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The loan structure and housing tenure decisions in an equilibrium model of mortgage choice

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Mortgage Contracts and Housing Tenure Decisions*

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Abstract

In this paper, we analyze various mortgage contracts and their implications for housing tenure and investment decisions using a model with heterogeneous consumers and liquidity constraints. We find that different types of mortgage contracts influence these decisions through three dimensions: the downpayment constraint, the payment schedule, and the amortization schedule. Contracts with lower downpayment requirements allow younger and lower income households to enter the housing market earlier. Mortgage contracts with increasing payment schedules increase the participation of first-time buyers, but can generate lower homeownership later in the life cycle. We find that adjusting the amortization schedule of a contract can be important. Mortgage contracts which allow the quick accumulation of home equity increase homeownership across the entire life cycle

Keywords: Housing finance, first-time buyers, life-cycle.

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1. Introduction

The home ownership rate, and the housing tenure decision have changed drastically in the United States. In the last century, the United States has gone from being a country of renters with a 44 percent homeownership rate to a country of homeowners with a homeownership rate of 68 percent. Over the same period, the size of the average home has also grown to almost 2,000 square feet. The expansion in homeownership and the growth in housing size during the postwar period is a result of the so-called "American Dream." A major factor, as documented in Chambers, Garriga, and Schlagenhauf (2005) is innovations in the home financing market. Specifically, mortgage contracts have evolved from being short duration with low loan-to-value ratios, to longer duration, with higher loan-to-value ratios. Increasing the homeownership rate continues to be a policy goal.

This paper explores the implications of innovations in home financing for the investment in owner occupied housing. We investigate the wealth-portfolio implications of these financial innovations, as well as the ramifications for the tenure decision. (i.e. renting vs. owning), and the duration decision, (i.e. frequency of changing the housing investment decision). Our investigation examines a variety of mortgage contracts using a quantitative equilibrium model with heterogeneous consumers and liquidity constraints.[1] Our model is in the tradition of the theoretical construct developed by Henderson and Ioannides (1983) and has the following features: homeownership is part of the household's portfolio decision; life-cycle effects play a prominent role; rental and ownership markets coexist; and households make the discrete choice of whether to own, rent, or lease.

The model economy is an overlapping generation framework were individuals face uninsurable labor income uncertainty. Households make decisions with respect to the consumption of goods, the consumption of housing services, and saving which can be in the form of either (real) capital and/or housing. Hence, the model stresses the dual role of housing as a consumption and investment good. Investment in housing differs from real capital in that a mortgage contract is employed, and changes in the housing investment position result in transaction costs. These latter costs are associated with the adjustment of the housing position and result in the infrequent changing of housing investment positions. We employ standard techniques to solve our heterogeneous agent economy.

[1] Some of the other research that examines housing in a general equilibrium setting are Berkover and Fullerton (1992), Díaz and Luengo-Prado (2002), Fernández-Villaverde and Krueger (2002), Gervais (2002), Nakajima(2003), and Platania and Schlagenhauf (2002).

We find that different types of mortgage contracts influence housing decisions through three dimensions: the downpayment constraint, the payment schedule, and the amortization schedule. Downpayment constraints are a major factor in the determination of entry into the housing market. Contracts with lower downpayment requirements, such as the combo-loan product allow younger households who tend to have small asset positions and low income to enter the housing market earlier. If the goal of policymakers is to increase homeownership of young, first time buyers, then programs must reduce the initial burden of buying a home.

A second factor that influences housing decisions is the payment schedule. Currently, most mortgages exhibit a constant payment schedule. However, payment schedules can be either increasing or decreasing. Mortgage contracts such as balloon or growing payment contracts exhibit growing mortgage payments over the life of the loan, while constant amortization contracts exhibit decreasing schedules. Quantitatively, the lower the initial payment, the higher will be the homeownership rate across younger households. However, there is a cost associated with a graduated payment schedule. The end of these contracts will exhibit payments which are higher than the standard fixed payment mortgage. As a result, these contracts can generate lower homeownership later in the life cycle. For instance, our results show that a balloon mortgage will cause a fall in homeownership across the bottom 40 percent of the income distribution. Thus, while this type of contract may spur homeownership among the young, older households with low income may not be able to afford the large back end mortgage payments and be forced to exit the homeownership state. We find that the graduated payment mortgages that we examine actually reduce the aggregate homeownership rate.

Third, we find that adjusting the amortization schedule of a contract can also be an important tool for increasing homeownership. Mortgage contracts which quickly accumulate equity or keep a relatively low loan-to-value ratio, such as a constant amortization loan, seem to increase homeownership across the entire life cycle. This equity effect is driven by the fact that housing is an investment good. Households with housing equity can more effectively smooth away risk than households that rely solely on capital assets. Our findings suggest that this equity effect is quite large. Even in an environment without housing capital gains, we find that this type of mortgage increases the aggregate homeownership rate by three basis points. If U.S. policy is striving for a relatively large increase in aggregate homeownership, mortgage contracts should be written in such a way that the investment role of housing is brought forward.

Beyond policy implications, this paper fills a few important gaps in the modeling of the housing market. First, we employ a model which explicitly models mortgage contracts which last for several periods over a life cycle. The fact that houses are typically purchased through long duration mortgages is often avoided in other life-cycle models with housing. These long duration loans will have an effect on households ability to accumulate capital assets. Second, we implement an endogenous rental market where supply and demand is completely driven by household decisions. As a result, we find that our model matches several features of the housing market including: the rate of homeownership, the average house and apartment size, and the age distribution of landlords just to name a few. Thus, we have a developed a model that can be used to address several additional questions about housing.

This paper is organized into five sections. In the first section, we describe the properties of different mortgage contracts. In the second section, we describe the model economy and define equilibrium. The third section discusses the estimation of the model to the US economy. The next section analyzes the performance of the model with a standard mortgage contract, while the final section examines the implications of alternative mortgage contracts.

2. Mortgage Contracts

A mortgage contract is a debt instrument which uses the dwelling unit to collateralize the loan. A variety of mortgage products exist in the marketplace. Even though a number of mortgage contracts are available, these products actually vary in terms of only three dimensions: the amortization schedule, the payment schedule, and the length of maturity.[2]

[2] It is important to note that in an environment with complete markets all mortgage contracts would be equivalent. In our framework with incomplete market, different mortgage types can have different implications.

In Table 1, we present types of primary mortgage contracts used in the U.S economy.

Table 1: Types of Primary Mortgage Contracts

(share of total contracts)

Type of Contract	1993	1999	2003
Fixed Payment(standard)	0.84	0.91	0.93
Adjustable rate mortgage(ARM)	0.11	0.06	0.04
Adjustable term mortgage	0.00	0.01	0.00
Graduated payment mortgage	0.01	0.01	0.01
Balloon	0.01	0.01	0.01
Other	0.02	0.00	0.00
Combination of the above	0.01	0.01	0.01
Sample Size	33,367	34,747	39,038

Source: American Housing Survey (AHS)

To characterize the different mortgage contracts, it is useful to introduce some notation. The decision to purchase a house of size h and price p requires a downpayment equal to ψ percent of the value of the house. Consequently, households need take on debt equal to $D_0 = (1-\psi)ph$. Let r^m be the interest rate of a mortgage contract with maturity length N. At each period, t, a household faces a mortgage payment that depends on the price of housing, the housing size, length of mortgage, downpayment fraction, the mortgage interest rate, as well as the type of mortgage contract. We denote the mortgage payment at time t as being determined by the function $m_t(x)$ where x is defined by the set (p, h, ψ, N, r^m). This payment can be decomposed into an amortization term, A_t, that depends on the amortization schedule and an interest term I_t which depends on the payment schedule. That is,

$$m_t(x) = A_t + I_t, \qquad \forall t, \tag{2.1}$$

where the interest payments are calculated by $I_t = r^m D_t$. The law of motion for the level of housing debt D_t can be written as,

$$D_{t+1} = D_t - A_t, \qquad \forall t. \tag{2.2}$$

If we rearranging terms, equation (2) becomes

$$D_{t+1} = (1 + r^m)D_t - m_t(x), \qquad \forall t. \tag{2.3}$$

The law of motion for the level of home equity with respect to the loan H_t is

$$H_{t+1} = H_t + A_t, \qquad \forall t, \tag{2.4}$$

where $H_0 = 0$ denotes the home equity in the initial period.

We consider a variety of mortgage contracts which differ in their amortization and payment schedule. More precisely, we will consider a contract with constant amortization; a balloon payment loan; a combo-loan with a financed downpayment; and a contract with payments that grow either arithmetically or geometrically. Each of these contracts are just special cases of the generalized contract we have discussed.

2.1. Mortgage with constant payments

This mortgage contract is the standard contract in the U.S., and is characterized by a constant mortgage payment over the length of the mortgage. The constant mortgage payment results in an increasing amortization schedule of the principal, and a decreasing schedule for interest payments. That is, the constant payment schedule is equal to

$$m_t(x) = A_t + I_t,$$

and satisfies

$$m_t(x) = \lambda D_0.$$

where $\lambda = r^m[1 - (1 + r^m)^{-N}]^{-1}$. The contract front loads the interest rate payments and back loads the principle payments where

$$A_t = \lambda D_0 - r^m D_t.$$

The laws of motion for debt and home equity are

$$D_{t+1} = (1 + r^m)D_t - m_t(x), \qquad \forall t, \tag{2.5}$$

and

$$H_{t+1} = H_t + \left[\lambda D_0 - r^m D_t\right], \qquad \forall t, \tag{2.6}$$

2.2. Combo loan

In the late 1990's a new mortgage product became popular as way to avoid large downpayment requirements and mortgage insurance.[3] This product is known as the combo loan and amounts to having two different loans. The first covers the standard loan $D_1 = (1-\psi)ph$, with mortgage payments $m_t^1(x)$, and maturity N_1. The second loan partially or fully covers the downpayment amount $D_2 = \varkappa\psi ph$,where $\varkappa \in (0,1]$ and represents the fraction of downpayment financed by the second loan). The second loan has an interest premium $r_2^m = r_1^m + \zeta$ (where $\zeta > 0$), a mortgage payment $m_t^2(x)$, and a maturity $N_2 \leq N_1$. [4] In this case

$$\begin{aligned} m_t(x) &= m_t^1(x) + m_t^2(x) \\ &= (A_{1t} + I_{1t}) + (A_{2t} + I_{2t}), \end{aligned}$$

the laws of motion for both loans, and home equity are computed as in the mortgage with constant repayment.

