Mortgage Innovation, Mortgage Choice, and Housing Decisions *

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Abstract

This article has two objectives. The first is to examine some of the new mortgage products that have appeared in the mortgage market in recent years. We illustrate how these products differ across important characteristics such as the downpayment requirement, repayment structure, and amortization schedule. The second objective is to present a model which has the potential to analyze the implications for various mortgage contracts for individual households as well as addresses many of the issues currently facing the housing market. In this paper, we use the model to examine the implications of alternative mortgages for homeownership.We utilize the model to show that both ARM style mortgages and combo loans can help explain the rise and fall in homeownership that we have witnessed since 1994.

1 Introduction

Housing is a big ticket item in the U.S. economy. At the macro level, residential housing investment accounts for between twenty and twenty-five percent of gross private investment. The large cost of a home purchase requires mortgage financing. In the aggregate, this financing is about 8 trillion dollars and uses a sizeable fraction of the financial resources of the economy. The importance of housing at the household level is more evident since the purchase of a house is the largest single consumer transaction. This decision has implications in the expenditure patterns and asset allocation decisions of the household.

In recent years, interest in the role that housing plays in the economy has increased, mainly due to two events. During the economic downturn in 2000, the housing sector seemed to mitigate the slowdown that occurred in many sectors of the economy as residential investment remained at high levels. More recently, the large number of foreclosures has again brought attention to the importance of housing. Fears have increased that mortgage market problemd will have ramifications for other credit markets and thus create a drag on the economy.

Events that illustrate the important role that housing plays in the economy are not limited to the last decade. During the Great Depression, housing foreclosures soared. This was as a result of two factors. The mortgage system was very restrictive as homeowners were required

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to make downpayments that averaged around 35 percent for loans lasting only five to ten years. At the end of the loan period, mortgage holders had to either payoff the loan or find new financing. The 1929 collapse resulted in numerous bank failures. Mortgage issuance fell drastically and homeowners were dragged into foreclosure. Faced with these problems, the government developed new housing policies as part of the New Deal legislation. The Home Owners Loan Corporation (HOLC) and the Federal Housing Administration(FHA) were created along with a publicly supported non-commercial housing sector. The HOLC was designed to help distressed homeowners to avert foreclosure by buying mortgages near or in foreclosure and replacing them with new mortgages with much longer durations. The HOLC financed these purchases by borrowing from the capital market and the Treasury. The FHA introduced new types of subsidized mortgage contracts by altering forms and terms as well as mortgage insurance. In addition, Congress created Federal Home Loan Banks (1932) and The Federal Home Loan Mortgage Corporation (1938), commonly known as Fannie Mae. The latter organization was allowed to purchase long-term mortgage loans from private banks and then bundle and securitize these loans as mortgage backed securities.[1] These changes had an important impact on the economy. The stock of housing units increased 20 percent during the 1940s, and the homeownership rate increased approximately 20 percent points over the period 1945 to 1965.

The need to increase our understanding housing markets, housing finance, and the linkage to the economy - the objective of this paper - should be obvious. We begin by examining the structure of a variety mortgage contracts. Given the array of mortgage products, mortgage choice can be a complex problem for a household. Households have to take into consideration many dimensions such as the downpayment, maturity of the contract, repayment structure, the ability to refinance the mortgage, and the impact of changes in interest rates and housing prices. We present a number of examples so that key features of prominant mortgage contacts can be clearly understood. The best mortgage for one household need not be the best mortgage contract for another household. In order to understand how the mortgage decision should be made and the aggregate implications for the economy, a model needs to be developed. This model must explicitly recognize the heterogeneity of households along age, income and wealth dimensions. In addition, these decisions must reflect the complexities of the tax code that favors owner-occupied housing. Such a framework allows individual decisions to be aggregated so that the impact that mortgages decisions for the economy can be clearly identified. In the second part of this paper we present a model appropriate for understanding how mortgage decisions impact the ecomony. We utilize the model to show the role that adjustable interest rate mortgages, ARM's, combo loans played since 1994. Since 1994, we have witnessed a rapid rise in homeownership and then a fall back in homeownership.

2 Mortgage Contracts

A mortgage contract is a loan secured by a real property. In real estate markets this debt instrument uses the structure and land as collateral. Mortgage lending is the primary mechanism used in most countries to finance the acquisition of residential property. These loans are typically long-term and require periodic payments, which can cover interest and principal. Lenders provide the funds to finance the loans. Usually, these loans are sold to parties interested in receiving a stream of payments from the borrower in a secondary market.

[1] This increased the flow of resources available in areas in which savings were relatively scarce. The intent was to increase the opportunities for low income families in the housing market. Because of the implicit backing of the government, the riskiness of these assets were preceived to be similar to the securities of the U. S. Treasury.

There are many types of mortgage loans that are available in the market place. These loans are differentiated by three characteristics: the payment structure, the amortization schedule, and the term of the mortgage loan. The payment structure defines the amount, and frequency of mortgage payments. The amortization structure determines the size of principal payments over the life of the mortgage. This schedule differs across mortgage loans and it can be increasing, decreasing, or constant. Some contracts allow for no amortization of principal and full repayment of principal at a future, specified date. Other contracts allow negative amortization, usually in the initial periods of the loan.[2] The term or duration usually refers to the maximum length of time given to repay the mortgage loan. The most common lengths of a mortgage contract are 15 and 30 years. The combination of these three factors allows a large variety of distinct mortgage products to be constructed.

Mortgage contracts impact the decisions of consumers. Some contracts are more effective at increasing homeownership for young households. What types of mortgage contracts are actually held in the United States? According to the *Residential Finance Survey* in 2001, roughly 97 percent of the housing units where purchased through mortgage loans, while only 1.6 percent were purchased with cash. Since most housing units were purchased using a mortgage product, Table 1 summarizes the type of mortgage contract used in the U.S. economy. As can be seen,the fixed rate (payment) mortgage loan is the dominant contract while the importance of adjustable (or floating) rate mortgage is substantially smaller. In contrast, in the United Kingdom and Spain where the homeownership rate is 71 and 80 percent, respectively, the adjustable (or floating) rate contract is the dominant contract. The popularity of the fixed rate contract in the U.S. is largely a result of the policies of the Federal Housing Administration (FHA), Veteran Administration (VA) and the various government sponsored enterprises (GSE). Fannie Mae and Freddie Mac, two of the GSE's, are among the largest firms that securitize mortgages. This means a mortgage contract is resold in the secondary market as a mortgage-backed security. In the early 1990s, a substantial changes occurred in the structure of the mortgage market in the United States. According to data presented in the *Mortgage Market Statistical Annual,* the market share of nontraditional mortgage contracts increased since 2000. Nontraditional or alternative mortgage products include interest-only loans, option ARMs, loans that couple extended amortization with balloon payment requirements and other contracts of alternative lending. For example, in 2004 these products accounted for 12.5 percent of the origination. By 2006, the fraction increased to 32.1 percent of new origination loans. With the share of conventional and conforming loans declining, the structure of mortgage contacts needs to be examined.

[2] A mortgage contract with negative amortization means the monthly payment does not cover the interest on the outstanding balance. As a result, the principal owed actually increases. We will illustrate such a contract a bit later in the paper.

