Innovations in Mortgage Markets and Increased Spending on Housing

Mark Doms
Federal Reserve Bank of San Francisco

and

John Krainer
Federal Reserve Bank of San Francisco

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Abstract: Over the past several decades, innovations in the mortgage market have benefited consumers through a variety of channels. Innovations include the lowering of down payment requirements, increased flexibility in repayment schedules, and the reduction of costs associated with extracting equity from homes. To ascertain the ways in which these innovations would alter spending on housing, we develop a model of the home buying and mortgage choice decision that produces a number of testable implications. For instance, the lowering of down payment requirements should result in homeownership rates increasing, especially for households that are traditionally cash constrained. In fact, we show that between 1994 and 2004, the homeownership rate for young and low-income households rose sharply. Increased flexibility of repayment schedules should assist households in smoothing their housing consumption choices. Empirically, we document that households have increased the share of their income spent on housing by a substantial margin. The result is robust to the changing composition of households and also to regional location. Households that have been traditionally cash constrained have increased their housing expenditures but tend to have low mortgage rates, suggesting that these households may be financing their increased housing consumption with alternative, flexible mortgage products.

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1. Introduction

The mortgage market has changed drastically over the past half-century in terms of the types of products offered to borrowers and the way these products are delivered.¹ Most recently (mid 1990s to mid-2000s), technology has played an important role in stimulating these changes in the mortgage market by improving the ability of lenders to gather and process information. Consumers now appear to face lower costs for obtaining mortgages, refinancing existing mortgages, and extracting home equity; a better ability of mortgage issuers to measure and price the risk of mortgage applicants; and a greater array of mortgage instruments from which consumers can choose.

In this paper we develop models to assess how these innovations in mortgage markets reduce the constraints consumers face while attempting to smooth housing and non-housing consumption over time. We demonstrate the ways in which constrained households adjust their spending and consumption following various changes in financing opportunities. The innovations yield similar empirical predictions, namely that those households that were the most constrained will increase their share of income devoted to housing the most. Coupled to these models, our empirical strategy examines changes in the spending on housing, focusing particularly on those demographic groups where innovations in the mortgage market would likely have had the biggest impact on constraints. As the innovations we discuss occurred during the same time period and yield similar empirical predictions, we do not claim to separately identify the effects of individual innovations. Instead, the observed changes in spending by households over time are consistent with the host of changes witnessed in the mortgage market.

The empirical results focus on two aspects of spending on housing: the timing of the house purchase decision (the extensive margin) and also on the share of income devoted to housing by homeowners (the intensive margin). In terms of the house purchase decision, the home ownership rate witnessed a remarkable 5 percentage point increase between 1994 and 2004 after being relatively stable for several decades. We show that demographic changes in the population played only a minor role in this increase. Further, the homeownership rate increased sharply for young households, especially for households with relatively high educational attainment. It is these

¹See Green and Wachter (2005) and Gerardi, Rosen, and Willen (2006) for descriptions of changes in the mortgage market.
households that have the greatest discrepancy between current income and permanent income (and hence are likely to be down payment constrained), and therefore it is these households that would benefit greatly from innovations in mortgage markets.

On the intensive margin, owner-occupied households have increased the share of their income devoted to housing by a several percentage points from 1997 to 2005. We document that lower income households increased their spending on housing more sharply than did higher income households, consistent with the view that higher income households are less likely to face binding financing constraints. To address a competing hypothesis that households increased their share of income going to housing because housing became a more attractive asset, we examine how spending varied between markets differentiated by observed house price appreciation. We find that spending on housing as a share of income increased markedly in virtually all markets, regardless of what happened to housing prices in those markets. Insofar as the possibility that alternative mortgage products have increased the potential for housing consumption smoothing, we find that young and educated households have significantly increased housing expenditures over time, but also tend to have relatively low mortgage interest rates. We interpret this finding to be consistent with the possibility that these households are financing their consumption with alternative mortgage products, as these mortgages are typically characterized by low initial interest rates.

This paper joins a growing literature on the evolution of financial constraints in housing markets and their effects on the consumption of housing, housing prices, and the consumption and prices of other goods and assets in the economy. Cocco (2004) and Yao and Zhang (2005) study the portfolio allocation problem in light of the housing investment, showing how stockholdings depend critically on the degree of leverage used in the housing purchase. Yamashita (2003) verifies that the housing investment tends to crowd out the household investment in equities. Similarly, Davidoff (2006) finds evidence that households with labor income that covaries strongly with house prices tend to invest and consume less housing. Stein (1995) and Ortalo-Magne and Rady (2005) study the interaction of house prices with income shocks when households face various collateral constraints in their housing purchase. Though the models in these papers are somewhat different, both papers demonstrate the way that financing constraints can amplify the effect of demand shocks on house prices.
Focusing on housing consumption, Bostic and Surette (2001) document the narrowing of the homeownership gap between whites and minorities over the past several decades, attributing a large part to mortgage market innovations such as credit scoring. Li (2005) notes that in addition to the increase in homeownership rates in the 1990’s, leverage (the loan-to-value ratio) conditional on homeownership has also increased. In addition to a relatively benign economic environment and the aforementioned mortgage market developments, Li stresses changes in the tax code that have made homeownership a more attractive proposition.²

The papers listed above focus on prices and consumption. There is also an important literature on the way the housing consumption decision is financed. Campbell and Cocco (2003) study mortgage choice in a risk management framework. They abstract from the decision of how much housing consumption to purchase and focus explicitly on the choice between fixed versus adjustable rate debt to finance the housing consumption, making the link between mortgage choice and risk aversion and income uncertainty. Empirically, Vickery (2006) finds that consumers are sensitive to expected inflation when choosing between fixed and adjustable rate mortgages (see also Koijen, Van Hemert, and Van Nieuwerburgh (2006)). Somewhat contrary to the approach taken in this paper, these empirical papers focus on market price data rather than household demographics as a way of explaining consumer choices. The theoretical literature on mortgage design started by Dunn and Spatt (1992) and extended by LeRoy (1996) and Stanton and Wallace (1998), by contrast, stresses the asymmetric information between borrowers and lenders. In this setup, household characteristics are the main determinants of the menu of mortgages supplied to the market. Alternative mortgage products can be viewed as a direct consequence of unobservable differences across households: different types of mortgages are created to separate out different kinds of borrowers.