2.3. Mortgage with constant amortization

An alternative mortgage contract assumes a constant amortization term $A_t = A_{t+1} = A$, with an interest payment schedule that depends on the size of outstanding level of debt D_t and the length of the loan N. The constant amortization terms is calculated as

$$A = \frac{D_0}{N} = \frac{(1-\psi)ph}{N}.$$

Under this contract mortgage payments decrease over time. The mortgage payment is

$$m_t(x) = \frac{D_0}{N} + r^m D_t,$$

while the law of motion for the outstanding level of debt and home equity are

$$D_{t+1} = D_t - \frac{D_0}{N}, \qquad \forall t,$$

[3] Government sponsored mortgage agencies initiated the use of this product in the late 1990's and this product became popular in private mortgage markets between 2001 and 2002.

[4] The combo-loan has been used to reduce the downpayment requirement while avoiding mortgage insurance. The "80-20" combo loan program corresponds to the traditional loan-to-value rate of 80 percent using a second loan for the 20 percent downpayment. The "80-15-5" mortgage product requires a 5 percent downpayment provided by the home purchaser with the remaining 15 percent coming from a second loan.

and

$$H_{t+1} = H_t + \frac{D_0}{N}, \qquad \forall t.$$

equivalent to a standard mortgage with constant payment.

2.4. Balloon loans

A balloon loan is a very simple mortgage contract where all the principal borrowed is paid in the last, N. This product is popular in times where mortgage rates are high and home buyers anticipate lower future mortgage rates. In addition, homeowners who expect to stay in their home for a short duration may find this attractive since they will never be paying the principal. The amortization schedule can be written as:

$$A_t = \begin{cases} 0 & \forall t < N \\ (1-\psi)ph & t = N \end{cases}$$

All the mortgage payments, except the last one, reflect interest rate payments $I_t = r^m(x)D_0$. The mortgage payment for this contract is:

$$m_t(x) = \begin{cases} I_t & \forall t < N \\ (1+r^m)D_0 & t = N \end{cases}$$

where $D_0 = (1-\psi)ph$. The evolution of the outstanding level of debt can be written as

$$D_{t+1} = \begin{cases} D_t, & \forall t < N \\ 0, & t = N. \end{cases}$$

2.5. Mortgage contract with growing payments

In an environment with high housing prices, another product that may help first time buyers is the graduated payment mortgage (GPM) where mortgage payments grow over time. This product could be attractive to first time buyers as mortgage payments are initially lower than payments in a standard contract. In addition. payments increase over time as does income which makes the house affordable in that housing expenses are stable. Of course, this product increases the lender's risk exposure because the borrower builds equity in the home at a slower rate than the standard contract which may explain the lack of popularity of this product.[5] The repayment schedule depends on the growth

[5] In 1974 Congress authorized an experimental FHA insurance program for GPM's. In this program, negative amoritization was permitted, but required higher downpayments so that the outstanding princi-

rate of these payments. We consider two different cases.

1. **Geometric Growth:** In this type of contract mortgage payments evolve according to a constant geometric growth rate given by

$$m_{t+1}(x) = (1+g)m_t(x)$$

where $g > 0$. Consequently, the amortization term and interest payments are also growing. Formally,

$$m_t(x) = A_t + I_t,$$

with the initial mortgage payments being,

$$m_0(x) = \lambda_g D_0,$$

where $\lambda_g = (r^m - g)[1-(1+r^m)^{-N}]^{-1}$. The law of motion for the level of debt satisfies

$$D_{t+1} = (1+r^m)D_t - (1+g)^t m_0(x),$$

and the amortization term is $A_t = \lambda_g D_0 - r^m D_t$.

2. **Arithmetic Growth:** In this case, the mortgage payment grows at a constant nominal amount $\triangle = m_1(x) - m_0(x)$. The law of motion for the repayment schedule is

$$m_{t+1}(x) = m_0(x) + t \times \triangle,$$

The initial payment is calculated as usual, and is given by

$$m_0(x) = \frac{[D_0 + \frac{\triangle N}{r^m}]r^m}{[1-(1+r^m)^{-N}]} - \triangle(\frac{1}{r^m} + N).$$

The law of motion for the outstanding debt is

$$D_{t+1} = (1+r^m)D_t - (m_0(x) + t \times \triangle).$$

In this case the amortization term is $A_t = (m_0(x) + t \times \triangle) - r^m D_t$.

pal balance would never be greater during the life of the mortgage than would be permitted for a standard mortgage insured by FHA. Activity under this program and successor programs has been limited.

3. The Model

The model economy is comprised of households, a representative firm, a financial intermediary and a government sector. The household sector is populated by overlapping generations of *ex ante* identical households who live a finite period, J, with certainty. The share of age-j households is denoted by $\mu_j > 0$ where $\sum_{j=1}^{J} \mu_j = 1$.

3.1. Households

In this economy, households have access to two assets to smooth out income uncertainty. Households can invest in a riskless financial asset we will call capital and denote by $a' \in \mathcal{A}$ with a net return r, and/or in a housing durable good denoted by $h' \in \mathcal{H}$ with a market price p. The prime is used to denote future variables. The housing asset generates shelter services according to the linear technology function $s = g(h') = h'$. Shelter services can be acquired in a rental market at the rental price, R, per unit of shelter.

Household preferences are given by the expected value of a discounted sum of momentary utility functions:

$$E \sum_{j=1}^{J} \beta^{j-1} \frac{\left[c_j^{\gamma} s_j^{1-\gamma}\right]^{1-\sigma} - 1}{1-\sigma}, \tag{3.1}$$

where β is the discount factor, c_j is the consumption of goods at age j, and s_j is the consumption of housing shelter services at age j. The utility function parameters are represented by σ, the curvature coefficient, and γ, the consumption share of non-durable goods.

Household income during working years, $j < j^*$, depends on a number of factors and stochastic. Basic wage income is denote by w. In addition, households earnings depend on age. This factor is denoted as v_j and introduces a life-cycle earnings pattern. The remaining factor is the idiosyncratic or stochastic factor, $\epsilon \in \mathcal{E}$ which is drawn from a probability space, and evolves according to the transition law $\Pi_{\epsilon,\epsilon'}$. After tax labor income is denoted by $(1-\tau_p)w\epsilon v_j$, were τ_p represents a tax used to fund an old age transfer. During the retirement years, $j \geq j^*$, a household receives a retirement benefit from the government equal to θ. The household's sequential budget constraint depends on the exogenous labor income and wealth $(1+r)a$, where r denotes the net interest rate and a is the current asset position. Formally we denote the period income by

$$y(\epsilon, j, w, a) = \begin{cases} (1-\tau_p)w\epsilon v_j + (1+r)a, & if \quad j < j^*, \\ \theta + (1+r)a, & if \quad j \geq j^*. \end{cases} \tag{3.2}$$

Given the income level $y(\epsilon, j, w, a)$, the current housing position h, and the number of periods remaining in the mortgage contract, n, a household chooses consumption, c, housing services to consume, s, tomorrow's asset position a', and housing position h'.

We assume away all mortality risk which rules out the existence of annuity markets. Consequently, a household only needs to self insure against income uncertainty. We also assume that households face a borrowing constraint. Finally, we assume that households are born with initial wealth dependent on their initial income level.

We can think of the household as being in one of five situations with respect to today's and tomorrow's housing investment position.

1. **Renter today** $(h = 0)$ **and renter tomorrow** $(h' = 0)$

   Consider a household that does not enter the current period with a house, $h = 0$, and decides not to buy a house in the current period, $h^{'} = 0$. In other words, the individual decides to remain a renter. The implied budget constraint is

   $$c + a' + Rs = y(\epsilon, j, w, a), \tag{3.3}$$

   where Rs denote the cost of housing services purchased in the rental market. Their is no restriction on the size of housing services rented.