Table 1: Types of Primary Mortgage Contracts

(share of total contracts)

Type of Contract	**1993**	**1995**	**1997**	**1999**	**2003**	**2005**
Fixed Payment Self-Amortizing (FRM)	84.4	82.6	86.5	90.6	92.8	90.0
Adjustable Rate Mortgage (ARM)	11.0	12.3	9.3	5.9	4.3	5.9
Adjustable Term Mortgage (ATM)	0.2	0.0	0.8	0.8	0.3	0.4
Graduated Payment Mortgage (GPM)	1.0	1.0	1.2	1.0	0.7	1.2
Balloon	0.9	1.6	1.0	0.9	1.1	1.2
Other	1.7	1.6	0.1	0.0	0.1	0.1
Combination of the above	0.8	0.9	1.1	0.8	0.7	1.1
Sample Size	37,183	39,026	35,999	39,034	42,411	45,450

Source: American Housing Survey (AHS)

2.1 General structure of mortgage contracts

Despite all the differences, mortgage loans are just special cases of a general representation. To characterize this representation, some notation needs to be introduced. Consider the expenditure associated to purchase a house of size h with a unit price p. We can think of h as as the number of square feet in the house and p is the price per square foot. If households purchase a house with cash, the total expenditure is then given by ph. Most households do not have assets available that allow a check to be written for ph. As a result, a loan must be acquired to finance this large expenditure.

In general, a mortgage loan requires a downpayment equal to χ percent of the value of the house. The amount χph represents the amount of equity in the house at the time of purchase, and $D_0 = (1-\chi)ph$ represents the initial amount of the loan. In a particular period which we will denoted by n, the borrower faces a payment amount m_n (i.e. monthly or yearly payment) that depends on the size of the original loan D_0, the length of the mortgage, N, and the mortgage interest rate, r^m. This payment can be decomposed into an amortization, (or principal) component, A_n, which is determined by the amortization schedule, and an interest component I_n, which depends on the payment schedule. That is,

$$m_n = A_n + I_n, \qquad \forall n. \tag{1}$$

where the interest payments are calculated by $I_n = r^m D_n$.[3] An expression that determines how the remaining debt, D_n, changes over time can be written as

$$D_{n+1} = D_n - A_n, \qquad \forall n. \tag{2}$$

This formula shows that the level of outstanding debt at the start of period n is reduced by the amount of any principal payment. A principal payment increases the level of equity in the

[3] The calculation of the mortgage payment depends on the characteristics of the contract, but for all contracts the present value of the payments must be equal to the total amount borrowed,

$$D_0 \equiv \chi ph = \frac{m_1}{1+r} + \frac{m_2}{(1+r)^2} + ... + \frac{m_N}{(1+r)^N}.$$

home. If the amount of equity in a home at the start of period n is defined as H_n, a payment of principal equal to A_n increases equity in the house available next period to H_{n+1}. Formally,

$$H_{n+1} = H_n + A_n, \qquad \forall n, \tag{3}$$

where $H_0 = \chi ph$ denotes the home equity in the initial period.[4]

This representation of mortgage contracts is very general and summarizes a large number of different contracts available in financial markets. For example, this formulation can accommodate a no downpayment loan by setting $\chi = 0$ so that the initial loan is equal to $D_0 = ph$. Since this framework can be used to characterize differences in the amortization terms and payment schedules, we use it to describe the characteristics of some of the prominent mortgage loan.

2.2 Mortgage loan with constant payments (FRM)

In the United States, fixed rate mortgages are typically considered the "standard" mortgage contract. This loan product is characterized by a constant mortgage payment over the term of the mortgage, $m \equiv m_1 = ... = m_N$. This value, m, has to be consistent with the condition that the present value of mortgage payments repays the initial loan. That is,

$$D_0 \equiv \chi ph = \frac{m}{1+r} + ... + \frac{m}{(1+r)^{N-1}} + \frac{m}{(1+r)^N}.$$

If this equation is solved for m, we can write

$$m = \lambda D_0,$$

where $\lambda = r^m[1-(1+r^m)^{-N}]^{-1}$. Because the mortgage payment is constant each period, and $m = A_t + I_t$, the outstanding debt decreases over time $D_0 > ... > D_N$. This means the fixed payment contract front loads interest rate payments,

$$D_{n+1} = (1+r^m)D_n - m, \qquad \forall n,$$

and, thus, back loads principal payments,

$$A_n = m - r^m D_n.$$

The equity in the house increases each period by the mortgage payment net of the interest payment component.

$$H_{n+1} = H_n + [m - r^m D_n], \qquad \forall n.$$

We we now present some example to illustrate key propertities of the FRM contract.

Example: Consider the purchase of a house with a total cost of $ph = \$250,000$ using a loan with a 20 percent downpayment, $\chi = 0.20.$,an interest rate of 6 percent annually, and a 30 year maturity. This mortgage loan is for \$200,000. Table 2 illustrates how interest and principal

[4] It is important to state that this framework assumes no changes in house prices for the sake of simplicity. If house prices are allowed to change, the the equity equation would have to allow for capital gains and losses.

payment change per month over the length of the mortgage contract.

Table 2: Characteristics of a Fixed Payment Mortgage

(Interest Rate 6 Percent, 30 year Maturity)

Payment	**Total Payment**	**Interest**	**Principal**	**Remaining Principal**
1	\$1,178.74	\$973.51	\$205.23	\$199,794.77
2	1,178.74	972.51	206.23	199,588.54
120	1,178.74	812.98	365.76	166,655.59
181	1,178.74	686.89	491.85	140,625.26
219	1,178.74	587.23	591.51	120,049.79
240	1,178.74	523.73	655.01	106,940.84
251	1,178.74	487.89	690.95	99,521.83
360	1,178.74	5.71	1,173.03	0.00
Total	424,346.40	224,346.40	200,000.00	

The first two rows of Table 2 examine the mortgage payment in the first and second month of the contract, As can be seen, the monthly payment on this mortgage is \$1,178.74. In the first period, \$973.51 of the monthly payment goes to interest rate payments. This means the principal payment is only \$205.23.[5] Now, consider the mortgage payment 10 years into the mortgage. While the monthly payment does not change, the principal payment has increased to \$365.76, and the interest payment component has decreased to \$812.98. After 10 years, the homeowner has paid off only \$33,344.41 of the original \$200,000 loan. The month after the halfway point in the mortgage occurs at period 181. The interest payment component of the monthly payment still exceeds the principal payment. In payment period 219 - 18 years and 3 month into the contract - the principal component of the monthly payment finally exceeds the interest payment component. From this point forward, the principal payment will be a larger component of the monthly payment as compared to the interest payment. At the end of 20 years, or period 240, we see that the homeowner the principal component of the \$1,178.74 monthly payment is \$655.01. However, \$106,941.84 is still owed on the original \$200,000 loan. The outstanding loan balance does not drop below \$100,000 until payment period 251. With a standard mortgage contract, it takes nearly 22 years to pay off half the of the mortgage loan. The remaining half of the mortgage will be repaid in the final 8 years of this mortgage.

Example: Table 3 examines the standard mortgage contract if the mortgage interest rate increases from 6 percent to 7 percent. A one percent increase in the interest rate increases the monthly mortgage payment from \$1,178.74 to \$1,301.85 - a \$123.11 increase in the monthly payment. Furthermore, the increase in the interest rate results in additional backloading of principal payments. After 10 years, less than \$30,000 of the original balance is paid off. The payment period where the principal component exceeds the interest component does not occur until period 239. In fact, the outstanding balance will not drop below 100,000 until payment 260 which is 9 months later than what occurs if the interest rate is 6 percent.

[5] This the exact same example used in McDonald and Thornton 2008. The numbers presented here are slightly different due to difference in interest rate calculation. McDonald and Thornton calculate the monthly interest rate as $0.06/12 = 0.005$. We calculate the monthly interest as $1.06(1/12) - 1 = 0.004868$. This explains why our payments are slightly lower.

