence

The parameter $\alpha$ is set at 0.3 to match the US share of labor in total income of 70% while $\beta$ and $\delta_k$ are chosen to match a ratio of capital to output ($\frac{K}{Y}$) between 2 and 2.2, a ratio of business investment to output ($\delta_k \frac{K}{Y}$) around 0.2 and interest rate $r$ around 3%.

5.3 Housing

The parameters $\chi$ and $\delta_h$ are chosen to match a ratio of the housing stock to output ($\frac{H}{Y}$) of around 1.4 and a ratio of housing investment to the housing stock ($\frac{I_h}{H}$) of between 0.04 and 0.07. The bequest motive parameter $\phi$ is calibrated so as to prevent any potential sharp decrease in ownership rates of the oldest agents. Indeed, when there are no bequest incentives, the oldest individuals would naturally prefer to sell their houses and increase their current and future consumptions. Actually, this parameter seems to have a very small
impact on the aggregate ownership rate. However, I need to set $\phi$ at a small positive value to avoid any steep decline in ownership curve at the end of the life cycle.\footnote{14}

The owning utility parameter $\theta$ is set to obtain an **adjusted** aggregate ownership rate of 65%. The data on mobility and home-ownership rates (as a function of age),\footnote{15} corresponds to the year 2009. However, I am using an age distribution that corresponds to a different year (Faber 1982).\footnote{16} Hence, I cannot simply target the reported aggregate ownership rate of 2009. For consistency purposes, I compute a new adjusted aggregate ownership rate target by weighting ownership rates of different age cohorts of 2009 by the same age distribution used in the model. The adjusted aggregate ownership target is around 65% instead of the actual one which is 67%. These manipulations do not have a significant impact on my qualitative and even quantitative results since I am mainly interested in studying the life cycle impacts. Actually, when I use the U.S. Decennial life tables for 1989-1991\footnote{17} instead of Faber 1982, the results do not change. This is mainly because of the fact that the survival probabilities remained almost unchanged, except for a slight variation in the survival probabilities of the very old households. This, by the way, has no significant impact since the bequest motive parameter is calibrated to match the last part of the ownership curve.

The adjusted aggregate rate is 65% which is clearly lower than the actual rate of 67%. Hence, I conclude that the increase in the US population ageing might be one of the reasons of the rise of the ownership rate in the United States\footnote{18}.

\footnote{14}The degree of the impact of $\phi$ on the shape of the last part of the ownership curve appears to be extremely unstable. Indeed, when $\phi = 0$, the curve steeply decreases after the age of 85 and for $\phi$ greater than 0.1, the ownership rates for old agents jump to unrealistically high values: 100%. However, any value between those two extreme cases generate almost the same ownership pattern for old agents.

\footnote{15}Data on home-ownership rates as a function of age is obtained from United States Census Bureau (Table17: Housing Vacancies and Home-ownership (CPS/HVS)).

\footnote{16}Which was also derived based on an estimation technique different from what is typically used for the computation of actual aggregate ownership rates.

\footnote{17}The survival probabilities presented in those tables are based on age-specific death rates calculated using data from the 1990 census of population and deaths occurring in the United States in the 3 years proximate to the 1990 census (i.e.,19891991).

\footnote{18}Which is confirmed in section 6.5
The downpayment parameter is set at $\kappa = 0.15$; I will change this parameter in order to assess its impact on the ownership rate of different age cohorts, more specifically for young households.

The minimum size house available for purchase $h$ costs 1.5 times the average annual pre-tax household income as in Iacoviello and Pavan (2011). This parameter seems to have no impact on results. It is true that when I set it at lower values, the aggregate ownership rate increases but when I recalibrate $\theta$ to match the target, I end up with very similar results.

Housing transaction cost is set at $\psi = 5\%$ (National Association of Realtors).

### 5.4 Geographic Mobility

Data on mobility is obtained from the United States Census Bureau (Table 1-01: Geographical Mobility: 2009 to 2010). The mobility rate, as a function of age, is calculated based on the proportion of movers belonging to the same age cohort.\(^{19}\) As may be seen in Figure 1, mobility is sharply decreasing in age, especially for households under 50 years.

However, one can argue that mobility rates are relatively low for young households not because of their age but rather because of their housing tenure status. In fact, most young households are renters, which might explain why they have higher mobility rates.

To address this issue, I use data from Table 7-01 of the same survey showing that the degree of mobility for young renters is much higher than it is for old renters (and the same is true for owners). Hence, there is no doubt that mobility does depend on age regardless of housing tenure status.

It is also true that, mobility rates for owners are clearly lower than those for renters of the same age. Having said that, the "opportunity" to move depends only on age and does not depend on tenure status. In fact, geographical mobility is mainly induced by new job offers and/or by new marital status. Such changes are more likely to affect young agents than old...
households. However, the acceptance of the "offer" does depend on tenure status; an owner will be less willing to accept the offer and move,\(^{20}\) while the renter is more likely to accept the offer. That's why mobility is higher for owners than it is for renters of the same age.

To relate this intuitive interpretation to my set up, we should remember that my model imposes an important restriction: Agents (renters and owners) have to move once they are subject to a mobility shock. In other word, they are not allowed to make decisions on whether to stay or move (accept the offer or deny it). In order to take this fact into account, I simply interpret the mobility shocks as the average mobility rates of owners and renters of the same age. Indeed, my model, by construction, does not allow me to study the tenure impact on geographic mobility.

5.5 The Earnings Process

The idiosyncratic shock to labor productivity is specified as:

\[
\log z_t = \rho z \log z_{t-1} + \sigma_z (1 - \rho^2 z) \frac{1}{2} \varepsilon_t, \quad \varepsilon_t \sim \text{Normal}(0, 1).
\]  

(7)

This AR(1) equation can be approximated with an \(N_z\)-state Markov process. There is a vast literature on how to specify this process as well as on how to set the parameters. Researchers have used different values for the calibration of the unconditional variance \(\sigma^2_z\) and the persistence parameter \(\rho_z\). In the housing literature, authors usually refer to previous empirical studies on the wealth distribution, such as Hugget (1993) or Storesletten Telmer and Yaron papers (1994, 1999, 2001, 2004a, 2004b, 2007) or others. However, these papers do not necessarily use the same economic environment as I do (or as other housing papers do), and may use different estimation strategies (different age-dependent component, variables

\(^{20}\)Mainly because of the associated illiquidity cost of house selling. Moreover, owners have relatively high moving costs since they, usually, make important investments in furniture and other housing related assets.
included in the estimation ...).\textsuperscript{21} Hence, it is not always appropriate to simply use their estimated parameters and impose them into any model. In this regard, it is necessary to recall that one of my main objectives in this project is to replicate the actual data on ownership with the highest degree of accuracy. Thus, I calibrate $\sigma_z$ so that the earnings GINI coefficient implied by the model matches its counterpart in the data (0.404).\textsuperscript{22} It is worth noting that when I use the same grid and the same transition matrix used in Fernandez-villaverde and Krueger (2005) to approximate the labor productivity process, the implied earnings GINI coefficient drops to 0.29 which is significantly lower than the real one.

The calibration of the persistent parameter $\rho_z$ is less challenging given that the unconditional variance is fixed. Nevertheless, recent empirical studies have been in favor of using a higher persistence parameter. Indeed, some studies have not rejected the hypothesis of a unit root. Yet, as the process becomes more persistent and closer to the unit root, the accuracy of the Markov approximation deteriorates. In fact, I chose $\rho_z$ so that the fraction of liquidity constrained households is not below 20\%.\textsuperscript{23}

An approximation with a large state space would be desirable, though it would have high computational costs. After several computational exercises, I choose to set $N_z = 5$.

Having said this, I think that, in reality, households of different ages do not necessarily face the same labor income shocks (age-invariant persistence and variance). Indeed, young households are more likely to face less persistent income shocks due to their high job mobility. However, the variance of these moderate persistent shocks is expected to be relatively high given their high wage growth rates. In fact, Karahan and Ozkan (2012) argue that the standard specification in the literature that assumes age-invariant persistence and variance

\textsuperscript{21}For instance, Storesletten Telmer and Yaron (2007) used a regime-switching conditional model, which is not the case for most of housing models

\textsuperscript{22}US Census Bureau: Table IE-2: Measures of Individual Earnings Inequality for Full-Time, Year-Round Workers by Sex: 1967 to 2010

\textsuperscript{23}Hall (2011) and Iacoviello and Pavan (2011)
of income shocks cannot capture the earnings dynamics of young workers. Indeed, they find that young workers face moderately persistent earnings shocks and that the variance of income shocks exhibits a U-shaped profile over the life cycle.

Based on these results, I could have calibrated the income process for each age cohort (young, middle aged, and old) to match the corresponding earnings GINI coefficient. However, I think this will have little effect on my results. In fact, the model, already, perfectly replicates the US ownership curve. Moreover, according to my findings, young households are not very influenced by changes in income risk.²⁴

There are many methods to approximate the process (Tauchen’s (1986), Tauchen and Hussey’s (1991), Rouwenhorst (2010) ...). According to simulation tests I have made, it seemed to me that Markov method is the most efficient procedure for the my case. This is in line with Floden (2007)’s findings that suggests using Tauchen’s (1986) method in the case of highly persistent processes.