2. **Renter today** $(h = 0)$ **and homeowner tomorrow** $(h' > 0)$

   In this case, we have a household who rents, $h = 0$, but decides to take a positive position in housing, $h^{'} > 0$. The purchase of a house requires a downpayment $\psi \in (0, 1)$, as well as the payment of some transaction costs $\phi_B \in (0, 1)$. Hence, households must make an initial investment $(\psi + \phi_B)ph'$ to enter in the housing market. The rest of the house is financed with a mortgage contract that requires a mortgage payment each period denoted as $m(p, h, \psi, N, r^m)$ for a total of N periods. The decision to take an investment position in housing gives the household another source of income if part of the housing services from their investment are leased to other households. This possibility is represented by the term $R(g(h') - s)$ where the housing investment generates $g(h')$ services.[6] Owning a house also generates a maintenance expense which is complicated by the option of renting housing services

[6] This formulation imples that a household that leases property uses a mortgage with a downpayment of ψ percent of the value of the property. Although this may seem to be an unrealistic assumption, the POMS Survey reports that 81.1 percent of rental property owners used some sort of mortgage financing in financing the acquisition of rental property.

to other households. Maintenance expenses depend on h' and the amount of home utilized by the homeowner h_c, and is summarize by a function $x(h', h_c)$[7]. The budget constraint for this case is:

$$c+a'+(\phi_B+\psi)ph'+m(p,h,\psi,N,r^m)+x(h',h_c) = y(\epsilon,j,w,a)+R(g(h')-s). \quad (3.4)$$

3. **Homeowner today** $(h > 0)$ **and renter tomorrow** $(h' = 0)$

   A third case has the household entering a period with a positive housing investment position, $h > 0$, and deciding to sell off their entire investment position and renting housing services, $h' = 0$. [8] The budget constraint for this situation is:

$$c + a' + Rs = y(\epsilon, j, w, a) + [(1 - \phi_S)ph - D_n]. \quad (3.5)$$

   The budget constraint indicates two important features of the housing investment position. First, if the initial housing position is sold, the individual must rent housing services equal to Rs. Second, the sale of the house generates income, ph, minus any selling costs, ϕ_S, and remaining principle which we denote as D_n.[9]

4. **Homeowner today** $(h > 0)$ **and homeowner tomorrow** $(h' > 0)$

   The last two cases deal with a household that enters the period with a housing investment position, $h > 0$, and decides to continue to have a housing investment position, $h' > 0$. The critical issue is whether the household decides to change their housing position.

[7] There is an implicit moral hazard problem in renting housing services to other households - renters decide on how intensely to utilize a house, but may not actually pay the resulting costs. In order to calculate the appropriate amount of maintence investment, the amount of housing that is subject to owner depreciation, δ_O, and the amount of housing that is subject to renter depreciation, δ_R, must be known. Let $h_c(s)$ correspond to the amount of housing required so that housing services of s can be generated. If this amount is equal or exceeds the anount of services generated by h', the depreciation costs are determined by the depreciation rate δ_O. If the household decides to consume less than the amount of services generated from the housing position, the part of the housing position that the housiehold lives in, $h_c(s)$, depreciates at the rate δ_O while the remaining part of the house, $(h' - h_c(s))$, depreciates at the rate δ_R

$$x(h', h_c) = \begin{cases} \delta_O ph', & \text{if } h_c(s) \geq h' \\ \delta_O ph_c(s) + \delta_R p[h' - h_c(s)], & \text{if } h_c(s) < h'. \end{cases}$$

[8] In the last period, all households must sell h, rent housing services and consume all their assets, a, as a bequest motive in not in the model. In the last period, $h' = a' = 0$.

[9] As our analysis will be conducted at the steady state, other than the differences between buying and selling transaction costs, there are no differences in the purchase and selling prices of housing.

1. **Homeowner maintains housing size**

   If the household decides to maintain their housing investment, $h = h'$, then the budget constraint is:

$$c + a' + m(p, h, \psi, n, r^m) + x(h', h_c) = y(\epsilon, j, w, a) + R(g(h') - s). \tag{3.6}$$

   In this situation, the household must make a mortgage payment if $n > 0$.

2. **Homeowner changes housing size**

   If the household decides to either up-size or down-size their housing investment position, (i.e., $h \neq h'$, $h > 0, h' > 0$), the budget constraint is more cumbersome

$$\begin{aligned} &c + a' + (\phi_B + \psi)ph' + m(p, h, \psi, N, r^m) + x(h', h_c) \\ &= y(\epsilon, j, w, a) + R(g(h') - s) + [(1 - \phi_S)ph - D_n], \end{aligned} \tag{3.7}$$

   This constraint accounts for the additional income from selling their home (net of transaction costs, $\phi_s ph$, and remaining principle).

3.2. The Financial Intermediary

The financial intermediary is a zero profit firm. The firm receives the deposits of the households, a' and offers mortgages to the household sector. These mortgages generate revenues each period.[10] In addition, financial intermediaries receive principal payments from those individuals who sell their home with an outstanding mortgage position. These payments are used to pay a net interest rate on these deposits, r. The balance sheet condition of the financial intermediary is:

Financial Intermediary Balance Sheet

Assets	**Liabilities**
Loans to firms	Deposits
Net mortgage loans	

3.3. Market Equilibrium

This economy has three markets: the asset market, the rental of housing services market, and goods market. In the asset market the total amount of deposits from households

[10]The spread between the mortgage rate and the return on capital is assumed to cover fixed costs.

has to be used to finance the mortgage market and capital used by firms. We assume a stand-in neoclassical firm that produces in a competitive market with a constant returns to scale Cobb-Douglas production function $F(K,N) = K^a N^{1-\alpha}$, where K denotes capital and N denotes effective labor input.

The second market in the model is the rental of housing services market. Equilibrium in this market requires that the total demand for housings services must be equal to the amount of housing services generated by the relevant housing stock. Finally, Walras Law ensures that the goods market clears. A formal definition of the recursive equilibrium is provided in the appendix.

4. Calibration and Estimation

We calibrate and estimate the parameters of the model to match some key moments of the U.S. economy. This strategy allows us to specify a limited number or parameter values while estimating the remaining parameters as an exercise in exactly-identified Generalized Method of Moments. With the parameterized model, we will evaluate the impact of different mortgage contracts across various dimensions.

4.1. Parameters Set in the Calibration

A period in the model is three years. Households start their life at age 20 and live until age 80 (model period 21) with retirement mandatory at age 65, (model period 16). Parameterization of preferences requires specifying values for the discount rate, β, the curvature coefficient, σ, and the consumption share of non-durable goods, γ. The values of β and γ will be estimated, but the curvature parameter, σ, is set to 2.0.

The specification of the stochastic income process is based on Storesletten, Telmer and Yaron (2001). We discretize this income process into a five state Markov chain using the methodology presented in Tauchen (1986). The values we report reflect the three year horizon employed in the model. As a result, the efficiency values associated with each possible productivity values are $\epsilon = \{4.41, 3.51, 2.88, 2.37, 1.89\}$ and the transition matrix becomes:

$$\pi = \begin{bmatrix} 0.47 & 0.33 & 0.14 & 0.05 & 0.01 \\ 0.29 & 0.33 & 0.23 & 0.11 & 0.03 \\ 0.12 & 0.23 & 0.29 & 0.24 & 0.12 \\ 0.03 & 0.11 & 0.23 & 0.33 & 0.29 \\ 0.01 & 0.05 & 0.14 & 0.33 & 0.47 \end{bmatrix}.$$

The age-specific permanent component υ_j is estimated from earnings data in the PSID. We set θ to be equal to a replacement ratio of thirty percent of average income and calculate the tax rate τ_p so as to make the retirement program self-financing.

In the housing market, we calibrate the transaction costs associated with buying and selling housing, ϕ_B and ϕ_S, to 3 and 6 percent respectively. These levels are consistent with observed buying and selling fees. We allow for a wedge between the rate of return on capital and the mortgage interest rate. We set the wedge to three percent which is close to the difference between the fixed and floating rate mortgage interest rates. In the benchmark model where the calibrated target is 1999, we set the length of the mortgage, N, to 10 which corresponds to 30 years, and the downpayment requirement, Ψ, to ten percent[11]. We set a minimum home size. We determine this value by determining the average size of the smallest 10 percent of home in the AHS. For these set homes we calculate ratio of house value to average labor income which is equal to 1.2. This value is used to set the smallest house size.

Other than social security taxes, we set taxes on all sources of income to be zero so as to focus on the "pure" financial effects of various mortgage contracts. We leave the analysis of the effects of government policy on mortgage contract and housing decisions for future work. Finally, each household is born with an initial asset position. The distribution of initial assets was based on the asset distribution observed in 1999 Panel Study on Income Dynamics (PSID). Each income state was given their corresponding level of assets to match the nonhousing wealth to earnings ratio measured in the PSID.

4.2. Estimation Targets

The parameters that need to be estimated are the three depreciation rates, δ, δ_O, δ_R, the relative importance of consumption goods to housing services, γ, and the discount rate, β. We identify these parameter values so that the statistics in the model economy are the same as five statistics observed in the actual economy. Our calibration or estimation of the five parameters is an exercise in exactly-identified Generalized Method of Moments. One calibration target is the ratio of capital to gross domestic product which is about 3.00 over the period 1958-2001. We define the capital stock in the U.S. economy as total private fixed assets plus the stock of durable goods as defined by the Bureau of Economic

[11] It is important to note that the choice of the downpayment requirement does not alter the qualitative results presented later in the paper. Also, in recent years the average downpayment, as calculated from the AHS, has repeatedly dipped below 20%, and since this is supposed to serve as a minimum requirement, not the average, we believe that a 10% downpayment requirement is reasonable.

Analysis. A second calibration target is the ratio of the housing capital stock to the nonhousing capital stock. The housing capital stock is defined as the value of fixed assets in owner and tenant residential property. If this measure of the housing stock is subtracted from the previously defined measure for the capital stock for the economy, we find ratio of the housing stock to nonhousing capital stock to be 0.60. This data also comes from the BEA.

The next estimation target is the fraction of output that goes to investment in capital goods and is equal to 0.043. The fourth target is the fraction of output that is allocated to investment in housing. For the same period, this ratio is 0.032 where we define housing investment as investment in residential structures. The final target is the ratio of the number of square feet in owner-occupied housing to the number of square feet in rental housing. Data from the 1999 *American Housing Survey* indicates that this ratio is 4.25.

Using these calibration targets, the annualized estimates of the utility parameters β and γ are equal to 0.964 and 0.804, respectively. The depreciation rate of capital, δ, is estimated to be 0.067. The depreciation rate on owner occupied housing, δ_0, is 0.022 while the estimated depreciation rate on rental housing, δ_R, is 0.090. The estimated parameters and calibration targets are summarized in Table 2. It is important to note that the estimation problem is not separate from the solution of the model. That is, we jointly solve the estimation problem and model solution. In the appendix, we sketch the computational algorithm.