Table 3: Characteristics of a Fixed Payment Mortgage Higher Interest Rate
(Interest Rate 7 Percent, 30 year Maturity)

Payment	Total Payment	Interest	Principal	Remaining Principal
1	$1,301.85	$1,130.83	$171.02	$199,828.98
2	1,301.85	1,129.86	171.99	199,656.99
120	1,301.85	967.32	334.53	170,746.58
181	1,301.85	830.00	471.85	146,322.72
239	1,301.85	647.47	654.38	113,858.74
240	1,301.85	643.77	658.08	113,200.66
260	1,301.85	565.22	736.63	99,965.68
360	1,301.85	7.31	1,294.54	0.00
Total	468,666.00	268,666.00	200,000.00	

This table clearly illustrates the impact of interest rate changes on a mortgage loan. If the total interest payments on the mortgage contract presented in Table 2 are compared with the total interest payments with the mortgage contract presented in Table 3, we find that a one percent increase in the interest rate results in $44,320 dollars of additional mortgage payments over the life of the mortgage.

2.3 Mortgage with constant amortization (CAM)

As we have seen in Table 2 and Table 3, the fixed rate mortgage has the feature that little equity is accrued in the initial years of the mortgage. As we saw, this is because most of the mortgage payment services interest payments. An obvious question is whether a mortgage contract can be designed to allow a homeowner to accrue more equity in the initial periods, and what would be the proprieties of such a contract. A mortgage contract with this property is known as the constant amortization contract. This loan contract allows constant contributions toward equity each period. That is, the amortization schedule is , $A_n = A_{n+1} = A$. Since the interest repayment schedule depends on the size of outstanding level of debt, D_n, and the loan term, N, the mortgage payment m_n is no longer constant over the duration of the loan. Formally, the constant amortization term is calculated by

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

If the expression for the interest payments is used, the monthly mortgage payment, m_n, will decrease over the length of the mortgage. This characteristic of the CAM follows from the decline in outstanding principal over the life of the contract. The monthly payment is determined by

$$m_n = \frac{D_0}{N} + r^m D_n.$$

For this contract, the way that the outstanding level of debt and home equity change are represented by

$$D_{n+1} = D_n - \frac{D_0}{N}, \qquad \forall n,$$

and

$$H_{n+1} = H_n + \frac{D_0}{N}, \qquad \forall n.$$

Example: In order to see the characteristics of this type of contract, we consider a 30 year loan with a 20 percent downpayment requirement and a 6 percent annual interest rate. In Table 4, we present the monthly mortgage payment, principal component, and interest component.

Table 4: Characteristics of a Constant Amortization Mortgage

(Interest Rate 6 Percent, 30 year Maturity, 20 Percent Down)

Payment	**Total Payment**	**Interest**	**Principal**	**Remaining Principal**
1	$1,529.07	$973.51	$555.56	$199,444.44
2	1,526.36	970.81	555.56	198,888.89
120	1,207.27	651.71	555.56	133,333.33
156	1,109.92	554.36	555.56	113,333.33
181	1,042.31	486.76	555.56	99,444.44
240	882.76	327.21	555.56	66,666,67
360	558.26	2.70	555.56	0.00
Total	375,718.58	175,718.58	200.000.00	

As can be seen, the monthly payment with this contract has a much different profile than that of a fixed payment mortgage loan. Clearly, the mortgage payment declines over the life of the loan. The initial payment is nearly 3 times the size of the payment in the last period. Principal payments are constant over the life of the loan, thus allowing for much greater equity accumulation. Half of the original principal will be repaid halfway through the loan. From a wealth accumulation perspective, this is an attractive feature of this contract. However, the declining payment profile is not positively correlated with a normal household's earning pattern during the first half of the life cycle. That is, mortgage payments will be highest when earnings tend to be lower. From a household budget perspective, this could be a very unattractive property.

2.4 Balloon and interest-only loans

The key property of the constant amortization contract is the payment of principal every period. In contrast, a balloon and an interest-only loan has the property of no amortization of principal along the term of the mortgage. A balloon loan is very simple contract where all the principal borrowed is paid-in-full in last period, N. This product tends to be more 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 contract attractive as they are not concerned about paying principal. The amortization schedule for this contract can be written as:

$$A_n = \begin{cases} 0 & \forall n < N \\ (1-\chi)ph & n = N \end{cases} .$$

This means that the mortgage payment in all periods, except the last period, is equal to the interest rate payment, $I_n = r^m D_0$. Hence, we can specify the mortgage payment for this contract as:

$$m_n = \begin{cases} I_n & \forall n < N \\ (1+r^m)D_0 & n = N \end{cases} ,$$

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

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

With an interest-only loan and in the absence of changes in house prices, the homeowner never accrues equity beyond the initial downpayment. Hence, $A_n = 0$ and $m_n = I_n = r^m D_0$ for all n. In essence, the homeowner effectively rents the property from the lender and the mortgage (interest) payments are the effective rental cost. As a result, the monthly mortgage payment is minimize as periodic payments toward equity are not made. With this type of mortgage contract, a homeowner is fully leveraged with the bank. If capital gains are realized, the return on the housing investment is maximized. Another by-product of this contract are large deductions from income taxes if the itemization option is selected.

Example: We will illustrate a balloon contract by examining a 15 year interest-only loan that is rolled into a 15 year fixed payment mortgage. The payment profiles for this contract are presented in Table 5. We also assume an interest rate of 6 percent, and a twenty percent downpayment requirement.

Table 5: Characteristics of a Balloon Mortgage

(Interest Rate 6 Percent, 30 year Maturity, 15 Year Interest Only, 20 Percent Down)

Payment	Total Payment	Interest	Principal	Remaining Principal
1	$973.51	$973.51	$0.00	$200,000.00
2	973.51	973.51	0.00	200,000.00
180	973.51	973.51	0.00	200,000.00
181	1,670.59	973.51	697.08	199,302.92
219	1,670.59	832.25	838.34	170,141.84
240	1,670.59	742.26	928.33	151,562.86
290	1,670.59	487.16	1,183.43	98,898.87
360	1,670.59	8.09	1,662.50	0.00
Total	475,938.02	275,938.02	200,000.00	

As can be seen in Table 5, the interest-only part of the loan means 180 mortgage payments of $973.51 just to cover the interest obligations on the $200,000 loan. After 15 years, the mortgage payment increases to $1,670.59. This is due to the fact that the 15 year balloon loans is rolled into a 15 year fixed rate mortgage. Payment number 219 denotes the month where principal payments exceed interest payments. In period 290, a homeowner will have paid off half of the $200,000 debt. With this type of mortgage contract, it takes more than 24 years to accrue $100,000 in equity.

Example: The structure of some adjustable rate mortgages (ARMs) that have been used in recent years have a very short period of interest only-payments. Table 6 presents the payment profiles for a three year interest-only ARM that rolls into a 27 year standard fixed rate contract. The assumptions for the interest rate, total contract length and downpayment requirement remain unchanged.

Table 6: Characteristics of an ARM, Constant Interest Rate

(Interest Rate 6 Percent, 30 year Maturity, 3 years interest only, 20 Percent Down)

Payment	**Total Payment**	**Interest**	**Principal**	**Remaining Principal**
1	$973.51	$973.51	$0.00	$200,000.00
2	973.51	973.51	0.00	200,000.00
36	973.51	973.51	0.00	200,000.00
37	1228.20	973.51	254.89	199,745.30
120	1,228.20	847.10	381.10	173,648.03
181	1,228.20	715.71	512.49	146,525.31
219	1,228.20	611.86	616.34	125,086.37
240	1,228.20	545.70	682.50	111,427.30
257	1,228.20	486.97	741.23	99,303.08
360	1,228.20	5.95	1,222.25	0.00
Total	432,983.16	232,983.16	200,000.00	

Interest payments for interest-only ARM are $973.51. Once the mortgage holder transitions into a 27 year standard contract, the payment rises by $254.69 to 1,130.83. This increase is not caused by an interest rate increase, but rather a payment toward principal.