²⁴See 6.4.
Table 1: *Calibration*

<table>
<thead>
<tr>
<th>Description</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival probabilities</td>
<td>$\alpha_a$</td>
<td>Figure 3</td>
</tr>
<tr>
<td>Deterministic age specific component</td>
<td>$\epsilon_a$</td>
<td>Figure 2</td>
</tr>
<tr>
<td>Capital share</td>
<td>$\alpha$</td>
<td>0.3</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.9758</td>
</tr>
<tr>
<td>Capital depreciation rate</td>
<td>$\delta_k$</td>
<td>0.094</td>
</tr>
<tr>
<td>Weight on housing in utility</td>
<td>$\chi$</td>
<td>0.16</td>
</tr>
<tr>
<td>Housing depreciation rate</td>
<td>$\delta_h$</td>
<td>0.043</td>
</tr>
<tr>
<td>Bequest motive parameter</td>
<td>$\phi$</td>
<td>0.055</td>
</tr>
<tr>
<td>Housing transaction cost</td>
<td>$\psi$</td>
<td>5%</td>
</tr>
<tr>
<td>Utility parameter (Renting Vs Owning)</td>
<td>$\theta$</td>
<td>0.76</td>
</tr>
<tr>
<td>Downpayment parameter</td>
<td>$\kappa$</td>
<td>0.15</td>
</tr>
<tr>
<td>Minimum size house available for purchase</td>
<td>$\bar{h}$</td>
<td>1.5 <em>Avg inc</em></td>
</tr>
<tr>
<td>Mobility shock probabilities</td>
<td>$\lambda_a$</td>
<td>Figure 1</td>
</tr>
<tr>
<td>Unconditional standard deviation of $\log(z_t)$</td>
<td>$\sigma_z$</td>
<td>0.637</td>
</tr>
<tr>
<td>Persistent parameter of $\log(z_t)$</td>
<td>$\rho_z$</td>
<td>0.925</td>
</tr>
</tbody>
</table>
Figure 2: Deterministic wage efficiency profile

Figure 3: Survival Probabilities
6 Results

6.1 Baseline Model (Figure 4)

Table 2 compares the the baseline model with the data, where the variables in the bottom are obtained by calibration.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>0.95</td>
<td>-</td>
</tr>
<tr>
<td>θ</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.76</td>
<td>-</td>
</tr>
<tr>
<td>Constr</td>
<td>Fraction of financially constrained house buyers</td>
<td>1.1%</td>
<td>-</td>
</tr>
<tr>
<td>Liquid</td>
<td>Fraction of liquidity constrained households</td>
<td>29.37%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Ownership y</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>42.66%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership m</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.11%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership o</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>82.40%</td>
<td>80.8%</td>
</tr>
<tr>
<td>Ho/Hr</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>3.9</td>
<td>3</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>r</td>
<td>Equilibrium interest rate</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>H/Y</td>
<td>Ratio of housing to output</td>
<td>1.53</td>
<td>[1.4, 1.55]</td>
</tr>
<tr>
<td>K/Y</td>
<td>Ratio of capital to output</td>
<td>2.4</td>
<td>[2, 2.5]</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>

I will start first by defining some of the variables in Table 2:

The fraction of financially constrained house buyers is the percentage of buyers who borrow exactly a fraction \((1 - \kappa)\) of the value of the house being purchased. It does not include owners who upgrade their housing stock.

The fraction of liquidity-constrained households is the percentage of households in the economy who are liquidity constrained. Following Hall (2011) and Iacoviello and Pavan (2011), I consider a household to be liquidity constrained if his holding of net liquid assets are less than two months (16.67% on an annual basis) of income, where liquid assets are defined as
follows: \((1 - \kappa)h' + k'\).

According to The Berkeley Electronic Press (2007), the average ratio of the stock of residential capital that is owned to that which is rented in the US economy during the period 1987-2005, \(H_o/H_r\), is around 3.

Figures 4 (a,b) compare the home-ownership curve as a function of age predicted by the baseline model to that implied by the data. Note that for the rest of the paper, Figures (a) report the life cycle curves of the exact values predicted by the model, while Figures (b) report the smoothed versions.\(^{25}\) Given the heavy computational cost of using a higher value of \(N_z\), the ownership curves, especially for the first age cohorts, show some undesirable fluctuations. In order to obtain smoother curves, I perform a simple moving average filter on the simulated rates. This manipulation does not seem to have a big impact on the predicted rates nor on the general curve shapes.

According to Table 2 and Figures 4 (a,b), the baseline model does a very good job in replicating the life cycle ownership rates. The differences between age cohorts rates are close to their empirical counterparts. Despite the fact that I have only targeted the aggregate ownership rate, the model’s accuracy in matching the life cycle ownership rates is outstanding and can be considered as a novel achievement. Having said this, the baseline model overpredicts the ratio of the owned housing stock to the rented one (3.9 Vs 3).

- **Life cycle patterns:** Figures 5 and 6 plot individual life-cycle profiles for a typical middle class household and for a random rich household (owners).

  A typical middle class household is assumed to always earn the median income given the age group to which he belongs.

\(^{25}\)More specifically for Figures (4,8,9,11,13 and 14).
The simulated patterns are very realistic: A typical middle class household buys his first (and last) house at the age of 32 and finishes repaying his loan (60% of the house value) at the age 41. Then, he increases his savings until the retirement age when he starts to increase his consumption and decreases his savings until he becomes liquidity constrained (borrows up to 85% of the value of his small house).

The rich household starts his life as a renter and increases his savings until he buys his first house at the age of 25 (with a loan equivalent to 65% of the home price). The typical rich household increases his housing stock twice during his life, at the age 34 and 52. At age 84, he sells his large house and buys a smaller one.

Obviously, the poorest households in this economy remain renters and never have the opportunity to own a house.
6.2 Is Mobility Important?

6.2.1 Experiment: Baseline model without mobility (Figure 7)

Table 3: Baseline model without mobility

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constr_f</td>
<td>Fraction of financially constrained house buyers</td>
<td>37.79%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Liquid_f</td>
<td>Fraction of liquidity constrained households</td>
<td>29.68%</td>
<td>29.37%</td>
</tr>
<tr>
<td>Ownership_y</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>61.63%</td>
<td>42.66%</td>
</tr>
<tr>
<td>Ownership_m</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>83.72%</td>
<td>74.11%</td>
</tr>
<tr>
<td>Ownership_o</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>89.28%</td>
<td>82.40%</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>77.23%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Geographic mobility affects the household’s tenure decision to become a homeowner through two different channels. The first effect is related to the transaction costs that a homeowner would pay when experiencing a mobility shock forcing him to move and sell his house. The second effect consists in the fact that the same homeowner will be also deprived from the option of buying a house during the first period following the shock. Thus, removing mobility shocks will certainly encourage homeownership.26

According to the Table 3 and Figures 8 (a,b), geographic mobility has, indeed, a significant impact on the aggregate ownership rate. In fact, without mobility shocks, the aggregate rate of ownership rises from 65% to 77.23%. It is important to note that the impact of mobility on the housing tenure decision is asymmetric with regard to the household’s age. The

---

26Beside this endogenous impact of mobility on home ownership, there exists another effect which is more mechanical and straightforwardly related to the assumption made on mobility. Indeed, when a homeowner experiences a mobility shock, he is obliged, by assumption, to rent for one period. Then, all else equal, if mobility shocks are removed from the economy, there will be less renters in the steady state. Hence, by construction, mobility has a mechanical negative impact on ownership rate, regardless of any other endogenous implication. To assess the relative importance of this effect, I compute new ownership rates by, simply, treating the forced renters (owners being hit by mobility shock) as if they remain owners. Even in this case, the endogenous impact of mobility is still significant and it is slightly more important than the mechanical one.

In the real world, some owners are, indeed, obliged to rent after moving from a city (or a state) to another due to the illiquidity aspect of housing. However, the fraction of these "temporary renters" is certainly less than what it is implied by the model.
largest impact is seen in households aged between 20 and 41: their aggregate ownership rate increases from 42.66% to 61.63%. The intuition is straightforward; mobility rates are higher for young agents. This rise in ownership rates of young agents will be partially transmitted to older generations.\textsuperscript{27} The important rise in ownership rates explains the steep increase in the fraction of constrained house buyers from 1.1% to 37.79%.

Thus, geographic instability is an important reason that may explain why too many young households choose to rent rather than to buy a house.

### 6.2.2 New Calibration Without Mobility: Model II (Figure 8)

In this section, I calibrate a new version of the model without mobility shocks in order to assess the relative importance of geographic instability in matching the data with a high level of accuracy. I also investigate whether or not the downpayment constraint can explain the low ownership rates among young households in an environment without mobility shocks.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Sum of absolute values of errors (Model II Vs Data)</td>
<td>1.41</td>
<td>-</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.92489577</td>
<td>-</td>
</tr>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>26.63%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>42.65%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.36%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>79.75%</td>
<td>80.8%</td>
</tr>
<tr>
<td>$H_o/H_r$</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>4.9</td>
<td>3</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>64.31%</td>
<td>65%</td>
</tr>
<tr>
<td>$r$</td>
<td>Equilibrium interest rate</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>$H/Y$</td>
<td>Ratio of housing to output</td>
<td>1.55</td>
<td>[1.4, 1.55]</td>
</tr>
<tr>
<td>$K/Y$</td>
<td>Ratio of capital to output</td>
<td>2.43</td>
<td>[2, 2.5]</td>
</tr>
</tbody>
</table>

Comparing Figures 4 (a,b) and Figures 9 (a,b), we can conclude that the baseline model is more effective in matching the US ownership rate curve, than model II.