Table 2: Calibration and Estimation of Model (Annualized Values)

Statistic	**Target**	**Results**
Ratio of wealth to gross domestic product (K/Y)	3.00	3.006
Ratio of housing stock to capital stock (H/K)	0.60	0.599
Housing Investment to Housing Stock ratio (x_H/H)	0.032	0.0319
Ratio owner-occupied to rental housing square feet	4.25	4.24
Ratio capital investment to GDP($\delta K/Y$)	0.043	0.0431
Variable	**Parameter**	**Estimated Value**
Individual Discount Rate	β	0.964
Share of consumption goods in the utility function	γ	0.804
Depreciation rate of owner occupied housing	δ_O	0.022
Depreciation rate of rental housing	δ_R	0.090
Depreciation rate of capital stock	δ_K	0.067

5. Evaluation of The Baseline Model

In order to examine the implications of alternative mortgage contracts, the model needs to be evaluated. We define the benchmark model as one where the mortgage function has constant payments with a ten percent downpayment requirement for every housing purchase. From an aggregate perspective, it is important to know whether the model generates reasonable housing statistics. We compare the model with data for 1999. Table 3 provides a summary of the aggregate performance of the model over certain key dimensions.

Table 3: Summary of Aggregate Results

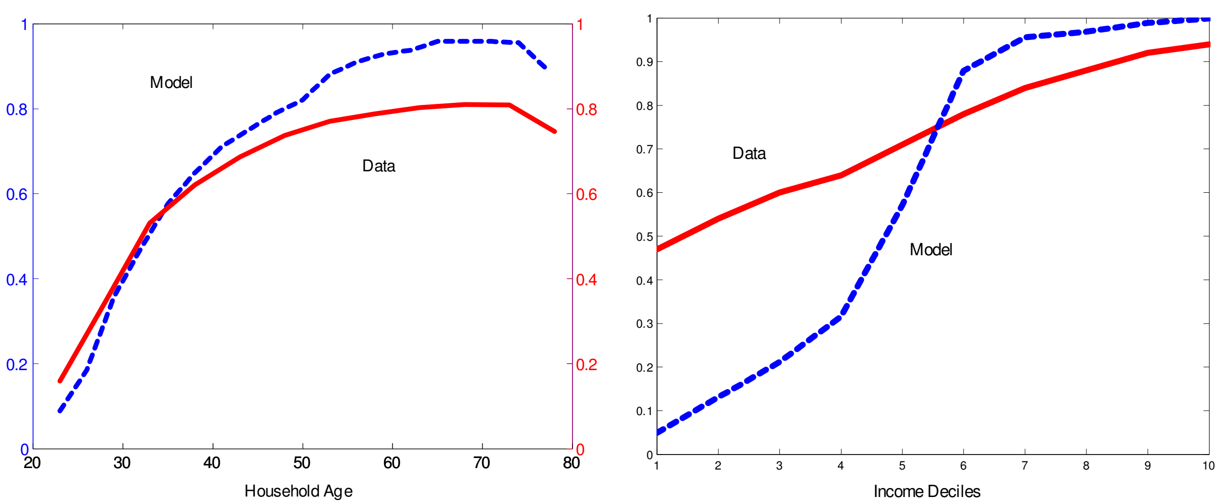
	Variable[1]					
	Home Own Rate (over 25)	Home Own Rate (under 35)	Avg House Size	Avg Apart. Size	SD House Size	SD Apart. Size
Data (AHS 1999)	66.8%	39.7%	1,973	1,050	179	94
Standard Mortgage Contract	68.2%	30.0%	2,082	825	144	75

[1] Housing and rental units size are measured in terms of square feet.

The ownership rate measures participation in the housing market. In 1999, the AHS estimates that the homeownership rate in the United States was 66.8 percent. Our model generates a participation rate of 68.2 percent. Another interesting dimension, and a focal point of current policy, is the participation of the younger households. The data indicates an ownership rate of 39.7 percent for all households under 35 while the model generates a corresponding homeownership rate of 30 percent. Next, we want to consider whether the model generates housing and apartment sizes consistent with the observed data. The observed average house size is 1973 square feet with a standard deviation is 179 square feet. The model predicts the average house size to be 2082 with a standard deviation of 144 square feet. As can be seen, the model slightly overpredicts average house size, and generates too little dispersion. In the rental market, the model underpredicts the mean and the variance of the average apartment size. Given some of the restrictions imposed on the model such as the income process which limits the model's ability to produce extremely rich young households, the model performs quite favorably.

In addition, we are particularly interested in determining how the model performs in terms of the age and income distribution. In Figure 1, we compare the homeownership rate by age and income generated from the model with the distribution observed in the 1999 **American Housing Survey.**

Figure 1: Homeownership Rate By Age and Income

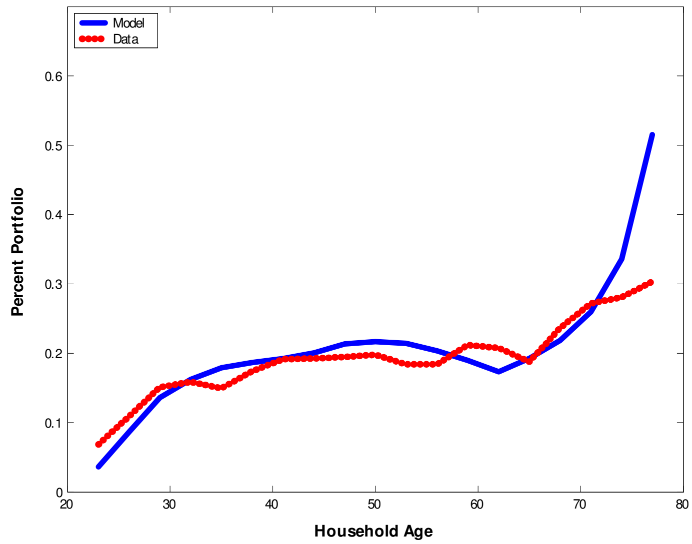


As can be seen, the general pattern over age generated by the model is consistent the pattern observed in the data. However, the model underestimates the homeownership rate for households younger than age 35. After age 35, the model overpredicts the homeownership rate. For example, at age 60, the homeownership rate is approximately eighty percent while the model generates a homeownership rate that is approximately ninety percent. However, it is important to note that some households rent in every age-cohort; a fact observed in the data. In terms of the income distribution, the American Housing Survey reports homeownership rates between fifty and sixty percent for households in the lowest four deciles. Meanwhile, households in the highest four deciles have homeownership rates between eighty and ninety percent. In the model, homeownership in the model is more sensitive to income than would be suggested by the data. However both the model and the data share the feature that the homeownership rate is increasing in income. It should also be noted that the income generating process employed in the model is based on PSID data which underestimates rich households while the AHS tends to overestimate rich (homeowner) households. This makes the model appear to perform worse than it actually does.

Another aspect of the model that needs to be considered is the relative share of housing in household portfolios. We use the 1998 *Survey of Consumer Finances* to calculate household portfolio values which include the estimated value of the house adjusted for remaining principle, (i.e., the net housing investment), stocks, and bonds. Bonds are defined as bond funds, cash in life insurance policies, and the value of investments and rights in trusts or estates. Stocks are defined as shares of stocks in publicly held corporations, mutual funds, and investments trusts including stocks in IRA's. In order to see if the model generates reasonable portfolio allocations, we calculated the share of housing in the average household portfolio over the life cycle. Housing is measured as net of mortgage principal, and the total portfolio is net housing plus other assets. In Figure 2 we present this ratio for data and the model.

Figure 2: Housing and the Financial Portfolio

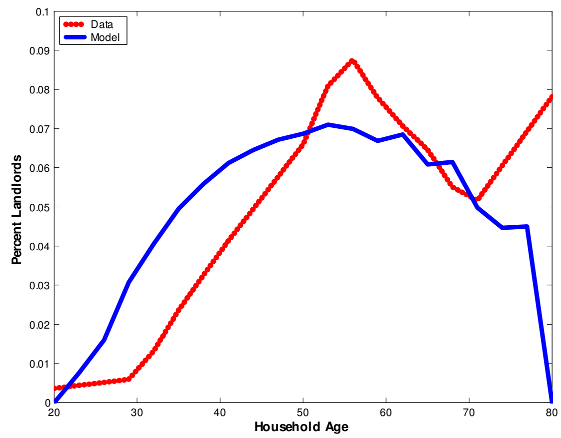
(all households)



Initially, very few individuals own housing, thus accounting for the low percentage of housing in the portfolio. The relative importance of housing in the portfolio increases rapidly because of a higher participation rate and existing owners have more equity in the house. After age 35 the ratio continues to slowly increase until age 65 when, once again, the relative share of housing increases rapidly. The increase in the relative importance of housing in older household's portfolios is a result of the relative liquidity of capital and housing assets. Because of the relatively illiquidity of houses, older households tend to maintain their housing position while consuming their more liquid capital assets. As can be seen, the model replicates the relative share of housing very well. Flavin and Yamashita (2002), and Li (2004) have argued that the ratio of housing investment to total assets has a "U-shaped" pattern by age. Yet, the ratio we presented in Figure 2 does not show a pronounced "U-shaped" pattern. This is due to fact that Figure 2 is a measurement over all households, (i.e., homeowners and renters). If we were to condition the data in Figure 2 to only include homeowners, we would get the aforementioned "U-Shaped" pattern.