Example: Recently, mortgage interest rates have begun to increase. In order to examine the effect of an interest rate increase for someone who has an interest-only ARM, we allow the interest rate to increase to 7 percent for the standard fixed rate mortgage that is taken out after the 3 year ARM expires. In Table 7, the various payment patterns are presented. A one hundred basis point increase in the interest rate causes the monthly payment to increase to $1,347.72 from $1,228.20. This is a 38 percent increase in the mortgage payment. This example illustrates the risk that a homeowner faces when the interest rate increases prior to transitioning into a standard fixed rate mortgage.

Table 7: Characteristics of an ARM, Rising Interest Rate

(Interest Rate 6 to 7 Percent, 30 year Maturity, 3 years interest only, 20 Percent Down)

Payment	**Total Payment**	**Interest**	**Principal**	**Remaining Principal**
1	$973.51	$973.51	$0.00	$200,000.00
2	973.51	973.51	0.00	200,000.00
36	973.51	973.51	0.00	200,000.00
37	1,347.72	1,130.83	216.89	199,783.11
120	1,347.72	1,001.40	346.32	176,762.45
181	1,347.72	859.24	488.48	151,477.91
239	1,347.72	670.28	677.44	117,869.91
240	1,347.72	666.45	681.27	117,188.65
264	1,347.72	567.74	779.98	99,630.97
360	1,347.72	7.57	1,340.15	0.00
Total	471,707.64	271,707.64	200,000.00	

2.5 Graduate Mortgage Payments (GPM)

The repayment structures of the previous contracts are relatively rigid. Payments are either constant during the entire contract, or proportional to the outstanding level of debt. It is possible to design mortgage contracts with a variable repayment schedule. In this section, we focus on a special case where the mortgage loan payments increase over time, $m_1 < ... < m_N$. This feature could be attractive to first time buyers as payments are initially lower than payments in a standard contract. In an environment where households income grows over the life-cycle, this loan product allows for an stable housing expenditure as a ratio to income. However, 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 historically. Mortgage contracts with variable repayment schedules are known as Graduated Mortgage Payment (GPM) contracts. This contracts are especially of interest as they have similar features to the mortgage contracts sold to subprime borrowers.

The repayment schedule depends on the growth rate of these payments. The growth rate of payments is specified in the mortgage contract and anyone considering this contract must know the value of this parameter. We will present some examples to illustrate why a household must be aware of value of this parameter if such a contract is selected. The typical growth patterns are either geometric or arithmetic. We will foucus on GPM's with geometric growth patterns.

With this type of contract, mortgage payments evolve according to a constant geometric growth rate given by

$$m_{n+1} = (1 + g)m_n,$$

where $g > 0$. This also means the amortization and interest payments also grow as,

$$m_n = A_n + I_n.$$

The initial mortgage payment is determined by

$$m_0 = \lambda_g D_0,$$

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

$$D_{n+1} = (1 + r^m)D_n - (1 + g)^n m_0,$$

and the amortization term is $A_n = \lambda_g D_0 - r^m D_n$.

Example: In order to see the implications of such a contract, Table 8 presents the payment details where the mortgage payments grow at 1 percent per payment. We maintain the assumption of a 30 year contract with a 20 percent downpayment requirement, and a 6 percent annual interest rate.

Table 8: Characteristics of a Graduated Payment Mortgage: Geometric

(Interest Rate 6 Percent, 30 year Maturity, 20 Percent Down, Payment Growth 1 Percent)

Payment	Total Payment	Interest	Principal	Remaining Principal
1	$195.18	$973.51	-$778.33	$200,778.33
2	197.13	977.30	-780.17	201,558.50
120	637.79	1,459.98	-822.19	300,763.84
181	1,170.26	1,666.83	-496.57	342,933.91
220	1,725.11	1,719.49	5.57	353,260.70
240	2,104.96	1,701.52	403.44	349,161.20
344	5,924.70	508.34	5,416.36	99,017.59
360	6,947.18	33.65	6,913.53	0.00
Total	682,149.10	482,149.10	200,000.00	

Clearly, the initial payments of this mortgage are very low which illustrates why this contract is attractive for first-time buyers. These low payments come at a cost - the monthly payment does not cover the interest on the outstanding balance. This means the remaining principal increases. This mortgage contract exhibits negative amortization. In this example, we see that throughout the first 219 months of this mortgage, the mortgage payment does not cover the interest on the principal. The maximum remaining principal for this example increases to over $350,000 from the original $200,000 debt. It is interesting to note that the final $100,000 principal is paid is the final 16 months of this mortgage. Because the principal is back-loaded and must be paid off, the monthly payment must increase over time. As can be seen, the monthly mortgage payment tops-out in the last month of the contract at $6,913.53. A homehold who chooses this contract pays $482,149.10 in total interest rate payments. Compared to the FRM contract presented in Table 2, total interest payments are more than double. These characteristics make GPM's risky from a lender's perspective as the potentail for default is greater. This is one reason why this type of contract has not historically been a factor in the mortgage market.

Example:In order to see the importance of the payment growth parameter, we reduce the monthly growth rate from 1 percent to .1 percent. The results from changing the monthly growth rate are presented in Table 9. With a lower monthly growth rate, negative amortization does not occur. Perhaps, the most striking result is over the total interest payments over the length of the mortgage contract. When the mortgage contract has a 1 percent monthly growth rate, total interest payments are $482,149.10. If the monthly growth rate fall to .1 percent, total interest payments are $246,356.77. Clearly there is a cost to loans with negative amortization.

Table 9: Characteristics of a Graduated Payment Mortgage: Geometric

(Interest Rate 6 Percent, 30 year Maturity, 20 Percent Down, Payment Growth .1 Percent)

Payment	Total Payment	Interest	Principal	Remaining Principal
1	$1030.68	$973.51	$57.17	$199,942.83
2	1031.71	973.23	58.48	199,884.36
120	1160.85	884.19	276.67	181,372.92
240	1308.78	614.19	694.59	125,485.59
273	1352.67	489.90	862.77	99,782.99
360	1475.56	7.15	1468.41	0.00
Total	446,356.77	246,356.77	200,000.00	

2.6 Combo loan (CL)

In the late 1990's a new mortgage product became popular as way to avoid large downpayment requirements and mortgage insurance.[6] This product is known as the combo loan and amounts to having two different loans. There are different type of combo loans offered in the industry; for example a "80-15-5 loan" implies a primary loan for 80 percent of the value, a secondary loan for 15 percent, and a 5 percent downpayment. Another example is the so-called "no downpayment" or a "80-20 loan" that is comprised of a primary loan with a loan-to-value ratio of 80 percent and a second loan for the 20 percent downpayment.

Formally, the primary loan covers a fraction of the total purchase, $D_1 = (1-\chi)ph$, with a payment schedule, m_n^1, and maturity, N_1. The second loan partially or fully covers the downpayment amount, $D_2 = \varkappa\chi ph$, 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_n^2, and a maturity $N_2 \leq N_1$. In this case

$$m_n = \begin{cases} m^1 + m^2 \text{ when } N_2 \leq n \leq N_1 \\ \\ m^1 \text{ when } n < N_2 \end{cases},$$

Since both loans are of fixed rate form, the laws of motion are equivalent to those presented in the FRM contract discussion.