\textsuperscript{27}Long term impact (stationary equilibrium).
Although the difference between the two simulated curves is not that big, except for young households, Model II predicts a owned-rental housing stock ratio $H_o/H_r = 4.9$, which is relatively far from the data, compared to the baseline model (3.9). Hence, the baseline model is also more effective in matching the US housing evidence.

It is worth noting that the calibration process has become extremely difficult. Indeed, I was not able to exactly match the aggregate ownership rate (65%) despite the many attempts I have performed to reach the target.\textsuperscript{28} It seems that the tenure decision has become very sensitive to $\theta$. Apparently, when the ownership premium is too low, the tenure decision becomes more sensitive and less robust. Indeed, in the case of no mobility shocks, I had to increase $\theta$ to a high value close to one in order to get an aggregate ownership rate of around 65%. Intuitively, we can conclude that the fact of ignoring geographic mobility can lead to the underestimation of the ownership premium $(1 - \theta)$.

- **Model II: No downpayment requirement ($\kappa = 0\%$):** (Figure 9)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Model II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>25.43%</td>
<td>26.63%</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>45.33%</td>
<td>42.65%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>75%</td>
<td>74.36%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>84.96%</td>
<td>79.75%</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>67%</td>
<td>64.31%</td>
</tr>
</tbody>
</table>

This experiment consists in setting the downpayment parameter to zero, which means that households are now allowed to borrow up to 100\% of the value of the purchased house. Despite the absence of any financial constraint to buy a house, the aggregate ownership

\textsuperscript{28}With $\theta = 0.92489577$, the aggregate rate is 64.31\% and with $\theta = 0.92489578$, it jumps to 65.8\%. Even when I use a bigger capital grid, the calibration remains extremely difficult.
rate only increases by 2.7%. In particular, the aggregate ownership rate of households aged between 20 and 41 has increased from 42.65% to 45.33%. Hence, I do not find the downpayment constraint to be an important reason for the relatively low ownership among young households.

In conclusion, geographic mobility seems to play a crucial role in explaining the low ownership rate among young agents. Modeling geographic instability is also important to accurately match the US ownership rates’ curve.
6.3 The Downpayment Requirement Impact (Figure 10)

In this section, I perform several counter-factual experiments on the baseline model in order to assess the impact of the downpayment parameter on home-ownership rates.

<table>
<thead>
<tr>
<th>Description</th>
<th>(\kappa = 0%)</th>
<th>(\kappa = 25%)</th>
<th>(\kappa = 50%)</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of financially constrained house buyers</td>
<td>1.69%</td>
<td>11.36%</td>
<td>18.63%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Fraction of liquidity constrained households</td>
<td>27.31%</td>
<td>30.31%</td>
<td>31.2%</td>
<td>29.37%</td>
</tr>
<tr>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>42.7%</td>
<td>42.18%</td>
<td>37.42%</td>
<td>42.66%</td>
</tr>
<tr>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.3%</td>
<td>74.07%</td>
<td>71.51%</td>
<td>74.11%</td>
</tr>
<tr>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>91.82%</td>
<td>79.32%</td>
<td>72.23%</td>
<td>82.40%</td>
</tr>
<tr>
<td>Aggregate ownership rate</td>
<td>67.67%</td>
<td>63.92%</td>
<td>59.26%</td>
<td>65%</td>
</tr>
</tbody>
</table>

The first counter-factual experiment consists in assuming that there is no borrowing constraint faced by households who want to buy a house (\(\kappa = 0\)). Despite this fact, the aggregate ownership rate rises from 65\% to 67.67\% which is a small increase relative to what many would expect. However, recalling Table 2, such a slight increase was predictable since the fraction of financially constrained house buyers in the baseline model was only 1.01\%. In fact, lowering the downpayment requirement was not expected to have a big impact since there was only a very small percentage of borrowing constrained home buyers when the downpayment was 15\%. Moreover, relaxing the downpayment constraint has an effect only on old households. Indeed, ownership rates for young and middle-aged households remain almost unchanged.

When the downpayment constraint becomes tighter (\(\kappa = 25\%\)), ownership rates remain almost unchanged for young and middle-aged households and decrease for old households (from 82.40\% to 79.32\%). However, the fraction of financially constrained house buyers clearly increases from 1.1\% to 11.36\%. In the third experiment, I increase \(\kappa\) to an unrealistically large value of 50\%. As expected, the aggregate ownership rate decreases by around 6\%.
The biggest impact is on old agents, then the young households and finally the middle-aged. To understand the intuition behind all these results, I need to analyze and track the effective downpayment paid by each age cohort. In order to avoid any potential bias that could be caused by home buyers who purchase a house after being subject to mobility shocks (which tends to amplify the average downpayment), I will focus on the minimum downpayment paid by every age group. We should also remember that the ownership curve always peaks before the retirement age. In such cases, the minimum downpayment paid by old households corresponds to the housing purchases made by elderly owners who had experienced a mobility shock during the previous period and were forced to rent. This explains the high minimum downpayments for this category of households.29

According to Figure 11, I can conclude that, for the baseline case, most households before the retirement age optimally choose to pay a downpayment higher than the minimum required. Hence, when \( \kappa \) decreases, these agents are not influenced.

After retirement age, renters, in general, do not invest in housing because of their low income since they receive the same relatively low pension \( P \) for the rest of their lives. Indeed, an old poor renter is not ready to give up a significant quantity of his actual goods consumption in order to become a homeowner, giving his low wealth and his relatively high probability of death. However, when the downpayment constraint is amply relaxed, many old poor renters, who, by construction, do not face any future earning uncertainty are better off borrowing almost all the money needed to buy a house without being obliged to significantly decrease their current consumptions.30 It is worth noting that a poor young or middle-aged household with the same wealth would, however, prefer to stay renter and wait for a good earning shock

---

29 For all the model versions, home purchases made by retired households correspond to the case of owners who experienced a mobility shock and had to rent for a period then buy a new house (except the case where \( \kappa = 0 \)).

30 However, the poorest old renters do not change their tenure status. Indeed, the rental housing is more convenient for an extremely poor retired as he can choose to live in a relatively small house and spend less money compared to the case where he purchases a house given the minimum housing quantity constraint.
to buy a house.

This explains the rise in the old households ownership rates and the decrease in the minimum downpayment paid by this category of households.

For the second experiment, the same intuition is still valid for young and middle-aged households. In fact, households who previously paid a downpayment less than 25% will simply increase their upfront cash to the new minimum required level and won’t change their decisions to become owners. Hence, we can conclude that the housing tenure decision for these two categories of household does not depend much on the downpayment constraint, but rather on risk factors like geographical instability and/or future income risk. For retired households, an increase in the downpayment constraint is equivalent to a decline in the house value. Indeed, retired owners use houses, mainly, as collateral to borrow money in order to smooth their consumptions given their low income. Therefore, when $\kappa$ decreases, the amount that they can borrow also decreases, as well as the period over which they can smooth their consumption before being financially constrained. This explains why some relatively old poor owners sell their houses.

For the last case, the huge increase in $\kappa$ obviously affects ownership rates for all different age categories. However, this impact remains small relatively to the sharp increase in the downpayment requirement.

I can conclude from all these results that the downpayment constraint is not a very important factor affecting a household’s decision to buy a house. Hence, the low ownership rates among young agents in the US is not necessarily related to the downpayment requirement.

\footnote{Tenure decision of any household obviously depends also on his wealth.}
6.4 Earnings Uncertainty Impact

- A lower earnings standard deviation: $\sigma_z$ from 0.6371 to 0.5. (Figure 12)

The last counter-factual experiment consists in decreasing the earnings variance from 0.406 (Baseline model) to 0.25 in order to analyze the impact of a lower income risk on ownership rates.

Table 7: Baseline model ($\sigma_z^2 = 0.25$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>4.05%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>26.94%</td>
<td>29.37%</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>45.83%</td>
<td>42.66%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>82.69%</td>
<td>74.11%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>88.09%</td>
<td>82.40%</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.345</td>
<td>0.404</td>
</tr>
</tbody>
</table>

A decline in the individual earnings variance is equivalent to a decrease in the households income risk. Such a change makes households less reluctant to buy a large asset that is costly to change, relative to a world with higher income risk. In fact, households become less willing to delay switching from renting to owning. The intuition is straightforward: as the earnings variance declines, the utility cost of a negative idiosyncratic income shock decreases. Thus, households tend to buy their first houses at younger ages.

Beside this endogenous impact on the household’s tenure decision, the income variance could also have a direct impact on the aggregate ownership rate. Indeed, the decline of the earnings variance affects the earnings GINI coefficient; as $\sigma_z^2$ decreases, the income inequality decreases as well. However, all else equal, the change in the income distribution does not seem to have a very significant impact on the aggregate ownership rate. In fact, the decrease in the income inequality implies that some categories of households will simply disappear; namely, the extremely rich and the extremely poor households. Being extremely or moderately rich,
should not affect the tenure choice of being homeowner. Similarly, if a very poor household becomes slightly wealthier, it is unlikely that he will change his tenure choice, especially, if we know that most of house buyers were not financially constrained.