The model has the feature that the rental market is endogenous as households make a decision about their housing position and a separate decision on the amount of housing services to consume. In 1996, HUD, in conjugation with the American Housing Survey, surveyed rental housing owners in detail using a survey known as the Property Owner and Manager Survey (POMS). We use this survey to assemble data on the characteristics of landlords. According to POMS, a household is defined as a landlord if they report that they are the sole or partial owner of rental property. The age characteristics of landlords are presented in Figure 3.

Figure 3: Distribution of Landlords by Age



As can be seen, the vast majority of landlords are over age 30. The fraction of landlords gradually increases until the late fifties where the peak reports that 9 percent of all landlords are 55 years old. After 55 the fraction of landlords in each age cohort declines until after age 70 when we see an increase again. This may be a result of the small number of households over age seventy in the data. We see that the modeled economy generates a very similar pattern with the only large differences occurring after age 70. For households under age fifty, the fraction of landlords in each cohort is somewhat overstated. This suggests that modeled households are taking larger housing positions than their housing service demands require with the goal of consuming the housing services at older ages. This is consistent with the feature that the model under forecasts the percent of landlords that in age cohorts 50 to 65.[12] We also examine the income characteristics of landlords. Although households in the lower half of income distribution do lease out housing services, most landlords are in the highest four deciles according to the model. Unfortunately, neither AHS or POMS reports data on the income levels of landlords.

In sum, we believe the model performs very well when compared to actual data.

6. Evaluation of Various Mortgage Contracts

This section will compare various mortgage contracts to the standard constant payment contract. We will focus on the implications of different contracts on the investment in

[12] This issue is studied in more detail in Chambers, Garriga, and Schlagenhauf (2005b).

housing with special interest given to first-time buyers, wealth-portfolio implications, and ramifications for the tenure decision, (i.e. renting vs. owning).

Table 4: Summary of Aggregate Results by Mortgage Type

	Variables[1]					
Mortgage Type	Home Own Rate (over 25)	Home Own Rate (under 35)	Avg House Size	Avg Apart. Size	SD House Size	SD Apart. Size
Data (AHS 1999)	66.8%	39.7%	1,973	1,050	179	94
Standard Mortgage Contract	68.2	30.0	2,082	825	144	75
Standard-Combo Loan	64.1	31.1	2,019	816	156	93
Balloon	65.4	33.6	2,041	1,011	166	151
Balloon-Standard	66.6	27.4	2,060	818	143	78
Constant Amortization	70.9	32.4	2,148	818	140	60
GPM-Arithmetic	64.5	31.2	2,025	815	155	91
GPM-Geometric (10 percent)	62.8	29.0	1,993	832	158	101

[1] Housing and rental unit size are measured in terms of square feet.

Table 4 presents a set of selected aggregate measures for various mortgage contracts. As can be seen, the type of mortgage contract can have important implications for these summary statistics. The first two columns report the homeownership rate for the entire economy and households under 35, while the next two columns consider average home and apartment size by mortgage type. The final two columns give us a glimpse about the dispersion in housing. These two columns measure the standard deviation of house and apartment size respectively. We begin with a discussion about the effects of mortgage type on the homeownership rate.

For households over age 25, a constant amortization mortgage will generate the highest participation rate when compared to the rates under the other contracts. In contrast, a GPM with a 10 percent geometric growth rate will generate the lowest ownership rate. If a policy maker desires to increase home ownership for the youngest cohorts, we find that a pure balloon mortgage results in the highest participation rate for households under age 35.[13] Interestingly, the balloon payment with a short duration that is rolled into a

[13] Balloon contracts have been available since the pre-war period. However, the duration of those contracts were between three to five years. It is clear that this specification would deter homeownership.

fixed payment mortgage generates the lowest homeownership rate for households under 35. Clearly, for a substantial number of young households, the long stream of interest only payments are strictly preferred to the shorter duration balloon contract that is rolled into a standard contract. The constant amortization mortgage is the only contract that increases the homeownership for young households and the economy as a whole.

In addition, Table 3 displays how the type of mortgage influences the size of the housing investment. We see a perfect matching between a contract's effect on the aggregate homeownership rate and the average size of a home in the economy. The constant amortization loan generates the highest homeownership rate and average house size. As for the average apartment size, changes in the equilibrium rental rate for housing are driving individual incentives to supply rental services, and this partially determines the average size of the rental unit. When the rental rate is high, the average apartment size is low, and vice versa.

As for the dispersion in housing, we see that the type of mortgage appears to have some relatively large effects on the spread in the size of houses and apartments. The pure balloon contract generates the largest dispersion in houses and apartments. These results are easily explained by thinking of the two types of renters that are present in this economy. The first type - the standard renter - is present in all of the economies. This household does not have enough assets and/or income to buy a house. These households would be characterized by having relatively low levels of housing consumption (small apartments). In the presence of the pure balloon mortgage, a second type of renter are those households who decide to exit the housing market and become renters before making the large balloon payment. These households are typically further along their life-cycle, and thus can afford to consume much larger apartments. Thus, we end up with a large dispersion in apartment sizes. This argument can be applied to other mortgage types to a lesser extent. Generally, it is the presence of rich renters which drive apartment dispersion higher. The dispersion for housing can argued in the opposite direction. In situations where relatively poorer households enter the housing market, we see a larger spread in house sizes. For example the pure balloon mortgage and GPM with geometric payments offer very low initial mortgage payments which encourage early entry. Because of this early entry, households have more opportunity to change to large house sizes and thus a larger spread in house size. The interpretation of these different descriptive facts becomes even clearer when the distribution implications of these contracts are examined over the life-cycle and across income.

6.1. Combo Fixed Payment Contracts (No Downpayment)

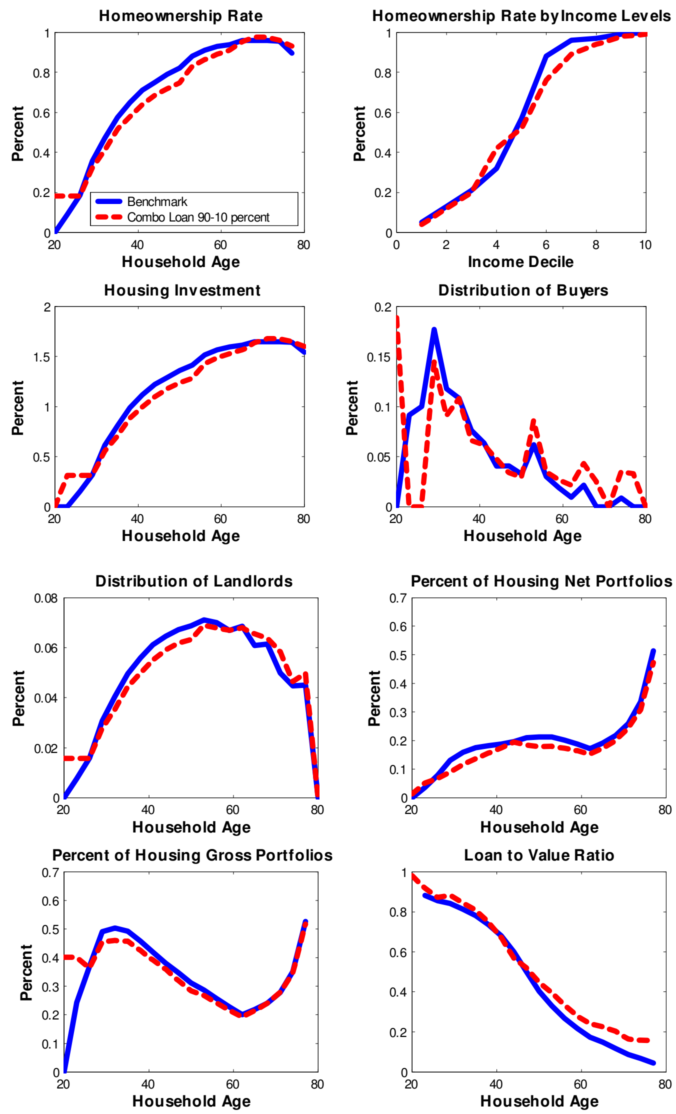
An alternative to the standard mortgage contract is the "combo-loan" product. The "80-20" and the "80-15-5" combo products have become popular as a way for home buyers to enter the housing market with a smaller downpayment while avoiding mortgage insurance that generates no housing equity. The former program corresponds to the traditional loan-to-value rate of 80 percent using a second loan for the 20 percent downpayment. The "80-15-5" mortgage product requires a 5 percent downpayment provided by the home purchaser with the remaining 15 percent financed from a second loan. The second loan has an interest rate approximately 2 percent higher than the interest rate on the primary mortgage. Since our baseline economy uses a downpayment of 10 percent, we will examine the implications of a "90-10" combo loan where the second mortgage is for the ten percent downpayment. This later contract is for half the length of the primary mortgage, and with a two percent interest rate premium.

For this contract, the overall homeownership rate is 64.1 percent which is somewhat lower than the standard contract. However, the homeownership rate for households under age 35 increases from 30.0 percent with the standard contract to 31.1 percent. Figure 4 shows that in the housing investment and distribution of buyers figures, the homeownership rate increases dramatically for the youngest individuals. Since the initial costs for buying a home are lower, this contract allows households to enter the housing market earlier. However, the number of buyers in the late twenties and early thirties actually falls suggesting lower income families are not benefiting from this product. This can be seen by examining the homeownership rate by income deciles. Households with income in the fourth decile show a large increase in the homeownership rate with this contract. Overall, we see that this product allows first time buyers to enter into the housing market and stresses the importance of the downpayment constraint for policymakers who want to increase the homeownership rate of young households. The overall ownership rate declines as homeownership falls for households age 35 to 60. This is a result of the higher overall mortgage payments which are now the sum of two individual mortgage payments. This increase in costs forces less wealthy households into the rental market.