Example: Table 11 presents the profile for a "80-20" combo loan for our $250,000 house. The first $200,000 is borrower with the standard fixed payment mortgage at 6 percent interest. The remaining $50,000 is financed using another fixed payment mortgage that incorporates a risk premium of 2 percent. We will assume the second mortgage is also for 30 years. In reality, the second mortgage is usually for 10 or 15 years. The second loan for $50,000 increases the monthly payment by $357.20. The mortgage payment pattern of this combo-loan is very similar to the basic fixed payment mortgage. Of course, this should not be a surprise as the combo-loan is nothing more that a combination of two fixed rate mortgages. An obvious question is why not take out one fixed rate mortgage with no downpayment? The reason is that mortgage insurance would have to taken out on such a mortgage. The total monthly payment including the mortgage insurance would exceed the monthly payment on the combo loan. The combo loan is attractive

[6] 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.

for one segment of households who desire to enter the housing market - young households with high income. These households have an income that can afford the mortgage payment, but have not had time yet to accumulate the amount of saving required for the downpayment.

Table 10: Characteristics of a Combo Loan Mortgage

(Interest Rate 6 Percent, 30 year Maturity, 2nd Loan Rate 8 Percent)

Payment	Total Payment	Interest	Principal	Remaining Principal
1	$1,535.94	$1,295.21	$240.73	$249,759.27
2	1,535.94	1,293.98	241.96	249,517.32
120	1,535.94	1,094.04	441.90	210,261.45
181	1,535.94	931.49	604.45	178,528.13
156	1,535.94	554.36	555.56	113,333.33
228	1,535.94	765.78	770.16	146,301.19
240	1,535.94	716.53	819.41	136,742.23
281	1,535.94	522.76	1,013.15	99,220.31
360	1,535.94	7.99	1,527.95	0.00
Total	552,938.40	302,938.40	250,000.00	

3 Model of Housing Decisions and Mortgage Choice

In the prior section, we described various features and properities of mortgage contracts that are available in the marketplace. However, this discussion did not go into detail about the charcateristics of individuals who might choose a particular contract. In addition, no mention was made on the ramification of alternative contracts for the aggregate economic performance. The only way to discuss these issues is by analyzing alternative mortgages in the context of a model economy where household have the ability to choose over a set of mortgage products. In this section, we will use a simplified version of the consumer problem employed in Chambers, Garriga, and Schlagenhauf (2007a,b) to address the implications of mortgage choice for the performance of the aggregate economy, (i.e. house prices, interest rates, etc.). This model will allow us to focus on how type of mortgage influences the homeownership decision. This modeling style allows for quick analysis of aggregate implications of mortgage markets and yet maintains the details needed to identify implications across different income and wealth distributions as well as age cohorts.

We will now describe key features of our framework.

Age structure: We develop a life-cycle model with *ex-ante* heterogeneous individuals. Let j denote the age of an individual and let J represent the maximum number of periods an individual can live. At every period, an individual faces mortality risk and uninsurable labor earning uncertainty. The survival probability, conditional on being alive at age j, is given by $\psi_{j+1} \in [0,1]$, with $\psi_1 = 1$, and $\psi_{J+1} = 0$. Earning uncertainty implies that the individual is subject to income shocks that cannot be insured via private contracts. In addition, we assume that annuity markets for mortality risk are absent. The lack of these insurance markets gives raise to a demand for precautionary savings to minimize fluctuations in consumption goods, c, and in the consumption of housing services, s, over the life-cycle.

Preferences: Individual preferences rank goods (consumption and housing) according to a utility function $u(c, s)$. The utility function has the property that additional consumption increases utility and also results in declining marginal utility. Consumption over periods is discounted at a rate β and, thus, lifetime utility is defined as:

$$v_1 = E\sum_{j=1}^{J}\psi_j\beta^{j-1}u(c_j, s_j). \tag{4}$$

The assumption that utility is separable over time allows for a simple recursive structure of preferences for every realization of uncertainty, $v_1 = u(c_1, s_1) + \beta E\sum_{j=2}^{J}\psi_j\beta^{j-2}u(c_j, s_j)$. Using the definition of expected lifetime utility we can write the previous expression as

$$v_1 = u(c_1, s_1) + \beta E v_2,$$

where $v_2 = \sum_{j=2}^{J}\psi_j\beta^{j-2}u(c_j, s_j)$ represents the future lifetime expected utility.

Asset structure: Individuals have access to a portfolio of assets to mitigate income and mortality risk. We consider two distinct assets : a riskless financial asset denoted by a' with a net return r, and a risky housing durable good denoted by h' with a market price p where the prime is used to denote future variables. To keep things simple, we assume that the price of housing does not change over time, so $p = p'$. This assumption simplifies the problem, since households do not need to anticipate changes in house prices. A housing investment of size h' can be thought of as the number of square feet in the house. A house of size h' yields s services.[7] If a household does not invest in housing, $h = 0$, the household is a renter and must purchase housing services from a rental market.. The rental price of a unit of housing services is R.

Housing investment is financed through long-term mortgage contracts and is subject to transaction costs. We need to summarize the information required so that monthly payment, remaining principal, and equity position in the house can be identified for any mortgage contract. It turns out that the critical information is the house size, h, the type of mortgage contract, z, and remaining length of the mortgage, n. With this information set, we can identify the desired information concerning a household's mortgage contract.

Household income: Household income varies over the life-cycle and is dependent on whether the individual is a worker or a retiree. For workers that are younger than the mandatory retirement age, $j < j^*$, income is stochastic and depends on the basic wage income,w, a life-cycle term that depends on age υ_j, and the persistent idiosyncratic component ϵ drawn from a probability distribution that evolves according to the transition law $\Pi_{\epsilon,\epsilon'}$. For an individual older than j^*, a retirement benefit, θ, is received from the government equal to θ. Income can be specified a

$$y(a, \epsilon, j, \upsilon_j) = \begin{cases} w\epsilon\upsilon_j + (1+r)a, & if \quad j < j^*, \\ \theta + (1+r)a, & if \quad j \geq j^*. \end{cases} \tag{5}$$

In the presence of mortality risk and missing annuity markets we assume borrowing constraints $a' \geq 0$, to prevent households from dying with negative wealth. We also assume that households are born with initial wealth dependent on their initial income level.

The Decision Problem: Individuals make decisions over consumption goods, c, housing services, s, a mortgage contract type, z, and investment in assets , a', and housing, h'. The household's current period budget constraint depends on the household's asset holdings, the current housing investment, the remaining length of the mortgage, labor income shock, and household age. We can isolate five possible decision problems that a household must solve. The value function for a household v is described by a vector of so-called state variables that provide sufficient

[7] For the sake of simplicity, we assume a linear relationship between house and services generated. In other words, $s = h'$.

information of the position of the individual at the start a the period. The state vector is characterized by the level of assets at the start of the period, a, the prior period housing position, h, the number of periods remaining on an existing mortgage, n, mortgage contract type, z,the value of the current period idiosyncratic shock ϵ and age of the household, j. To keep the notation of the individual's characteristics relatively brief, we define $x = (a, h, n, z, \epsilon, j)$. Using a recursive approach, we know that the household decisions for c, s, z, a', and h' depend the x vector. For example, suppose that x contains the following information, $x = (1000, 2000, 56, FRM, 2, 36)$. This vector is telling us that the individual has \$1,000 of non-housing wealth, a 2,000 square feet home with a market value given by $p \times 2,000$ where p represents the given price per square feet, 56 pending mortgage payments with the bank, has a FRM mortgage, the income shock this period is 2 times average income, and the individual's age is 36. The decisions made by this individual are going to be different than those of an individual that has a different state vector $x(20000, 2000, 56, FRM, 2, 41)$, since this other individual has more wealth and is 5 years older. Individuals that do not own a home, the information vector would have many zeros entries, such as $x = (a, 0, 0, 0, \epsilon, j)$.