The only remaining channel through which the income inequality can affect the aggregate ownership rate is the implied change in the income distribution across households. Actually, there exists an earning productivity cut-off value for each group of households of the same age and holding the same housing and capital stocks, such that any household experiencing a productivity shock higher than this critical value is better off owning than renting a home. The sign of the impact of the earnings’ variance on the proportion of homeowners for a specific households’ group depends on whether the corresponding cut-off value is greater or lower than the earnings shocks average. For the baseline model, these cut-off values are, in most cases, equal or lower than the earnings shocks average (except for very young and relatively poor households groups). Hence, all else equal, a decline in the income inequality is expected to have a small positive impact on the aggregate ownership rate. However, since in this model the continuous earnings process is approximated with a $N_z$ discrete state Markov process, the effect described previously will be certainly underestimated. In order to accurately assess the impact of a change in the income distribution on the aggregate ownership rate, we need to substantially increase $N_z$, which would eventually incur extremely high computational costs. Even in such a case, the net impact of income inequality on ownership might be ambiguous and would depend on the household’s age and wealth.

As one might expect, the aggregate ownership rate increases from 65% to 70.77%. The middle-aged households seem to be the the most influenced by the decline in income risk. In fact, their aggregate ownership rate increases from 74.11% to 82.69%, while the aggregate

\[32\text{In fact, the change in the income distribution will affect the proportion of households with earnings shocks greater than their corresponding cut-off values. For instance, if the cut-off values are lower than the earnings shocks average, all else equal, a decline in the variance of the earnings shocks distribution would increase the proportion of homeowners, and vice-versa.}\]
ownership for young households rises only by around 3%, which explains the relatively small increase in the fraction of financially constrained house buyers. In fact, given the significant negative impact of geographic mobility on young households decisions to become homeowners, only the wealthiest among them choose to buy houses. Hence, it is not at all surprising that the decline in the income risk has not a significant impact on the ownership rates of this category of young households.

Given that the income of retired households is constant, they are not supposed to be affected by the decrease in $\sigma_z$. Thus, the increase in their aggregate ownership rate is simply due to the transmitted rise in ownership rates of younger generations.

I therefore conclude that the low ownership rates among young households is mainly due to their limited financial resources as well as to their high mobility rates. On the other hand, the housing tenure decision for middle-aged households is strongly influenced by future income risk. As for retired households, they do not usually invest in housing; they would rather keep their housing stock constant or decrease it if they have large houses. The only case where they buy houses is when the downpayment constraint is amply relaxed.
6.5 Shift in the Homeownership Curve: 1993 VS 2009

Based on the previous findings, I propose a novel explanation for the long run increase in ownership rates over the last two decades. Contrary to what is commonly believed, the rise of the US aggregate homeownership rate is not necessarily due to mortgage market innovations and the relaxation of downpayment requirements. Instead, it could simply be an implication of the demographic evolution of the US society, most notably, population ageing and the decline in geographic mobility. Empirical evidence on mobility and US population distribution are perfectly in line with this hypothesis. This is demonstrated in Figures 13 and 14 which illustrate mobility rates and population distributions, respectively, for 1993 and 2009. Obviously, there has been a shift in the US population distribution toward older ages; a decline in the proportion of young households and a rise in the proportion of the population that is elderly. More importantly, geographical mobility in the US has significantly declined, especially for young households.

This brings up the following question: To what extent can the US population ageing and the decrease in geographical mobility together, explain the rise in the aggregate ownership rate between 1993 (64.5%) and 2009 (67.4%), given the increase in income risk that has been noticed over the same period? To answer this question, I calibrate a version of the model using 1993’s data on mobility and population distribution, to match an aggregate ownership rate of 64.5% and an earnings GINI coefficient of 0.389, of the same year.\textsuperscript{33} Then, I conduct a counter-factual experiment by using 2009’s data on mobility, population distribution and income risk.

According to the experiment results, the simulated aggregate ownership rate has increased from 64.5% to 66.6%. Hence, the population ageing and the decline in mobility can, together, account for almost 70% of the total increase in the US homeownership rate between

\textsuperscript{33}The population distributions are derived based on the Life Tables for males: US Department of Health and Human Services
1993 ad 2009. Having said this, the geographic mobility seems to be the main reason for the reported rise in homeownerhsip, while the population ageing explains only 25% of this increase.\textsuperscript{34}

Figures 15 and 16 show the simulated and the actual transitions of the ownership distribution, respectively, between 1993 and 2009.\textsuperscript{35} Interestingly, the shapes of the simulated and the actual transitions are very similar. In fact, the rise in ownership rates has been mainly noticed among young and retired households. However, the ownership rates of middle-aged households have remained almost unchanged. Indeed, as mentioned earlier, the tenure decision of middle-aged households is influenced by the income risk more than any other factor including geographical mobility which seems to play the main role in the long run increase of ownership rates in the US over the period 1993-2009. For this category of households, the positive effect of lower mobility rates on homeownerhsip was fully offset by the negative impact of the relatively small increase of the income risk.

\textsuperscript{34}When I use the same age distribution for both calibrations (1993 and 2009), the aggregate ownership rate increases from 64.5\% to 66.7\% instead of 67.1\%, which represents 83\% of the total simulated increase.\textsuperscript{35}Smoothed versions
7 Sensitivity Analysis

In this section, I consider three alternative calibrations of the model in order to check the robustness of the model results to changes in the income process parametrization, the mobility rates calibration and the minimum housing quantity constraint $h$. In the fourth subsection, I study the impact on an increase and a decrease in the housing transaction cost parameter.

7.1 Model III: F-Villaverde and Krueger (2005) income process parametrization (Figure 17)

As I have mentioned, most of previous works on housing have not been very successful in replicating the US ownership curve. In particular, they tend to over-predict the differences in rates between young and older households. I suspect the underestimation of the income risk to be a potential reason behind this common bias. Indeed, we already know that the earnings variance has a significant impact on the ownership curve.

To investigate this hypothesis, I calibrate a new version of the model using exactly the same earnings productivity grid vector and the same transition potability matrix used in F-Villaverde and Kruegers (2005) to approximate the earnings process.

\[
z = [0.57, 0.93, 1.51]
\]

\[
\pi = \begin{pmatrix}
0.75 & 0.24 & 0.01 \\
0.19 & 0.62 & 0.19 \\
0.01 & 0.24 & 0.75 
\end{pmatrix}
\]

The implied standard deviation and persistence of the earnings process are: $\sigma_z \approx 0.38$ and $\rho_z \approx 0.75$. It is clear that this approximation implies a significantly lower income risk
(from 0.637 to 0.38) and less persistent income process (from 0.925 to 0.75). I call the new calibrated version: model III (No mobility shocks).

Table 8: Model III

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>7.48</td>
<td>-</td>
</tr>
<tr>
<td>θ</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.97515</td>
<td>-</td>
</tr>
<tr>
<td>Constr_f</td>
<td>Fraction of financially constrained house buyers</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>Liquid_f</td>
<td>Fraction of liquidity constrained households</td>
<td>12.07%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Ownership_y</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>26.97%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership_m</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>83.76%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership_o</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>90.19%</td>
<td>80.8%</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.293</td>
<td>0.404</td>
</tr>
<tr>
<td>Ho/Hr</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>2.6</td>
<td>3</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>64.85%</td>
<td>65%</td>
</tr>
<tr>
<td>r</td>
<td>Equilibrium interest rate</td>
<td>3.45%</td>
<td>3%</td>
</tr>
<tr>
<td>H/Y</td>
<td>Ratio of housing to output</td>
<td>1.47</td>
<td>[1.4, 1.55]</td>
</tr>
<tr>
<td>K/Y</td>
<td>Ratio of capital to output</td>
<td>2.33</td>
<td>[2, 2.5]</td>
</tr>
</tbody>
</table>

According to Table 8 and Figure 17, we can see that the model III’s performance in replicating data on ownership rates has dramatically deteriorated. Moreover, it underpredicts the fraction of liquidity constrained households, which is, in large part, due to low persistent parameter $\rho_z$.

It is clear that the Model III overpredicts the differences in rates between young and older households. Indeed, the simulated aggregate ownership rate for young agents is significantly less than its empirical counterpart (26.97% vs 44.3%), while the opposite is true for middle-aged and retired households. These observations remind us the results usually reported in the literature. Hence, it is very likely that the underestimation of the earnings variance is the main reason why many models overpredict the differences in ownership rates between age cohorts. Indeed, the GINI coefficient drops from 0.404 (data) to 0.293.

The intuition here is related to the previous result on how income risk effects on ownership.
In fact, we now know that middle-aged households are more influenced by the decrease in income risk than young households. Thus, they will have more incentives to own. Yet, I need to recalibrate $\theta$ in order to match the adjusted aggregate ownership rate (65%). So, the increase of $\theta$ will affect young households more than the others.

7.2 Model IV: Owners mobility rates (Figure 18)

In this subsection, I use the mobility rates of owners instead of the average mobility rates as in the baseline model. As it is shown in Figure 18 and Table 9, the model IV predicts an ownership curve very similar to the baseline case. However, the ratio of the owned housing stock to the rented one ($H_o/H_r$) jumps to 4.5 instead of 3.9 (baseline model), which is relatively far from the data. In fact, given that mobility rates of owners are significantly low, the number of relatively rich homeowners who are forced to rent for a period decreases as well. Therefore, the total rented housing stock goes down since rich owners are those who usually rent important housing quantities.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Error$</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>0.74</td>
<td>-</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.865</td>
<td>-</td>
</tr>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>27.51%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>43.17%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.54%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>81.26%</td>
<td>80.8%</td>
</tr>
<tr>
<td>$H_o/H_r$</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>4.47</td>
<td>3</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>
7.3 Model V: Higher minimum housing quantity constraint $h$ (Figure 19)

As mentioned before, the US housing market is enough flexible with regard to home prices. Indeed, it is possible to buy a house with a very low price. However, it would be interesting to increase the minimum housing quantity constraint $h$ and see if the relaxation of the down-payment constraint would have any significant impact on homeownership, in particular, for young households, as it has been often argued.