In Chambers, Garriga, and Schlagenhauf (2005), we show that the combo loan increases the aggregate homeownership rate. In this analysis, we find that this rate falls. The difference is do to the fact that households in this economy use a mortgage to finance the entire housing purchase resulting in a larger mortgage payments. This stresses the importance of the downpayment constraint in the housing investment decision.

This product has implications for the amount of investment in housing as well as the role of housing in the financial portfolio. Except for the youngest households, the role of housing declines slightly until age 60, once again caused by the higher mortgage payments. After this age, household portfolios seem to be similar to the portfolios under the standard contract. This contract also seems to generate an older distribution of landlords.

Figure 4: The Combo Loan

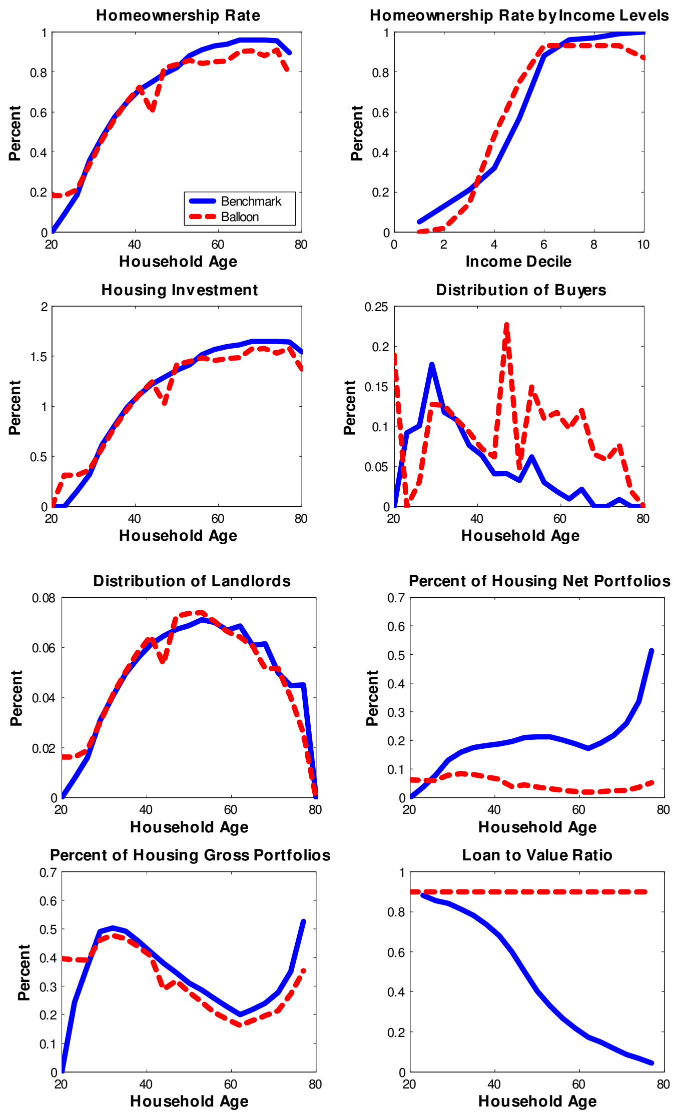


6.2. Balloon Type Mortgage Contracts

As stated earlier, balloon mortgage contracts have the property that households pay an interest payment each period, but do not make a contribution to the outstanding principal until some late period when principle payments become due. Although there are few balloon mortgage contracts in the U.S., this type of mortgage contract is more popular in some European countries. We are going to consider two types of balloon contracts. Both contracts assume that the total length of the mortgage is thirty years. The first contract assumes that interest only payments are made until the terminal period when the entire principal is paid. The second balloon contract assumes a four period (or twelve year) contract of interest only payments followed by a six period (or eighteen year) standard fixed payments mortgage contract. With a simple balloon contract the mortgage payment is lower than with a standard contract. This allows some young households to enter the housing market and this is reflected in an increase in the participation rate for households under the age of thirty-five which increases to 33.6 percent. Yet, the overall homeownership falls to 65.4 percent. A decline in homeownership occurs around the time the first balloon payments comes due. Some households choose to sell and, since they have built no housing equity, some cannot afford to immediately to take a positive investment position in housing because of bad income shocks. In the presence of capital gains, this may not hold.

The results from the balloon contract are presented in Figure 5. The balloon mortgage contract imposes a large impact on savings and portfolio allocations. This can be seen in the visible shift in the relative share of housing in the portfolio pictures. As younger and poorer households take advantage of lower interest only payments, home ownership positions exceed the standard contract positions. Because households realize they are faced with a large balloon payment in the future, they begin to save earlier in the life cycle. As a result, the percentage of net housing in the portfolio is much lower under the balloon contract for households over age 25. Thus, savings is much higher under this contract.

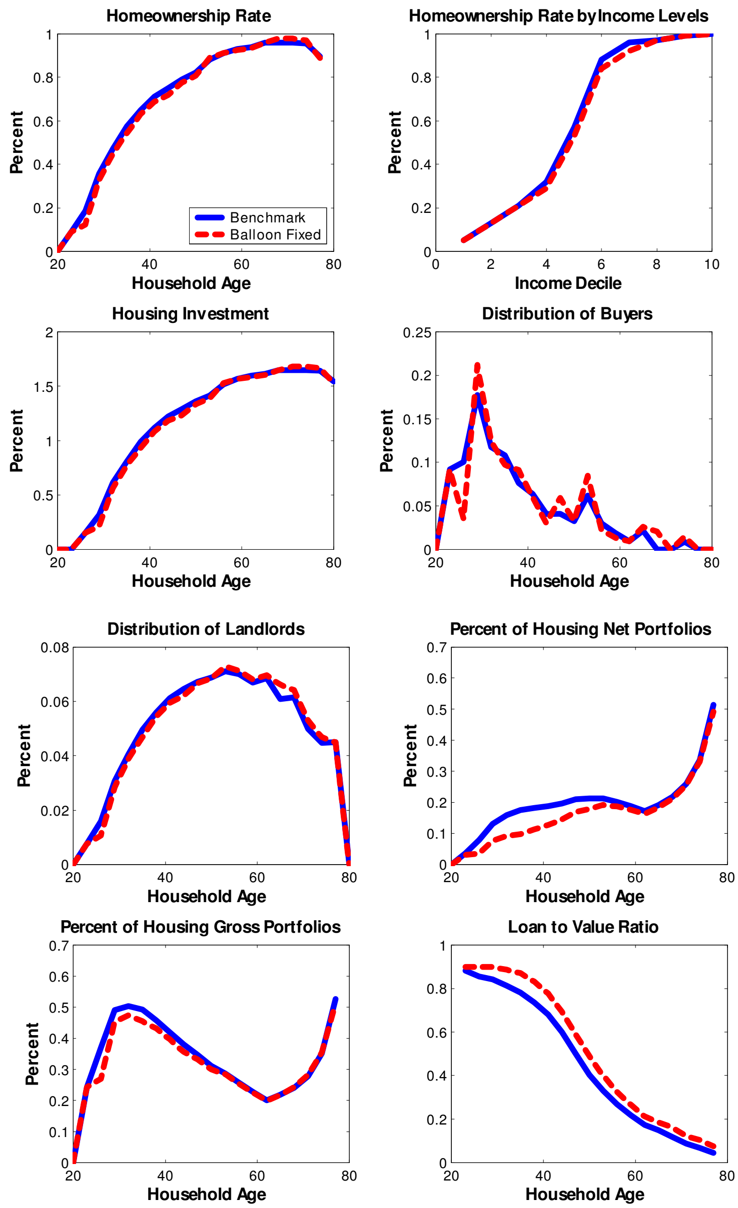
Figure 5: A Simple Balloon Contract



An alternative balloon mortgage contract is one where the principal is no longer paid with a single balloon payment in the final period but with a short duration standard mortgage contract. For this experiment, we assume the interest payments last four periods (twelve years) and the standard contract last six periods (eighteen years). The results for this run are presented in Figure 6. Compared to the simple balloon contract, this type of mortgage product results in a higher overall homeownership rate. This is entirely a result of a higher homeownership by older households. The homeownership rate for households under age thirty-five is lower than under either the standard or simple balloon contract. Compared to the simple balloon contract this result seems obvious. The initial mortgage payments are the same under the two balloon contracts, however, the fact that principal payments are now six periods closer to the front of the loan makes the total cost of the mortgage increase. As a result some young households decide to remain renters. The short duration of the six period standard mortgage generates mortgage payments which are significantly larger than the typical standard contract. These larger payments make housing less affordable for some young households and they stay out of the housing market.

Looking across the income distribution, we find that the homeownership rate is similar to that of the standard contract. From the figure, it is clear that the distributions of assets and relative share of housing by age are also similar to the distributions under the standard contract.