Given all the possible options, we can think of the individual as being in one of five situations with respect to the housing investment and mortgage choice decisions. These five decisions are summarized in Table 11.

Table 11: Basic Structure of the Model

Current renter: $h = 0$	Continues renting $h' = 0$
	Purchases a house $h' > 0$
Current owner: $h > 0$	Stay house: $h' = h$
	Change size (Upsize or downsize): $h' \neq h$
	Sell and rent: $h' = 0$

We now will explain in more detail the various decisions problems. First, we consider an individual that starts as a renter, and then we consider the decision problem of an individual that starts as a home-owner.

- **Renters:** An individual that is currently renting ($h = 0$) has two options: continue renting ($h' = 0$), or purchase a house ($h^{'} > 0$). This is a discrete choice in ownership that can easily be captured by the value function v (present and future utility) associated with these two options. Given the relevant information vector $x = (a, 0, 0, 0, \epsilon, j)$, the individual chooses the option with the higher value which can be expressed as

  $$v(x) = \max\{v^r, v^o\}.$$

  The value associated with continued renting is determined by the choice of goods consumption, c, housing services, s, and a' which solves the problem

  $$v^r(x) = \max u(c, s) + \beta_{j+1} E v(x'), \tag{6}$$

$$s.t. \quad c + a' + Rs = y(x).$$

The decisions are restricted to positive values for c, s, a' and the evolution of the state vector that summarizes the future information as given by $x' = (a', 0, 0, 0, \epsilon', j+1)$ where a' denotes next period's wealth, ϵ' represents next period's realization of the income shock, and $j+1$ captures the fact that the individual will be one period older.

The individual that purchases a house solves a different problem as choices must now be made over $h\prime > 0$, a mortgage type, z, as well as c, s, and a'. This decision problem can be written as:

$$v^o(x) = \max u(c, s) + \beta_{j+1} E v(x'), \tag{7}$$

$$s.t. \quad c + a' + [\phi_b + \chi(z')]ph' + m(x) = y(x),$$

It should be noted that a purchase of a house requires two up front expenditures: a transaction costs (i.e. realtors fees, closing costs, etc.) that are proportional to the value of the house $\phi_b ph'$, and a downpayment to the mortgage bank for a fraction $\chi(z')$ of the value of the house (i.e. 20 percent down of the purchase price). These payments are only incurred at the time of the purchase. Home owners also must make mortgage payments. These payments denoted by $m(x)$ and depends on relevant variables such as the loan amount $(1-\chi)ph'$, the type of mortgage (i.e. FRM vs. ARM), the length of the contract (i.e. 30 or 15 year), and the interest rates associated with a particular loan. It is important to restate that a homeowner that purchase a house of size h' receives s units of housing consumption. The value of these housing services is given by Rs^h.This value does not appear in the budget constraint as these services are consumed internally. As a result, the value of services generated are cancelled by the value of services consumed internally. The household's decisions influence the information state in the following period. That is, $x' = (a', h', N(z) - 1, z', \epsilon', j+1)$. Again, to determine the choice of whether to continue renting or purchase a home, we need to solve both problems $v^r(x)$ and $v^o(x)$ and find the one that yields the highest value. When $v^r(x) > v^o(x)$ the individual continues to rent, and otherwise becomes a home owner.

- **Owners:** The decision problem for individual that currently owns a house, $(h > 0)$, has a similar structure. However, a homeowner faces a different set of options as they can choose stay in the same house, $(h' = h)$, purchase a different house, $(h' \neq h)$, or sell the house and acquire housing services through the rental market, $(h' = 0)$. Given the relevant information $x = (a, h, n, z, \epsilon, j)$ the individual solves.

$$v(x) = \max\{v^s, v^c, v^r\},$$

Each of these three different values are calculated by solving three different decision problems. If the household decides to stay in the current house the optimization problem can be written as:

$$v^s(x) = \max u(c, h') + \beta_{j+1} E v(x') \tag{8}$$

$$s.t. \quad c + a' = y(x) - m(x).$$

This problem is very simple, since the home owner only as to make decisions on consumption and saving after making the mortgage payment. If the counter of pending mortgage payments is zero, $n = 0$, then the implied mortgage payment is also set to zero, $m(x) = 0$. The future state of information for this case is given by $x' = (a', h, n', z', \epsilon', j+1)$ where $n' = \max\{n-1, 0\}$.

For the individual who decides to either up-size or down-size, $(h \neq h')$, the household problem becomes

$$v^c(x) = \max u(c, h') + \beta_{j+1} E v(x')$$

$$s.t. \quad c + a' + [\phi_b + \chi(z')]ph' + m(x) = y(x) + [(1 - \phi_s)ph - D(n, z)].$$

This individual has to sell the property to purchase a new one. The choices depend on the income received from selling the property, ph, net of transactions costs from selling, ϕ_s, and remaining principal $D(n, z)$ owed to the lender. The standing balance depends on whether the mortgage has been paid off ($n = 0$ and $D(n, z) = 0$) or not ($n > 0$ and $D(n, z) > 0$) and the type of loan contract. For example, mortgage loans with a slow amortization usually imply large remaining principal when the property is sold over the length of the loan, whereas contracts such as the constant amortization imply a much faster repayment. For the new home, a new loan $z\prime$ must be acquired to purchase the house $h' > 0$. The relevant future information is given by $x' = (a', h', N - 1, z', \epsilon', j + 1)$.

Finally, we solve the problem of an individual that sells the house $h > 0$ and becomes a renter $h' = 0$. [8] The optimization problem is very similar to the previous one. However, in this case the individual must sell their home and rent Rs. Formally:

$$v^r(x) = \max u(c, s) + \beta_{j+1} E v(x'), \tag{9}$$

$$s.t. \quad c + a' + Rs = y(x) + [(1 - \phi_s)ph - D(n, z)],$$

where the relevant future information is simply given by $x' = (a', 0, 0, 0, \epsilon', j + 1)$. Given the initial information summarized in x, the choice of whether to stay in the house, change the housing size, or sell the house and become a renter depends on the sizes of v^s, v^c,and v^r.

4 Aggregation and Parameterization

We want our model economy to be consistent with certain features of the US economy. In particular, we want to ensure that the choice of functional forms and parameter values are consistent with key features of the U. S. housing market. To replicate these features, we need to aggregate the microeconomic behavior of all the households in the economy. Since individual are heterogenous along 5 different dimensions: level of wealth, housing holdings, pending mortgage payments, type of mortgage use to finance the house, income shock and age, we need to aggregate taking into account the number of individuals that have the same characteristics, and the sum across these characteristics. In order to aggregate we define $\Phi(x)$ as the fraction of individuals that have a given level of characteristics $x = (a, h, n, z, \epsilon, j)$.

We can calculate aggregate statistics of the economy be taking the weighted average of all the household level decisions across characteristics. As an example we would generate the aggregate housing stock by calculating

$$H = \int h'(x)\Phi(dx);$$

aggregate wealth by calculating and aggregate housing services would be calculated as

$$W = \int a'(x)\Phi(dx);$$

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

and the aggregate consumption of housing services as

$$S = \int s(x)\Phi(dx).$$

The model can generate other aggregates of interest in a similar manner.

We will start by discussing how the model is parameterized.