Table 10: Model V ($\ h = 2 \times \text{Avg inc}$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>0.84</td>
<td>-</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.54</td>
<td>-</td>
</tr>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>3.78%</td>
<td>-</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>29.59%</td>
<td>20% or more</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>44.88%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>73.75%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>80.26%</td>
<td>80.8%</td>
</tr>
<tr>
<td>$H_o/H_r$</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>4.25</td>
<td>3</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>

According to Table 10 and Figure 19, Model V does a good job in replicating the real US ownership curve. Indeed, the simulated curve is very close to the one implied by the baseline model. Hence, the change in the calibration of $h$ does not have a significant impact on the model ability to predict ownership rates. However, the ratio $H_o/H_r$ rises to 4.25 which is a direct implication of the increase in the minimum housing quantity.
Table 11: Model V (No downpayment requirement)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>$\kappa = 0%$</th>
<th>$\kappa = 15%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Error}$</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>1.09</td>
<td>0.84</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Utility parameter (Renting Vs Owning)</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>$\text{Constr}_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0.14%</td>
<td>3.78%</td>
</tr>
<tr>
<td>$\text{Liquid}_f$</td>
<td>Fraction of liquidity constrained households</td>
<td>25.57%</td>
<td>29.59%</td>
</tr>
<tr>
<td>$\text{Ownership}_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>44.9%</td>
<td>44.88%</td>
</tr>
<tr>
<td>$\text{Ownership}_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>73.66%</td>
<td>73.75%</td>
</tr>
<tr>
<td>$\text{Ownership}_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>82.76%</td>
<td>80.26%</td>
</tr>
<tr>
<td>$H_o/H_r$</td>
<td>Ratio of the owned housing stock to the rented one</td>
<td>5.26</td>
<td>4.25</td>
</tr>
<tr>
<td>$\text{Ownership}$</td>
<td>Aggregate ownership rate</td>
<td>65.75%</td>
<td>65%</td>
</tr>
<tr>
<td>$\text{Gini}$</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>

Similarly to the baseline model, setting the minimum downpayment constraint $\kappa$ to zero does not have a significant impact on housing tenure decision for young and middle-aged households (Figure 20). The relaxation of the downpayment constraint has only an impact on the homeownerhsip of retired households. However, the increase in the aggregate ownership rate of retired households is small relative to the baseline model case. In fact, with a higher $h$ it becomes more difficult for poor retired households to buy houses given the higher interest paid on the borrowed funds.

Thus, even if we increase the minimum housing quantity to a relatively high value, the model results with regard to the downpayment impact do not significantly change.

7.4 Housing Transaction Costs

I consider two extreme cases; zero and high transaction costs. Table 12 reports the corresponding results.

In fact, with no transactions costs, housing investment becomes less risky. Therefore, the aggregate homeownerhsip rate increases from 65% to 71.7%. With a higher transaction cost of 10%, the aggregate ownership rate decreases from 65% to 54.7%. It is interesting to note that the decrease of the aggregate ownership rate is due largely to the drop in the ownership
rates of young households. Indeed, their aggregate rate sharply falls from 42.66% to 18.28%, while the aggregate rates of the other age cohorts remain relatively close to those reported for the baseline model. Hence, we can conclude that young households are the most influenced by the illiquidity costs of housing. In fact, this is mainly due to the fact that mobility rates for young households are very high compared to the rates of other households. As, I already mentioned, one of the costs incurred by geographical mobility is directly related to the housing transaction costs.

Table 12: *Housing transaction costs sensitivity analysis*

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\psi = 5%$</th>
<th>$\psi = 0%$</th>
<th>$\psi = 10%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>0.76</td>
<td>0.76</td>
<td>0.76</td>
</tr>
<tr>
<td>Constr$_f$</td>
<td>1.1%</td>
<td>19.32%</td>
<td>0%</td>
</tr>
<tr>
<td>Liquid$_f$</td>
<td>29.37%</td>
<td>28.79%</td>
<td>29.26%</td>
</tr>
<tr>
<td>Ownership young</td>
<td>42.66%</td>
<td>52.34%</td>
<td>18.28%</td>
</tr>
<tr>
<td>Ownership middle-aged</td>
<td>74.11%</td>
<td>80.67%</td>
<td>71.38%</td>
</tr>
<tr>
<td>Ownership old</td>
<td>82.40%</td>
<td>85.56%</td>
<td>80.82%</td>
</tr>
<tr>
<td>$H_o/H_r$</td>
<td>3.9</td>
<td>5.32</td>
<td>2.25</td>
</tr>
<tr>
<td>Ownership</td>
<td>65%</td>
<td>71.71%</td>
<td>54.67%</td>
</tr>
<tr>
<td>Gini</td>
<td>0.404</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>
8 Endogenous Geographic Mobility

One of the key assumptions of the previous baseline model states that whenever a homeowner is subject to a mobility shock, he has no choice other moving. In fact, he has to sell his house and rent for at least one period. Clearly, this assumption can overstate the impact of mobility on homeownerhsip since mobility shocks will, by construction, have a negative mechanical impact on the aggregate homeownerhsip rate given the unrealistically large number of moving renters\textsuperscript{36}. Moreover, the calibration of the mobility shocks was extremely challenging given the relatively unrealistic mobility shock assumption\textsuperscript{37}.

In this section, I relax the mobility shock assumption in such a way that both owners and renters receive offers to move. A household who has the opportunity to move can deny the offer or accept it. A mover can choose to rent or to own regardless of his initial housing tenure status. I assume that a household receives a moving bonus whenever he accepts the offer and moves. This bonus is implemented as an age-depending utility prime that a household receives only during the first period after his move. It can be interpreted as the actualized total benefits of moving, which could include wage primes, location preference...

The cost of moving consists, simply, in paying the transaction costs that a mover owner would incur when he sells his house before moving ($\phi \ast h$). In the previous baseline model, a homeowner who does not adjust his housing stock does not have to pay any transaction cost since he will be staying in the same house. However, in this new baseline model, a mover homeowner has to pay a transaction cost even he keeps the same housing stock level ($h$) as he has to sell his house before moving to the new location. Hence, renters will never deny the offer to move since they do not incur any moving costs. However, a homeowner can deny

\textsuperscript{36}In reality, the fraction of movers who decide to rent during the first period is relatively lower than what the model implies.

\textsuperscript{37}In baseline model calibration, I simply interpret the mobility shocks as the average mobility rates of owners and renters of the same age.
the offer, or accept it and remain owner, or accept it and become renter.

8.1 New Household’s Problem

Now, the household has to make two decisions if he has the opportunity to move: whether to move or to stay and whether to rent or to own.

The problem of a household of age \( a \) can be written recursively as:

\[
W_a(x) = (1 - m) \ W_a^{Stay}(x) + m \ [\max \{W_a^{Stay}(x), W_a^{Move}(x)\}] 
\]  

(8)

Where:

\[
W_a^{Stay}(x) = \max_{D \in \{0,1\}} \{D \ W_a^{o,s}(x) + (1 - D) \ W_a^{r,s}(x)\} 
\]  

(9)

\[
W_a^{Move}(x) = \max_{D \in \{0,1\}} \{D \ W_a^{o,m}(x) + (1 - D) \ W_a^{r,m}(x)\} 
\]  

(10)

\( W_a \) is the value function of a household of age \( a \) with a state vector \( x = \{k, h, z, m\} \) where the indicator \( m \) takes the value 1 when the household has an offer to move. \( W_a^{Stay} \) is the value function of a stayer and \( W_a^{Move} \) is the value function of a mover. Both mover and stayer have to choose between renting and owning given the value function of each option \((W_a^{o,s}, W_a^{r,s}, W_a^{o,m}, W_a^{r,m})\). If the \( m = 1 \), the household can choose between moving and staying, otherwise he will simply stay. Again, the variable \( D \) is a choice variable that takes the value 1 when the household chooses to be a homeowner and 0 otherwise.

- **Value of being a stayer homeowner:** \( W_a^{o,s} \)

The problem of a stayer homeowner consists of choosing consumption, house size and savings position.
\[ W_{a,s}(x) = \max_{c,k',h'} \left\{ U(c,h') + \beta (1 - \alpha_a) \phi \log(Q_w) \\
+ \beta \alpha_a \sum_{z'} \pi(z' | z) \left\{ (1 - \lambda_{a+1}) W_{a+1}(k', h', z', 0) + \lambda_{a+1} W_{a+1}(k', h', z', 1) \right\} \right\} \]

\[ Q_w = (1 - \delta_h) h' + (1 - \delta_k) k', \]

\[ c + k' + h' + \Lambda(h', h) = y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h) \]

\[ k' \geq -(1 - \kappa)h', \quad c \geq 0 \quad \text{and} \quad h' \geq h \]

where \( \lambda_{a+1} \) is the probability of receiving an offer next period. This is exactly the same homeowner problem in the baseline model set up.