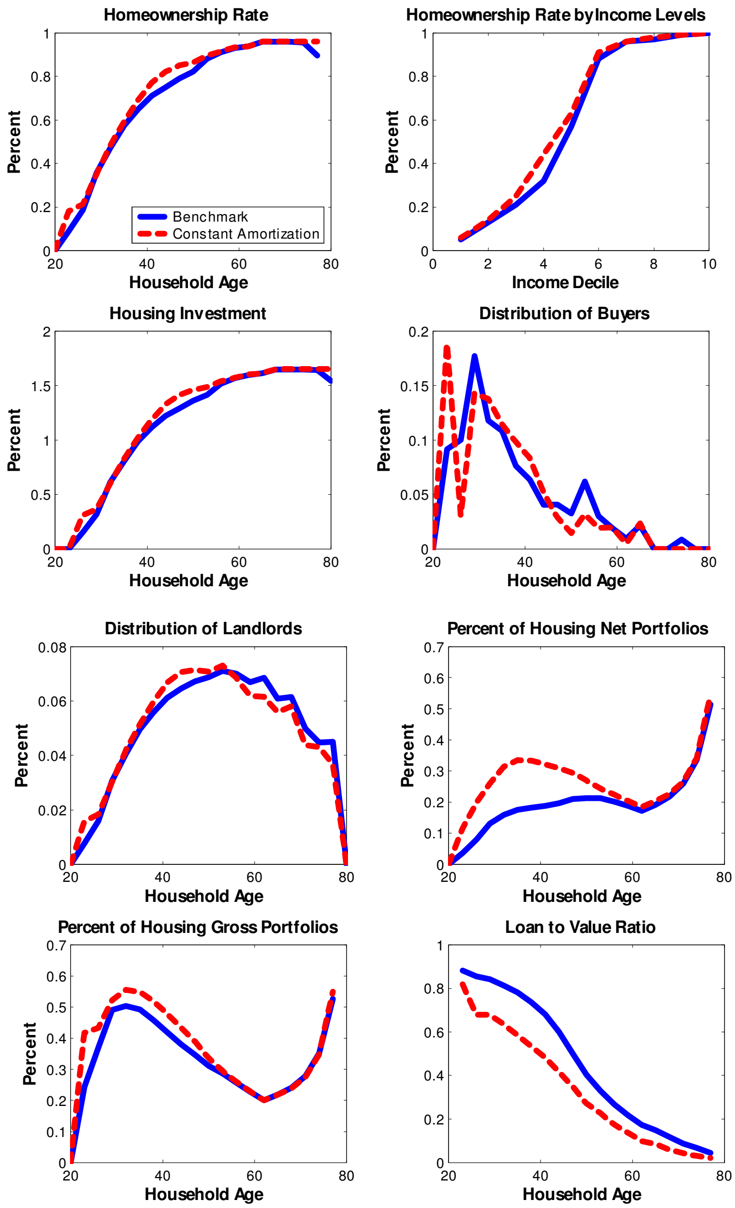
Figure 6: Balloon Contract Followed by a Standard Contract



6.3. Mortgage with Constant Amortization (Home Equity Line)

Constant amortization mortgages require a household to pay a constant fraction of the total principal each period. As a result, unlike other contracts, mortgage payments are actually decreasing over the life of the loan. With this mortgage contract, the overall homeownership rate increases to 70.9 percent. The increase in the homeownership rate is a result of an increase participation from households under 30 and between ages 40 and 50. In addition, the homeownership rate is higher for all income deciles with the change especially pronounced for the lowest income deciles. The effect of this contract can be clearly seen by looking at financial portfolios under this contract and the standard contract. As can be seen in Figure 7, the decline in mortgage payments results in households entering into the housing market at younger ages. This translates into households under age 50 having a larger fraction of their portfolio in housing. Younger households skew their portfolios toward housing. In the late thirties, they begin to rebalance their portfolios toward assets, and by age sixty, their portfolios look like the portfolios under a standard contract. The initial skewness towards housing is a function of the fact that equity grows at a constant rate throughout the mortgage. Compared to an identical household with a standard mortgage, a household with a constant amortization mortgage will have higher housing equity. This can be seen by noting that the loan to value ratio is lower across the entire life cycle. The increase in the housing investment by the younger households also results in the distribution of landlords becoming younger.

Figure 7: Mortgage Contract with Constant Amortization

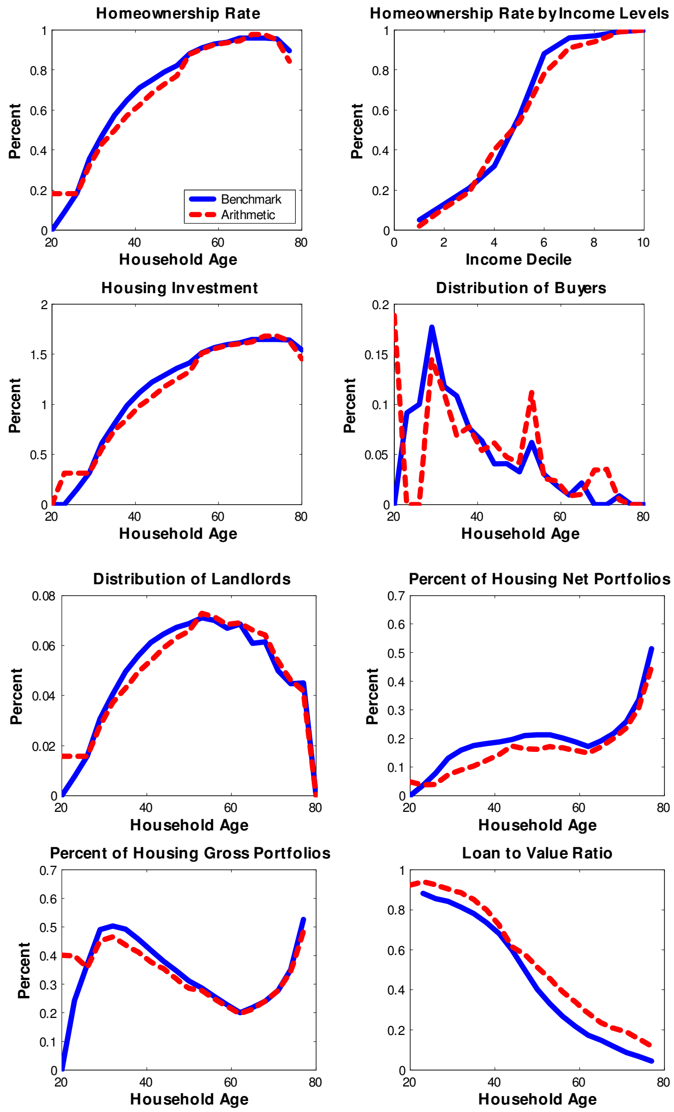


6.4. Graduated Payment Mortgages

Our final set of experiments will examine mortgage contracts which have payments that grow throughout the life of the loan, GPMs. With respect to this type of contract, we will consider a GPM with an arithmetic payment schedule and a GPM with a geometrically increasing payment schedule. We assume an increase of five percent each period in the arithmetic contract. In the geometric contract, we will assume the growth rate is ten percent per period which converts to an annualized rate of about 3.2% with respect to the first period payment.

The distributional implications of the arithmetic contract are presented in Figure 8. The fact that the mortgage payment is lower for younger households allows an earlier entry into the housing market. As a result, the homeownership rate for households under age thirty-five is 31.2 percent which is higher than the baseline case. Despite the increase in homeownership for the young, the aggregate homeownership rate is 3.7 percent lower than with the standard contract. The explanation can be seen by examining homeownership by income deciles. Across the income distribution, we find that households in the fourth income decile show the largest increase in homeownership. Individuals in the lowest three deciles actually have lower homeownership rates. The current low income of these households in the face of growing payments makes housing an unattractive investment. These households have a low probability of having income grow fast enough to keep up with the mortgage payments. Over the life cycle, the homeownership rate is lower for households in between ages 35 and 55. Some households never enter the housing market because of the previously discussed threat of rising mortgage payments. Saving behavior is not much different from the standard contract. With a lower homeownership rate, more households desire rental services. The additional demand for housing is supplied by older households as depicted by the rightward shift in the age distribution of landlords.

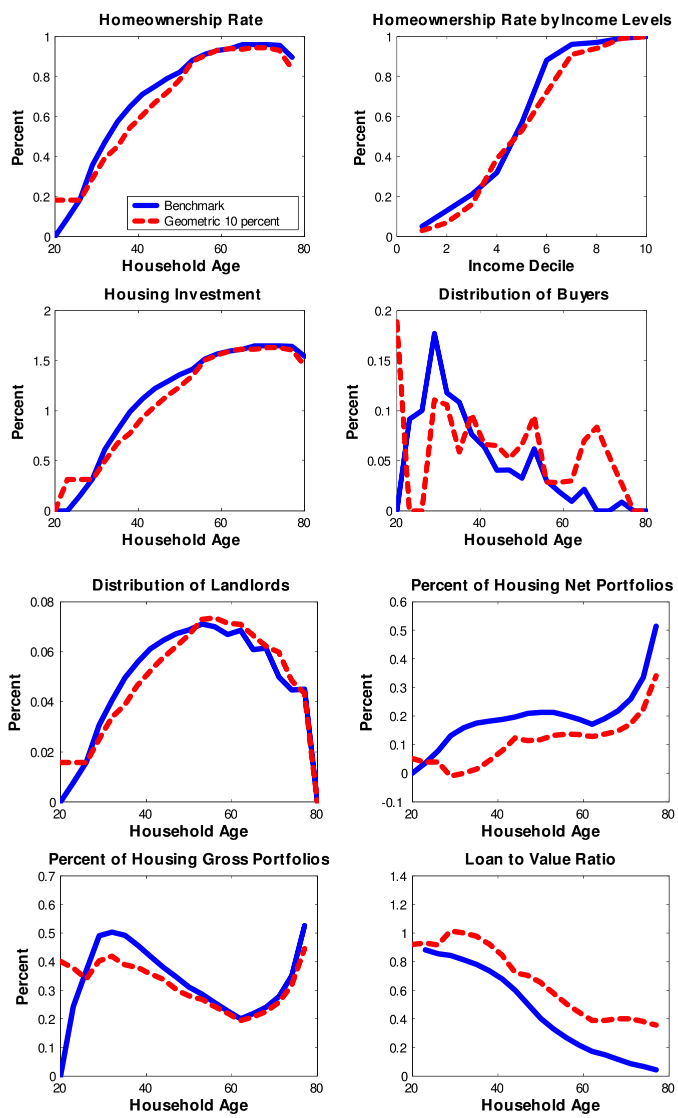
Figure 8: GPM with Arithmetic Schedule



A geometrically increasing mortgage contact seems attractive at first glance since mortgage payments will be lower at younger ages and then increase at a rate corresponding to earnings growth. Because of a lower initial burden, this contract seems to suggest a boost for homeownership, particularly for young households. Our analysis of the arithmetic contract suggests a less enthusiastic result. Figure 9 displays the results for the geometric GPM.