Demographics: A period in the model is taken to be three years. Individuals enter the labor force at age 20 (model period 1) and potentially live till age 86 (model period 23). Retirement is assumed to be mandatory at age 65 (model period 16). Individuals survive to the next period with probability $\psi_{j+1.}$These probabilities are set at survival rates observed in 1994, and the data are from the National Center for Health Statistics, *United States Life Tables*, 1994. The size of the age specific cohorts, μ_j, need to be specified. Because of our focus on steady state equilibrium, these shares must be consistent with the stationary population distribution. As a result, these shares are determined from $\mu_j = \psi_j \mu_{j-1}/(1+\rho)$ for $j = 2, 3, ..., J$ and $\sum_{j=1}^{J} \mu_j = 1$, where ρ denotes the population growth rate. Using the resident population as the measure of the population, the annual growth rate is set at 1.2 percent.

Functional forms: The choice of preferences is based on empirical evidence. The first-order condition that determines the optimal amount of housing consumption is given by

$$\frac{u_{s_j}}{u_{c_j}} = R,$$

where at the optimum $s_j = h'_j$. Jeske (2005) documents that the h_j/c_j ratio is increasing by age j. He points out that standard homothetic preferences over consumption and housing services $u(c_j, s_j) = [\gamma c_j^\sigma + (1-\gamma)s_j^\sigma]^{\frac{1}{\sigma}}$ imply a constant ratio

$$\frac{h_j}{c_j} = \left(\frac{(1-\gamma)}{\gamma R}\right)^{\frac{1}{1-\sigma}},$$

since the parameters γ and σ as well as the rental price R do not vary across age. Therefore, this preference specification is inconsistent with the empirical evidence over the life cycle. A preference structure that is consistent with the evidence is given by

$$u(c, s) = \gamma \frac{c^{1-\sigma_1}}{1-\sigma_1} + (1-\gamma)\frac{s^{1-\sigma_2}}{1-\sigma_2}$$

where the implied first-order condition is given by

$$\frac{h_j^{\sigma_2}}{c_j^{\sigma_1}} = \frac{(1-\gamma)}{\gamma R},$$

This expression represents a nonlinear relationship between h_j and c_j that varies by age j. The coefficients, σ_1, and σ_2, determine the curvature of the utility function with respect to consumption and housing services. The relative ratio of σ_1 and σ_2 determines the growth rate of the housing to consumption ratio. A larger curvature in consumption relative to the curvature in housing services implies that the marginal utility of consumption exhibits relatively faster diminishing returns. When household income increases over the life-cycle (or different idiosyncratic labor income shocks), a larger fraction of resources are allocated to housing services. We set $\sigma_2 = 1$ and $\sigma_2 = 3$ to match the observed average growth rate while the preference parameter γ is estimated. The discount factor, β, is set at 0.976 which is derived from Chambers, Garriga, and Schlagenhauf (2007a).

Endowments: Workers are assumed to have an inelastic labor supply, but the effective quality of their supplied labor depends on two components. One component is an age-specific, $\upsilon_{j,}$ and is designed to capture the "hump" in life cycle earnings. We use data from U.S. Bureau of the Census, "Money, Income of Households, Families, and Persons in the Unites Stated, 1994," *Current Population Reports*, Series P-60 to construct this variable. The other component captures the stochastic component of earnings and is based on Storesletten, Telmer and Yaron (2004). 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 value ϵ are

$$\epsilon \in \mathcal{E} = \{4.41, 3.51, 2.88, 2.37, 1.89\}$$

and the transition matrix is:

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

Each household is born with an initial asset position. The purpose of this assumption is to account for the fact that some of the youngest households who purchase housing have some wealth. Failure to allow for this initial asset distribution creates a bias against the purchase of homes in the earliest age cohorts. As a result we use the asset distribution observed in *Panel Study on Income Dynamics* (PSID) to match the initial distribution of wealth for the cohort of age 20 to 23. Each income state has assigned the corresponding level of assets to match the nonhousing wealth to earnings ratio.

We choose the basic level of earnings w as a scaler to match labor earnings over total earnings

Housing: The housing market introduces a number of parameters. The purchase of a house requires a mortgage and downpayment. In this paper we focus on the 30 year fixed rate mortgage as the benchmark mortgage. As a result of the assumption that a period is three years, we set the mortgage length, N, to ten periods. The downpayment requirement, χ, is set to twenty percent matching facts from the *American Housing Survey.* Buying and selling property is subject to transaction costs. We assume that all these costs are paid by the buyer and set $\phi_s = 0$ and $\phi_b = 0.06$.

Because of the lumpy nature of housing, the specification of the second point in the housing grid has important ramifications. This grid point, $\underline{h}$, determines the minimum house size, and has implications for the timing of the purchase of housing investment, wealth portfolio decisions and, the homeownership rate. To avoid having the choice of this variable having inadvertent implications for the results, we determine the size of this grid point as part of the estimation problem.

4.1 Estimation

We estimate five parameters using an exactly-identified method of moments approach. The parameters that need to be estimated are the interest rate , r, the rental rate for housing, R, the price of housing, p, the wage rate w, and the size of the smallest housing investment position. We identify these parameter values so that the resulting aggregate statistics in the model economy are equal to five targets observed in the U.S. economy.

1. **Wealth to gross income ratio** (W/I) :We find the target is the ratio of non-housing wealth to gross income which is about 2.541, (annualized value) for the period 1958-2001.

2. **Housing stock to wealth ratio** (H/W) : In this ratio the housing capital stock is defined as the value of fixed assets in owner and tenant residential property. The housing stock data is from the fixed asset tables of the Bureau of Economic Analysis. We find the ratio of the housing stock to nonhousing wealth to be 0.43.

3. **Housing services to consumption of goods ratio** (RS/C) : The targeted housing consumption to nonhousing consumption is also based on NIPA data where housing services are defined as personal consumption expenditure for housing and nonhousing consumption is defined as nondurable and services consumption expenditures net of housing expenditures. The targeted ratio for 1994 is 0.23, but the number does not vary greatly over the period 1990-2000. This value is from Jeske(2005).

4. **Labor earning over total earnings:** The evidence suggest from NIPA data that labor share of the economy is about 70 percent. We determine the value of w to match this observation.

5. **Homeownership Ratio:** This target is based on data from the *American Housing Survey* for 1994 and is equal to 64.0 percent.

Table 11 summarizes the parameter estimates and the empirical targets. The moments and the parameter values are presented in annual terms. As can be seen, the model does a good job of matching the moments of the U.S. economy.

Table 11: Method of Moments Estimates (values in annual terms)

Statistic	Data	Model Estimate	% Error
1) Ratio of wealth to gross domestic product	2.541	2.549	0.314
2) Ratio of housing stock to Fixed capital stock	0.430	0.4298	-0.047
3) Ratio housing services to consumption of goods	0.230	0.235	2.7
4) Labor earnings over total earnings	0.700	0.71	1.4
5) Homeownership Rate	0.640	0.643	0.468

Parameter	Value
1) Interest rate, r	0.0546
2) Rental price, R	0.3403
3) Housing price, p	1.4950
4) Wage rate, w	0.8768
5) Minimum house size, $\underline{h}$	1.4480

4.2 Model Evaluation

We can now take a more in depth look at the results generated in a distribution manner. In Table 12, we will begin by looking at the homeownership rate across both the age and income distribution.