**Value of being a stayer renter**: \( W_{a}^{r,s} \)

The problem of a stayer renter consists of choosing consumption, rental housing services and savings position.

\[ W_{a}^{r,s}(x) = \max_{c,k',s} \left\{ U(c,s) + \beta (1 - \alpha_a) \phi \log(Q_w) \\
+ \beta \alpha_a \sum_{z'} \pi(z' | z) \left\{ (1 - \lambda_{a+1}) W_{a+1}(0, z', 0) + \lambda_{a+1} W_{a+1}(k', 0, z', 1) \right\} \right\} \]

\[ c + k' + p s + \Lambda(0, h) = y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h) \]

\[ k' \geq 0, \quad c \geq 0 \quad \text{and} \quad h' = 0. \]

In this version of the model, a mover, whether he is a renter or an owner, receives
a bonus. Hence, the value function of an actual renter takes into account the future probability of receiving an offer, unlike the baseline model where only owners are concerned about mobility shocks.

• **Value of being a mover homeowner:** $W_{a,m}^{o}$

The problem of a mover homeowner consists of choosing consumption, house size and savings position.

$$
W_{a,m}^{o}(x) = \max_{c,k',h'} \left\{ U(c, h') + \text{Prime}_a + \beta (1 - \alpha_a) \phi \log(Q_w) \\
+ \beta \alpha_a \sum_{z'} \pi(z' | z) \{(1 - \lambda_{a+1}) W_{a+1}(k', h', z', 0) + \lambda_{a+1} W_{a+1}(k', h', z', 1)\}\right\}
$$

$$(13)
$$

$$Q_w = (1 - \delta_h) h' + (1 - \delta_k) k',
$$

$$c + k' + h' + \Lambda(h) = y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h)
$$

$$k' \geq -(1 - \kappa)h', \quad c \geq 0 \quad \text{and} \quad h' \geq h
$$

where $\Lambda(h) = \psi h$, and $\text{Prime}_a$ is the prime or the bonus that a household of age $a$ receives when he accepts the offer and moves. It is calibrated so that the predicted owners’ mobility rates match their empirical counterparts\(^{38}\).

Note that if $h = 0$ or $| h' - h | > 0$, $W_{a,m}^{o}(x) = W_{a,s}^{o}(x) + \text{Prime}_a$, since $\Lambda(h) = \Lambda(h', h)$.

• **Value of being a mover renter:** $W_{a,m}^{r}$

The problem of a mover renter consists of choosing consumption, rental housing services and savings position.

\(^{38}\)see the calibration section for more details
It is obvious that a mover renter will make the same decisions as a stayer renter. In fact, if a stayer finds it optimal to rent, he will definitely choose to move and rent if he receives an offer.

It is worth noting that a household who would optimally choose to rent if he is a stayer (even if he is an actual owner), will definitely move if he receives an offer\(^{39}\). Obviously, renters will always move if they have the opportunity, since \(\Lambda(h) = 0\). The same intuition is valid for an owner who would optimally choose to adjust his housing stock if he does not have the opportunity to move. Such homeowner will definitely accept the offer, if any, and move since he won’t incur any extra housing transaction costs compared to the situation where he denies the offer\(^{40}\).

The only case where the decision of the household on wether to accept or to deny the offer is uncertain is when the household is a homeowner who would optimally choose to remain owner and to keep the same housing stock level, if he has no offer. In this case, the household has three options:

1. Deny the offer and stay.
2. Accept the offer and own.
3. Accept the offer and rent\(^{41}\).

\(^{39}\)because: \(W^{r,m}_a(x) = W^{r,s}_a(x) + \text{Prime}_a\), \(W^{r,m}_a(x) = W^{r,s}_a(x) + \text{Prime}_a\), and \(W^{r,m}_a(x) = W^{r,s}_a(x) + \text{Prime}_a\) for various variables.

\(^{40}\)\(\Lambda(h) = 0\Lambda(h', h) = \phi*h\).

\(^{41}\)In fact, a mover homeowner may find it optimal to move and rent even if an identical stayer homeowner would optimally choose to remain owner.
8.2 Calibration

The moving offer rates are calibrated to match the empirical renter geographic mobility rates. Indeed, in reality, renters would, in most cases, accept the offer to move given their very low moving costs relative to the homeowners. Hence, their empirical geographic mobility rates represent a reasonable proxy for the real offer rates.

*Prime* is calibrated so that the predicted homeowners mobility rates match their empirical counterparts (see Figure 21).

The calibration of the remaining structural parameters is similar to the baseline model parametrization. However, in this version of the model, I have increased $N_z$, the number of Markov process states used to approximate the income process, from 5 to 11 in order to have more accurate results.\(^{42}\)

\(^{42}\)Hence, the income process parametrization should be updated: $\sigma_z = 0.629$, and $\rho_z = 0.95$
8.3 Results

8.3.1 New Baseline Model

Table 13 compares the new baseline model with the data, where the variables in the bottom are obtained by calibration.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Sum of absolute values of errors (Model Vs Data)</td>
<td>0.87</td>
<td>-</td>
</tr>
<tr>
<td>Constr(f)</td>
<td>Fraction of financially constrained house buyers</td>
<td>0.1%</td>
<td>-</td>
</tr>
<tr>
<td>Ownership(y)</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>42.94%</td>
<td>44.3%</td>
</tr>
<tr>
<td>Ownership(m)</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.52%</td>
<td>73.83%</td>
</tr>
<tr>
<td>Ownership(o)</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>81.57%</td>
<td>80.8%</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Gini</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
<tr>
<td>r</td>
<td>Equilibrium interest rate</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Figure 22 compares the home-ownership curve as a function of age predicted by the new baseline model to that implied by the data. According to Table 13 and Figure 22, the new baseline model does a very good job in replicating the life cycle ownership rates even better than the previous baseline model. This is because of the relatively high Markov states number used to approximate the income process (\(N_z = 11\)).

Figure 23 reports the life cycle empirical mobility rates for renters (blue curve) between 2009 and 2010 that are used as proxy for the moving offer rates. It also compares the predicted owners mobility rates (green curve) to their empirical counterpart (red curve).
8.3.2 Mobility Impact

The main motivation for the relaxation of the mobility shock assumption is to have a more accurate and realistic assessment of the impact of geographical mobility on the housing tenure decision over the life cycle. Table 14 reports the results of a version of the model where there is no moving cost. Hence, by construction, any household who receives an offer to move will accept it.

Table 14: New Baseline model without mobility

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constr$_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>31.32%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Ownership$_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>55.26%</td>
<td>42.94%</td>
</tr>
<tr>
<td>Ownership$_m$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>78.96%</td>
<td>74.52%</td>
</tr>
<tr>
<td>Ownership$_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>86.92%</td>
<td>81.57%</td>
</tr>
<tr>
<td>Ownership</td>
<td>Aggregate ownership rate</td>
<td>72.57%</td>
<td>65%</td>
</tr>
</tbody>
</table>

According to Figure 24 and Table 14, we can conclude that the impact of geographic mobility is still significantly important and that the young households are, still, the most influenced age group. However, the magnitude of the geographic mobility impact has decreased compared to previous results, which is not surprising since in this new context, there is no forced renters.

8.3.3 Zero Downpayment

The experiment consists in relaxing the downpayment requirement to $\kappa = 0$ in order to assess the impact of downpayment requirement on the decision of a household to whether buy or rent a house. I would like to investigate to what extent the results, previously reported regarding the downpayment constraint impact on homeownerhsip, are affected by the relaxation of the mobility shocks assumption.
Table 15: *New Baseline model ($\kappa = 0$)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Constr_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0.42%</td>
<td>0.1%</td>
</tr>
<tr>
<td>$Ownership_{yg}$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>42.42%</td>
<td>42.94%</td>
</tr>
<tr>
<td>$Ownership_{ym}$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td>74.24%</td>
<td>74.52%</td>
</tr>
<tr>
<td>$Ownership_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>84.89%</td>
<td>81.57%</td>
</tr>
<tr>
<td>$Ownership_r$</td>
<td>Aggregate ownership rate</td>
<td>65.65%</td>
<td>65%</td>
</tr>
<tr>
<td>$r$</td>
<td>Equilibrium interest rate</td>
<td><strong>3.11%</strong></td>
<td><strong>3%</strong></td>
</tr>
</tbody>
</table>

According to table 15 and Figure 25, the relaxation of the minimum downpayment requirement does not have a significant impact on the life cycle homeownership curve, except for old households. Having said that, the slight increase in homeownership rates for non-retired households is explained by the small increase of the interest rate. Obviously, new old owners would borrow in order to finance their home purchases. The rise of the aggregate borrowing demand implies a higher interest rate, which makes several poor working households more reluctant to take a relatively more costly mortgage loan.

### 8.3.4 Impact of Income Uncertainty

In this counter factual experiment, I decrease the income variance so that the GINI coefficient falls from 0.404 to 0.33 ($\sigma z = 0.47$).