Under the geometric contract, the aggregate homeownership rate is lower than the arithmetic rate and the baseline model. Also, the homeownership rate for households under age 35 is even lower. All of the influence of growing payments with the arithmetic mortgage are accentuated in the geometric contract. So as expected, households in the lower half of the income distribution have lower homeownership rates. This pattern is reflected onto the life cycle in the decline in the homeownership rate between ages 30 and 55. This contract leads to a slight increase in savings which results from current homeowners attempting to accumulate wealth to payoff the high mortgage payments at the end of the loan. Due to the lower homeownership rate, there is an increase in the demand for rental services which is provided by households over 60 who take a greater position in being landlords.

Figure 9: GPM with Geometric Schedule



7. Conclusions

A goal of current U.S. housing policy is to increase the homeownership rate. One tool used to achieve this goal has been the reduction in financial restrictions which has lead to greater flexibility in mortgage contracts. This paper explored the implications of several different mortgage contracts for tenure and housing investment decisions, and thus the homeownership rate. The analysis was conducted using a quantitative equilibrium model with heterogeneous consumers and liquidity constraints. Our life cycle model is characterized by considering the housing decision as part of the portfolio decision, and allowing households to make discrete choices of whether to own, rent or lease.

Various mortgage contracts were examined relative to the standard payment contract. We focused on the implications of various contracts for the investment in housing with special interest on first-time buyers, wealth-portfolio implications, and tenure decisions. Some of the primary conclusions are:

- Combo and graduated payment type loans allow young households to participate earlier, but reduce the participation rate for middle age households. Under these contracts, the average home size is smaller.

- The constant amortization loan increases the participation of young and middle age households. This type of contract encourages larger houses when compared to the standard contract.

- The largest increase in the participation rate for young households occurs with a pure balloon contract. However, the participation rate falls for middle aged households. This contract has the feature of reducing duration.

We find that the constant amortization mortgage (or home equity line) is the only contract that increases the homeownership rate for the relatively young and poor. This is the constant amortization mortgage contract which has the property of a lower present value of payments. This raises the question of why such contracts have not been offered by government sponsored agencies.

Our analysis suggests a number of extensions that we are presently investigating. The model abstracts from demographics. Existing housing literature suggests that changes in family size is an important factor in households changing their housing position within the housing market. The introduction of demographic factors into the model seems to be an obvious next step. Given current policy interest on first time buyers, further work is needed on this type of buyer. Lastly, the question of what the optimal mortgage contract would look like given public policy desires is of interest.

8. Appendix:

8.1. Stationary Equilibrium

In the model economy, we restrict ourselves to stationary equilibria. The individual state of the economy is denoted by $(a, h, n, \epsilon, j) \in \mathcal{A} \times \mathcal{H} \times \mathcal{M} \times \mathcal{E} \times \mathcal{J}$ where $\mathcal{A} \subset \mathbb{R}_+$, $\mathcal{H} \subset \mathbb{R}_+$, $\mathcal{M} \subset \mathbb{R}_+$, and $\mathcal{E} \subset \mathbb{R}_+$. For any individual, define the constraint set of an age j individual as $\Omega_j(a, h, n, \epsilon, j) \subset \mathbb{R}^4_+$ as all four-tuples (c, s, a', h') such that the appropriate budget constraint $(9) - (13)$ is satisfied as well as the following nonnegativity constraints hold:

$$c > 0, \;\; s > 0, \;\; a' \geq 0, \;\; h' \geq 0.$$

Let $v(a, h, n, \epsilon, j)$ be the value of the objective function of an individual with the state vector (a, h, n, ϵ, j) defined recursively as:

$$v(a, h, n, \epsilon, j) = \max_{(c,s,a',h') \in \Omega_j} \{U(c, s) + \beta \Pi E[v(a', h', \max(0, n-1), \epsilon', j+1]\}$$

where E is the expectation operator conditional on the current state of the individual and Π represents transition probabilities across the state space.

Definition 1 (Stationary Equilibrium): *A stationary equilibrium is a collection of value functions* $v(a, h, n, \epsilon, j) : A \times H \times M \times E \times J \to R$; *decision rules* $a'(a, h, n, \epsilon, j) : A \times H \times M \times E \times J \to R_+$, *and* $h'(a, h, n, \epsilon, j) : A \times H \times M \times E \times J \to R_+$; *prices* $\{r, p, R\}$; *government policy variables* $\{\tau, \theta\}$; *and invariant distribution* $\Gamma(a, h, n, \epsilon, j)$ *such that*

1. *Given prices,* $\{r, p, R\}$, *the value function* $v(a, h, n, \epsilon, j)$ *and decision rules* $c(a, h, n, \epsilon, j)$, $s(a, h, n, \epsilon, j)$, $a'(a, h, n, \epsilon, j)$, *and* $h'(a, h, n, \epsilon, j)$ *solve the consumer's problem;*

2. *The price vector* $\{r, r^m\}$ *is consistent with the zero-profit condition of the financial intermediary;*

3. *The asset market clears*

$$\int_{\mathcal{A}\times\mathcal{H}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j a'(\Lambda)\Gamma(\Lambda) = K' + \int_{\mathcal{A}\times\mathcal{H}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j m(h', n, i)\Gamma(\Lambda)$$

$$- \int_{\mathcal{A}\times\mathcal{H}_{h(\Lambda)\neq h'(\Lambda)}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j (1-\psi)h'(\Lambda)\Gamma(\Lambda) + \int_{\mathcal{A}\times\mathcal{H}_{h(\Lambda)\neq h'(\Lambda).h(\Lambda)>0}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j B_{n-1}(\Lambda)\Gamma(\Lambda),$$

4. *The rental market clears*

$$\int_{\mathcal{A}\times\mathcal{H}_{h'>0}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j s(\Lambda)\Gamma(\Lambda) + \int_{\mathcal{A}\times\mathcal{H}_{h'=0}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j s(\Lambda)\Gamma(\Lambda) = \overline{H},$$

5. *The retirement program is self-financing*

$$\int_{\mathcal{A}\times\mathcal{H}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j \theta I_\omega \Gamma(\Lambda) = \int_{\mathcal{A}\times\mathcal{H}} \sum_{\mathcal{E}\times\mathcal{M}\times\mathcal{J}} \mu_j (1-I_\omega)\tau_p \epsilon \upsilon_j \Gamma(\Lambda),$$

6. *Let T be an operator which maps the set of distributions into itself aggregation requires*

$$\Gamma'(a', h', n-1, \epsilon', j+1) = T(\Gamma),$$

and T be consistent with individual decisions.

We will restrict ourselves to equilibria which satisfy $T(\Gamma) = \Gamma$.

8.2. Computational Method

Our computation strategy allows us to jointly solve for the equilibrium and the estimation process. To compute the equilibrium we discretize the state space by choosing a finite grid. However, choices for both types of consumption are continuous. The joint measure over the state space Λ (assets, a, housing, h, periods remaining on the mortgage, n, income shock, ϵ, and age, j), is denoted by $\Gamma(\Lambda)$ and can be represented as a finite-dimensional array. The estimation method is a mix between non-linear least squares and an exactly identified generalized method of moments. The objective function to minimize can be written as the sum of two criteria:

$$L(\Theta) = \min_{\Theta}\{\lambda L_1(\Theta) + (1-\lambda)L_2(\Theta)\},$$

The first criteria requires the estimate parameters to be consistent with market clearing in the asset market and housing market

$$L_1(\Theta) = \sum\nolimits_{i=1,2} \gamma_i \left(\frac{\overline{p}^i_{j+1}(\Theta_{j+1})}{\overline{p}^i_j(\Theta_j)} - 1 \right)^2 .$$

where $\overline{p}^i_{j+1}(\Theta_{j+1})$ represents the equilibrium price calculated with parameters Θ_{j+1} in iteration $j+1$. The second criteria requires the implied aggregates in the model $\overline{F}_n(\Theta)$ to match their counter part in the data $\overline{F}_n$

$$L_2(\Theta) = \sum\nolimits_N \alpha_n (\overline{F}_n - \overline{F}_n(\Theta))^2,$$

The indirect inference procedure proceeds as follows:

- Guess a vector of parameters $\Theta \equiv (\beta, \gamma, \delta, \delta_r, \delta_o)$ and a vector of prices $\overline{p} = (r, R)$.
- Calculate the social security transfers from the invariant age-distribution Π.
- Solve the household's problem to obtain the value function $v(a, h, n, \epsilon, j)$,and the decision rules $a'(a, h, n, \epsilon, j)$, $h'(a, h, n, \epsilon, j)$, $c(a, h, n, \epsilon, j)$, $s(a, h, n, \epsilon, j)$ starting with $v(\cdot, \cdot, \cdot, \cdot, J+1) = 0$.
- Given the policy functions, calculate the implied invariant distribution Γ, the implied aggregates $\{\overline{F}_n\}_{n=1}^N$ and market prices $\overline{p}$.
- Calculate $L(\Theta)$, and find the estimator of $\widehat{\Theta}$ that solves

$$\min_{\Theta} L(\Theta).$$

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