Table 12: Homeownership Rates by Age

Variable	Homeownership Rate					
by Age Cohorts	**Total**	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Data 1994	64.0	40.0	64.5	75.2	79.3	77.4
Baseline Model 1994	64.3	37.1	80.6	81.5	81.5	62.5

Data source: Housing Vacancies and Homeownership (CPS/HVS) and American Housing Survey (AHS)

Another dimension of interest is the consumption of housing services. We measure average consumption of housing services by computing the average size of an owner-occupied house. Data from the *American Housing Survey* (AHS) finds the average owner-occupied house is 2,137 square feet. Our model implies an average house size of 1,895 square feet. In Table 13, we report observed housing size by age cohorts. We find that the model does a reasonable job of getting homeowners in appropriately sized homes. The average of most age cohorts is within a few hundred square feet of the data. We find that home size is increasing with age which is observed only until age 65 in the data. [9]

Table 13: Owner-occupied Housing Consumption

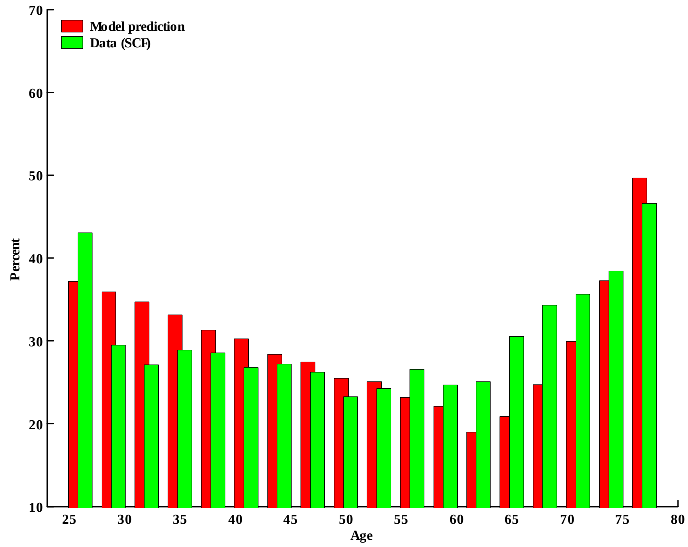
Simulation	Sqft. Owners[1]					
		by Age Cohorts				
	Total	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Data 1994	2,137	1,854	2,220	2,301	2,088	2,045
Baseline Model 1994	1,896	2,013	1,787	1,736	2,242	2,452

Data source: American Housing Survey (AHS)

Since households make savings decisions with respect to assets, the portfolio allocations implied by the model can be analyzed. In the model, a households financial portfolio is comprised of asset holding and equity in housing investment. We use data from the 1994 *Survey of Consumer Finances* to determine the importance of housing in household portfolios. We define assets as bond and stock holdings and housing is defined as the respondent's estimated value of their house adjusted for the remaining principal. The data indicates housing makes up a large fraction of a household's portfolio in the youngest age cohorts. This fraction declines as the household ages until around the retirement age, and then increases as households consume their non-housing wealth after retirement. As can be seen in Figure 1, the model generates a very similar pattern.

[9] It should be noted that the full equilibrium model with landlords in Chambers, Garriga, and Schlagenhauf (2007a,b) does capture the humped shaped pattern in home size.

Figure 1: Housing in the Portfolio by Age



Data source: Survey Consumer Finance (SCF)

5 Mortgage Choice

In this section we look at the implications of mortgage innovation on the housing market paying particular attention to the rate of home ownership. We will focus on two of the largest mortgage innovations: the introduction of an ARM-type mortgage contract, and the introduction of the combo loan contract. In the first example households face an addition decision on the type of mortgage to utilize to finance their home purchase. We will allow potential home buyer to choose between a 30 year fixed payment mortgage with a 20 percent downpayment and a ARM style mortgage with 3 years of interest only payments followed by a 27 year fixed payment mortgage. This simulation generates an aggregate homeownership rate of 65.83 percent which is an increase of 1.5 percent from the baseline simulation. The effects are even more dramatic when looking at homeownership rates by age.

Table 14: Homeownership by Age Including an ARM Mortgage

Simulation	**Homeownership Rate**					
		by Age Cohorts				
	Total	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Benchmark	64.3	37.1	80.6	75.2	79.3	77.4
Model	65.8	49.1	80.3	76.3	72.9	64.7

The table shows a very similar pattern to the baseline case with a few important differences. The biggest difference is the large increase in homeownership by the youngest cohort. For households under 35 the homeownership has surged to nearly 50 percent. Some of this increase in ownership is offset by a slight decrease in ownership later in life. The explanation for this is the labor income shocks for some of those that became owners using the ARM mortgage.

The decision to own early in the life delays the accumulation of capital assets which insures the homeowner against bad income shocks. The average house size in this economy is 1759 square feet. This implies that the introduction of ARMs leads to a large increase in the purchase of smaller homes which tend to be purchased by lower income households who tend to be more exposed to labor income shocks. Without this protection some homeowners will be unable to make mortgage payments and are thus renters.

When looking at mortgage finance and selection, we find that 51.7 percent of homeowners have some form of mortgage debt. As for the type of mortgage 35.5 percent are carrying debt with a fixed payment mortgage and 16.2 percent are using the ARM mortgage. We find that the only households that utilize the ARM mortgage lie in the bottom quintile of the income distribution. The ARM mortgage is attracting only the low income households into the housing market. Thus, we see that mortgage contracts can influence the asset decisions over the life cycle.

The next example considers the choice between a standard fixed rate mortgage and a combo loan where 80 percent of the home value is financed with a traditional fixed payment mortgage and the other 20 percent is financed with a another fixed payment mortgage with 2 percent interest rate premium. We find that the aggregate homeownership rate in this economy is 68.65 percent. The introduction of a combo loan increase the homeownership rate by 4.3 percent. Table 15 shows how the homeownership rate breaks down by age in this example. Just as with the ARM mortgage we see that the homeownership rate of the youngest cohort increases from 37 to nearly 43 percent. However, because the payments of the typical combo loan are higher than a corresponding ARM, income constraint prevent some young households from entering the market. Unlike the ARM mortgage, the combo loan appears to have a positive effect across the entire age profile. Every age cohort has a homeownership rate at or above what was found in the baseline case.

Table 15: Homeownership by Age Including Combo Loans

Simulation	**Homeownership Rate**					
		by Age Cohorts				
	Total	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Benchmark Model 1994	64.3	37.1	80.6	81.5	81.5	62.5
Model	68.6	42.2	88.0	81.6	83.2	66.9

The average home size in this economy is 1909 square feet. This implies that the combo loan encourages the purchase of larger homes which are only affordable to the higher income households. We find that only 45.3 percent of the households are carrying mortgage debt with 32.6 percent having debt through a fixed payment mortgage, and 12.7 percent carrying a combo loan. We also find that combo loans are used in the bottom 40 percent of the income distribution. The income of an ARM household is lower than that of your average combo loan household.

6 Conclusions

This paper addresses a number of issues facing mortgage finance and potential home buyers. The recent innovations in the mortgage market have greatly expand the types of loans home buyers could utilize. These products very greatly in terms of payment size, composition of interest versus principal, and amortization schedule. Some products, like interest-only loans, increase affordability by reducing the payments size. However, these products typically slow the accumulation of equity and thus become less attractive for wealth accumulation. Some mortgage types can generate negative amortization which would seem to be highly unattractive to potential mortgage lenders. Other products, like combo loans, seeks to increase affordability by reducing downpayment requirements. These mortgages are characterized by larger mortgage payments. Given the typical government stance of seeking greater homeownership, both types of products appear to do what was intended. In a standard macroeconomic model, we find that the typical ARM style mortgage should generate large increases in the homeownership rate of young households. However, because of a delay in capital asset accumulation, you may find lower homeownership by older households. Combo loans tend to also drive up homeownership. For the young households this increase in homeownership is not a pronounced as with ARMs, there appears to be no reduction in homeownership further down the life cycle. Thus, it should come as no surprise that the introduction of these mortgage products coincided with the increase in homeownership we saw from 1995 through 2005. It should also not be surprising that as these instruments are removed from the mortgage market, the homeownership rate declines.

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