Table 16: *New Baseline model without lower GINI*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Constr_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>8.7%</td>
<td>0.1%</td>
</tr>
<tr>
<td>$Ownership_{yg}$</td>
<td>Aggregate ownership rate for hhs between 20 and 26</td>
<td><strong>17.51%</strong></td>
<td>19.7%</td>
</tr>
<tr>
<td>$Ownership_{y}$</td>
<td>Aggregate ownership rate for hhs between 20 and 41</td>
<td>46.01%</td>
<td>42.94%</td>
</tr>
<tr>
<td>$Ownership_{ym}$</td>
<td>Aggregate ownership rate for hhs between 41 and 60</td>
<td><strong>80.98%</strong></td>
<td>74.52%</td>
</tr>
<tr>
<td>$Ownership_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>86.72%</td>
<td>81.57%</td>
</tr>
<tr>
<td>$Ownership_r$</td>
<td>Aggregate ownership rate</td>
<td><strong>69.84%</strong></td>
<td>65%</td>
</tr>
</tbody>
</table>

As expected the aggregate ownership rate increases by 7.5%, as well as the fraction of
financially constrained house buyers (See Table 16 and Figure 26). Again, the middle-aged households seem to be the the most influenced by the decline in income risk. However, the homeownership rates of very young households have slightly decreased, unlike the baseline model. This new result is not related to the relaxation of the mobility assumption, but rather to the fact of increasing $N_z$ from 5 to 11. Actually, when we significantly increase the number of Markov states, we expect to get a much more accurate approximation of the income process. Hence, the income distributional impact on homeownership is more likely to be noticed, in particular for young households \(^{43}\). In fact, when the income inequality decreases, the fraction of relatively rich young households, who can potentially buy houses, will decrease as well. This negative income distribution effect seems to dominate the positive impact of the decrease of the income uncertainty on homeownership for very young households.

Based on the previous results of the new model, we can conclude that the key results of the first baseline model do not seem to depend much on the assumption made on mobility shocks. Having said, the relaxation of this assumption makes the model more consistent with the reality. Indeed, in this new environment, we can study the impact of the home-ownership status on the decision of moving. Something that we were not able to investigate in the first baseline context.

\(^{43}\)see section 6.4 (page 36)
8.4 Income and Homeowner’s Geographical Mobility

So far, I have only studied the impact of geographic mobility on homeownerhsip. It would be also interesting to investigate the impact of housing tenure status on mobility. Obviously, being a homeowner makes the household more reluctant to move given the relatively high associated costs. In this section, I investigate the impact of income uncertainty (as well as the change in the income distribution) on the relation between homeownerhsip and geographic mobility.

8.4.1 Accept or Deny the Offer?

In order to accurately assess the impact of income on the geographic mobility of homeowners, there is one key issue to consider: What really determines the decision of a homeowner to whether move or not?

It seems that the owner’s income level is the main determinant of the moving decision. In fact, homeowners receiving an offer to move could be sorted into five groups, from poor to richer:\textsuperscript{44}:

1. Very poor homeowners who would sell their houses and return to the rental market even if they get no offer. Such homeowners would definitely accept the offer and rent.

2. Relatively poor homeowners who would keep their housing status unchanged in the case where they receive no offer to move. Yet, because of their relatively low income, they would accept the offer, if any, and then rent. Such homeowners are willing to increase their consumption and decrease their housing spending. In other words, they will prefer to move, get the bonus, rent and may stay renters until they will become wealthier. Hence, the moving offer accelerates the decision of those homeowners to switch from owning to renting.

\textsuperscript{44}Without loss of generality, we assume that these homeowners live in a minimum size house $h$. 

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3. Homeowners who are relatively richer than the previous ones, yet not very rich. These
homeowners are satisfied with their current situation, and they would simply deny the
offer and stay. In fact, given their relatively moderate income, they are not willing to
sacrifice a significant part of their consumption due to the moving transaction costs.
At the same time, these homeowners are not willing to move, rent for period, and then
become a homeowner again, because of the relatively high utility loss associated with
this decision as well as the transaction cost incurred when selling their houses.

4. Moderately rich homeowners who are willing to accept the offer (move) and stay owner.
Indeed, for this category of owners, the bonus received when accepting the offer is
higher than the utility loss related to the current consumption decline due to the
moving costs$^{45}$.

5. Significantly rich homeowners (i.e. the richest homeowners category) who would up-
grade their housing services if they don’t receive any offer. Such homeowners would
certainly be better off accepting the offer and move, since moving has no cost for them,
as they would sell their houses anyway.

It is worth noting that the fraction of homeowners of types 1, 2 and 5 is very small
compared to homeowners of types 3 and 4, who, actually, represent the vast majority of
homeowners receiving offer to move, in particular for young homeowners. Hence, the richer
the homeowner is, the more likely he is going to accept the offer and move.

$^{45}$It is obvious that the consumption is highly correlated with the income level. Hence, as the income level
increases, the marginal utility loss of a consumption decline, decreases.
8.4.2 Impact of Income on Homeowners Mobility

Income can affect the mobility of homeowners through two different channels: a distributional effect that affects the average wealth of homeowners, and an endogenous impact related to the income uncertainty, and more specifically to the owners’ beliefs about their future income shocks.

8.4.3 Income Distribution Effect

The experiment consists in increasing the earnings variance so that the earnings GINI coefficient rises from 0.404 to 0.52.

| Table 17: New Baseline model \((\sigma_z = 0.9)\) |
| --- | --- | --- | --- |
| Variable | Description | Value | Baseline model |
| Constr | Fraction of financially constrained house buyers | 0.0003% | 0.1% |
| Ownershipy | Aggregate ownership rate for hhs between 20 and 41 | 36.86% | 42.94% |
| Ownershipm | Aggregate ownership rate for hhs between 41 and 60 | 65.61% | 74.52% |
| Ownershipo | Aggregate ownership rate for hhs older than 61 | 88.65% | 81.57% |
| Ownership | Aggregate ownership rate | 61.66% | 65% |
| r | Equilibrium interest rate | 2.22% | 3% |

It is not surprising that the aggregate homeownership declines when the income risk increases\(^{46}\). However, according to Figure 27, the magnitude of this decline decreases significantly for retired households. Obviously, retired people are not influenced by income risk since they receive a fixed pension until they die. Moreover, the steep increase in income uncertainty presents a precautionary saving motive, which drives the interest rate down\(^{47}\), (i.e. increase in the savings demand side). This substantial decrease of interest rate makes

\(^{46}\)The decline in homeownership rates has been also noticed among the very young households, which means that the income risk impact on homeownership is more important then the distributional effect. We can conclude that, for relatively high earnings variance, the negative impact of income uncertainty on homeownership of young households dominates the income distribution effect.

\(^{47}\)The equilibrium interest rate \(r\) dramatically falls from 2.22% to 3% (see Table 17).
the home mortgage relatively less costly for retired households, which explains the sharp increase in homeownership rates for very old households.

According to Figure 28, the actual homeowners moving rates have overall increased. Actually, one could think that when the income risk increases, homeowners would be less willing to move. Yet, this would be perfectly true if we do not take into account the implied change in the wealth distribution of homeowners. Firstly, holding everything else constant, as the income risk increases, households, in particular the young people, become more reluctant to buy a house, which means that only the wealthiest among them would decide to become homeowners. Secondly, a larger income distribution implies a significantly higher wealth average for young homeowners. 

Thus, the average income (wealth) of homeowners will significantly go up, in particular for young households, who are now relatively richer compared to the case where income variance is lower. We already know that the richer the homeowner is, the more likely he is willing to accept the offer and move. Hence, a higher income inequality implies higher mobility rates, in particular for young homeowners.

8.4.4 Income Shock Persistence Effect

The beliefs of the households about their future income depend strongly on the earnings shock persistent parameter $\rho_z$. In fact, holding the earnings unconditional variance fixed ($\sigma_z^2$), a higher $\rho_z$ implies a less near future income uncertainty for the the households since their future income states will be much more correlated with their current states\footnote{It is true that when we increase the earnings persistence parameter and we hold the unconditional income variance constant, households become less uncertain about their near future income. However, in aggregate terms, a higher income persistence implies a larger income distribution and, hence, a higher income inequality.}, and vice versa. In what follows, I decrease the earnings shock persistent parameter $\rho_z$ from 0.95 to 0.88.
8.4.4.1 Impact on Homeownerhsip  As the unconditional income variance is held constant (i.e. same earnings GINI coefficient), we expect that the impact of changing the earnings shock persistence on the household’s housing tenure decision would exclusively depend on his current income, and consequently on his age.

Table 18: New Baseline model ($\rho_z = 0.88$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
<th>Baseline model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Constr_f$</td>
<td>Fraction of financially constrained house buyers</td>
<td>0%</td>
<td>0.1%</td>
</tr>
<tr>
<td>$Ownership_y$</td>
<td>Aggregate ownership rate for hhs between 20 and 31</td>
<td>25.42%</td>
<td>29.07%</td>
</tr>
<tr>
<td>$Ownership_m$</td>
<td>Aggregate ownership rate for hhs between 31 and 60</td>
<td>76.45%</td>
<td>68.52%</td>
</tr>
<tr>
<td>$Ownership_o$</td>
<td>Aggregate ownership rate for hhs older than 61</td>
<td>90.23%</td>
<td>81.57%</td>
</tr>
<tr>
<td>$Ownership$</td>
<td>Aggregate ownership rate</td>
<td>71%</td>
<td>65%</td>
</tr>
<tr>
<td>$r$</td>
<td>Equilibrium interest rate</td>
<td>2.85%</td>
<td>3%</td>
</tr>
<tr>
<td>$Gini$</td>
<td>Earnings GINI coefficient</td>
<td>0.404</td>
<td>0.404</td>
</tr>
</tbody>
</table>

According to Table 18 and Figure 29, the homeownerhsip rates of very young households (aged between 20 and 31 years old) have slightly decreased. It is true that this decline is relatively small, yet, it is quite significant. To understand this result, we should remember that young homeowners are exclusively the richest people of their age groups. As $\rho_z$ decreases, some moderately rich young households, who, previously, were willing to buy a house, are now more concerned about their future income given the lower income persistence. Indeed, future negative income shocks are more likely to occur for those households. Thus, it is not surprising that a significant number of these moderately rich young households become more reluctant to buy houses.

For older households, the story is different. Usually, households who reach relatively old ages without being homeowners are believed to be relatively poor. Hence, those who would buy their first homes are more likely to be not very wealthy. Thus, as $\rho_z$ decreases, those people are more likely to receive positive income shocks in the future. Hence, they
become less reluctant to buy a house, which explains the steep rise in the homeownership rates among these categories of households.

8.4.4.2 Impact on Homeowners Mobility As I already showed, a less persistent income shocks process makes young homeowners more concerned about their future income, which explains the important decline in their mobility rates (See Figure 30). Indeed, young homeowners become less willing to accept offers and move.

For older households, the impact of a higher income persistence on their mobility rates can be ambiguous. In fact, for these age groups, homeowners are more heterogenous in terms of income and wealth levels. Thus, the impact of a lower $\rho_z$ would depend on the income class to which the homeowner belongs. Indeed, rich homeowners mobility will decrease, while the mobility of poor homeowners will go up. Overall, the magnitude of the decline in owners mobility decreases as we move along the mobility life cycle curve.
9 Concluding Remarks

In this paper, I study the housing tenure decision in the context of a life cycle model. The simulated life cycle ownership curve is very realistic and close to data. One of the most important key elements of this quantitative success is the accurate parametrization of the earnings process (earnings GINI coefficient). Indeed, I believe that the underestimation of the income variance is the main reason why most of previous housing works overpredict differences in rates between households age groups. According to my results, the relatively low ownership rate of young households is mainly explained by their high geographic mobility. Downpayment constraints have minor quantitative implications on ownership rates, except for retired households. Having said this, the short term impact of downpayment on housing dynamics is still an open question. I also find that idiosyncratic earnings uncertainty has a significant impact on ownership rates. In particular, middle-aged households are the most influenced by changes in income risk.

I was also able to propose an explanation for the long term increase in ownership rates observed over the period 1993-2009. According to the model’s results, this was not necessarily due to the mortgage market innovations and the relaxation of the downpayment requirements that have characterized the US housing market during the same period. Instead, it was simply an implication of the US demographic evolution, most notably the decline in interstate migration and, less importantly, the population ageing. This hypothesis is empirically confirmed. In fact, the model is able to account for the actual rise in aggregate ownership rate and to accurately replicate the transition pattern of the ownership distribution between 1993 and 2009 with a high degree of accuracy.

I have also showed that the assumption made on mobility shocks does not have a significant impact on the key results of the model. In fact, when I relax this assumption, the results do not change much. Finally, I showed that an increase in the income inequality could have a
positive distributional effect on the geographic mobility of homeowners, given the low moving costs of the very poor and rich owners.

An interesting extension to this model is to allow households to default on their mortgage loans. The fact that the impact of the relaxation of the downpayment requirement on the homeownerhsip is not significant, does not necessary mean that it won’t have an effect on the default rate.
Figure 4: Ownership rate: Model (Baseline Calibration) Vs Data
Figure 5: A Typical Life-cycle Profile
Figure 6: A Typical Life-cycle Profile: A rich household
Figure 7: Ownership rate: Model (Without Mobility) Vs Baseline
Figure 8: Ownership rate: Model II (Calibration without mobility) Vs Data
Figure 9: Ownership rate: Model II (Zero downpayment) Vs Model II
Figure 10: Downpayment impact: \( \kappa = \{0\%, 15\%, 25\%, 50\%\} \)
Figure 11: Minimum Downpayment as function of age: $\kappa = \{0\%, 15\%, 25\%, 50\%\}$
Figure 12: Ownership rate: Baseline Model with Lower Earnings Variance Vs Baseline Model
Figure 13: Age Distribution: 1993 VS 2009

Figure 14: Mobility Rates: 1993 VS 2009

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Figure 15: Ownership distributions of 1993 and 2009: Actual data

Figure 16: Ownership distributions of 1993 and 2009: Model predictions
Figure 17: Model III (New calibration: Lower earnings variance and less persistent process) Vs Data
Figure 18: Model IV (New calibration: Owner Mobility Rates) Vs Data
Figure 19: Model V (New calibration: $\underline{h} = 2 \times \text{Avg inc}$) Vs Data
Figure 20: Model V (Zero downpayment) Vs Model V
Figure 21: Calibration of the Moving Prime as Function of Age
Figure 22: Life Cycle Homeownership Curve (New Baseline Model)

Figure 23: Mobility Rates
Figure 24: Ownership Rates: Model (Without Moving Cost) Vs New Baseline Model

Figure 25: Ownership Rates: New Baseline Model with Zero Downpayment ($\kappa = 0$) Vs New Baseline Model
Figure 26: Ownership Rates: Baseline Model with Lower Earnings Variance Vs Baseline Model
Figure 27: Life Cycle Homeownerhsip Curve: New Baseline Model VS New Baseline Model with Higher Income Variance

Figure 28: Mobility Rates: New Baseline Model New Baseline Model with Higher Income Variance
Figure 29: Life Cycle Homeownership Curve: New Baseline Model VS New Baseline Model with Lower Income Persistence

Figure 30: Mobility Rates: New Baseline Model New Baseline Model with Lower Income Persistence
A Computation

I compute the stationary equilibrium of the model using a standard computational method of solving overlapping generations models. However, I proceed with a new method on how to define the capital grid that allows households to borrow up to the limit \(((1 - \kappa)h')\) when buying a house, without being forced to use a huge grid.

A.1 State space discretization

I discretize the state space for housing stocks, asset holdings, productivity shocks and mobility shocks: \(S = \{h, h_1,...,\bar{h}\} \times \{k, k_1,...,\bar{k}\} \times \{z_1,...,z_5\} \times \{1, 2,...,100\} \times \{0, 1\}\). Hence, the total number of the state space is: \(N_h \times N_k \times N_z \times T \times 2\). I should be careful when choosing the grids, because I can easily end up with an extremely high dimensional problem that could require weeks to be numerically solved (or even more). At the same time, using small grids has its own cost in term of results accuracy.

- The upper bounds on grids, \(\bar{h}\) and \(\bar{k}\), are chosen large enough so that when I increase one or both of them, the policy functions remain unchanged.
- The number of grid points are as follows: 5 values of the idiosyncratic shock, 8 points for the housing stock and 193 points for the asset holdings.
- I use a "new" method to build the capital grid (negative part) that allows to model agents to borrow up to the limit \(((1 - \kappa)h)\) when buying a house, without being forced to use a huge grid. In fact, grid steps depend on the downpayment parameter \((\kappa)\) and the minimum housing quantity \((\bar{h})\).

A.2 Algorithm

I solve the steady state equilibrium as follows:
1. Guess the interest rate $r$ and the accidental bequest transfers $B_k$ and $B_h$.

2. Compute house rental price $p$, capital rental price $q$ and wage $w$.

3. Compute aggregate labor and capital demands, average income, output, pension and tax transfers.

4. Given $W_T(.) = 0$, I solve the household’s problem by backward induction. I start first by solving the optimal policy functions $k'$, $c$ and $h'$, for each of the points of the grid, for renter’s and the owner’s problems\footnote{For $m = 1$, I only solve the renter’s problem.}. Then, based on $W^o_a$ and $W^r_a$, I derive the housing tenure policy function $D$.

- I exploit the additively separable logarithmic preferences to simplify the renter’s problem. In fact, I can derive the consumption directly from the budget constraint:

$$c = \frac{y_a + (1 + r)(k + B_k) + (1 - \delta_h)(h + B_h) - k' - \Lambda(0, h)}{1 + \chi}$$

- The tenant per-period utility function simplifies to:

$$U(k) = (1 + \chi)\log(c) + \chi \log \left( \frac{\theta \chi}{\theta p} \right)$$

- I exploit the strictly concavity of the value function in $k'$ for the renter’s problem and in $k'$ for a given housing choice $h'$, for the owner’s problem.

- I also exploit the monotonicity of the the policy function function $k'$ in $k$ for the renter’s problem.
5. Given the transition probabilities $\pi(z'|z)$ and the age dependent mobility probabilities $\{\lambda_a\}_{a=1}^{a=T}$, I proceed with the same optimization routine described in step 4, for T-1.

6. I repeat step 5 until the first period.

7. I compute the stationary distribution $\Phi$ given the policy functions and the transitions probabilities (productivity and mobility shocks) by forward induction starting from the first period. Since my model is an overlapping generations model where the total number of population is constant, I only need the initial distribution of capital and housing for the first generation (age = 1), to compute $\Phi$.

8. I compute the aggregate supplies: $Y$, $K'$ and $H'$ and verify the market clearing conditions. If all markets clear, the equilibrium is solved, otherwise, I update $r$, $B_k$ and $B_h$ and I go back to step 1.
References