The paper is organized as follows. In Section 2 we provide a brief history of developments in the mortgage market and provide some specific examples to support our interpretation that innovation has altered the constraint set faced by home buyers. In Section 3 we outline a household’s consumption/housing consumption problem to motivate the main empirical predictions of mortgage market innovation for consumer

²See also Campbell and Hercowitz (2006).
behavior. In Section 4 we document that U.S. households in virtually all parts of the age and education distribution have increased housing consumption while these product market developments were taking place. We show that the households that have increased their housing consumption the most are the young and the well-educated. Section 5 concludes.

2. Innovations in the Mortgage Industry

The mortgage market has changed drastically over the past half-century. Since the mid-1990s, the most profound changes in the mortgage market appear to have stemmed from improvements in the ability of mortgage issuers to gather and process information. Like all lending, mortgage lending is information-intensive. Lenders must learn about the credit quality of the borrower and the value of the collateral. Traditionally, these information requirements have led to high transaction costs. In the case of mortgage origination, lenders must share information with credit bureaus, title companies, appraisers, and insurers, among others. Rarely are all of these service providers integrated within the same entity. Danforth (1999) estimates that, prior to the introduction of internet-based features to the mortgage origination process, transaction costs associated with mortgage origination reached three percentage points of total loan value.

Changes in technology, broadly defined, have done much to bring these costs down and speed up the overall lending process.\(^3\) First, there have been numerous “general purpose” innovations that have impacted the entire economy, but have had a particularly strong affect on the mortgage industry because of its information-intensive nature. These innovations include the development and widespread use of communications equipment and data processing and storage devices. Prior to the availability of easy-to-use email and fax machines, much of the data needed to make an underwriting decision was assembled slowly as the different parties exchanged information through the mail. Now, data are exchanged electronically. Credit histories are available upon demand. The industry now speaks of the “paperless” mortgage and its potential to dramatically reduce the amount of time between closing of the loan and securitization.

\(^3\)See LaCour-Little (2000) for an excellent summary of the role of technology in mortgage finance.
A second class of innovations that have impacted the mortgage industry is more specific to finance and mortgage lending. Statistical models designed to estimate changes in collateral value, or automated valuation models (AVMs), are now in widespread use in the mortgage industry. AVMs have been particularly important for reducing the cost of refinancing, as many lenders rely heavily on the AVM for a quick estimate of the collateral value to see whether the borrower (re)qualifies for the new mortgage loan. Credit scoring models have led to better risk management and have helped lenders to form better estimates of repayment probabilities, particularly for borrowers with more opaque credit quality, like first-time and low-income home buyers (see Barakova, Bostic, Calem, and Wachter (2003)).

Both of these classes of innovations should have driven down costs for mortgage lenders. While it is hard to get precise mortgage lending costs for commercial banks or mortgage companies, one way to proceed is to look at productivity measures for the industry as a whole. The productivity measure used here is defined as the ratio of the Mortgage Bankers’ index of refinance-mortgage originations to total employment in the industry, as reported by the Bureau of Labor Statistics. By this crude measure, labor productivity in the mortgage industry was about 2-1/2 times higher in the 2000s than in the early 1990s.

If the mortgage market is sufficiently competitive, we would expect lenders to pass some of these cost savings on to borrowers. This seems to have occurred, to some extent. Figure 2 shows the points, spread, and interest rate for 1-year adjustable rate mortgages (ARMs). Although spreads surged during the period of abnormally low rates in the early 2000s, points have drifted steadily down. Notice that at the end of the time period, spreads have fallen to below average and points are also very low.

A final class of innovations concerns the design of the mortgage instruments themselves. Although the traditional 30-year fixed rate mortgage remains a popular instrument, other less-traditional instruments have gained market share, especially during the early 2000s. These instruments vary by interest rate charged, term, amortization

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4 Hurst and Stafford (2004) document the importance of tapping household home equity in response to adverse economic shocks. See also Bennett, Peach, and Peristiani (2001) for evidence of structural change in the propensity to refinance.

5 The average number of points paid with 30-year fixed rate mortgages fell by 1-1/2 between the late 1980s and 2005. However, during this period, the average spread between a 30-year fixed rate mortgage and the 10-year Treasury note trended up by a couple tenths of a percentage point.

6 While demand for alternative mortgage products surged in the early 2000s, these products could not be considered new at the time. For example, the graduated payment mortgage was first offered in 1977. See Alm and Follain (1984)
and payment schedule, and differ substantially from more traditional fixed-rate or even many adjustable-rate mortgages. One reason that mortgage issuers are better able to tailor mortgage instruments to consumers is because of thicker secondary markets and the increased ability of participants in these secondary markets to assess the risk of mortgage-backed securities. It is not easy to get a measure of the total market share of various types of alternative mortgages. Most household surveys list only whether the mortgage is adjustable-rate or not. We can take an indirect approach by noting that the mortgages ending up in pools sponsored by the government sponsored agencies are almost certainly not going to be of the alternative type that we are mentioning. Anecdotally, borrowers with alternative mortgage loans tend not to satisfy one or several of the underwriting guidelines set by the GSEs. As shown in Figure 3, the share of private label MBS, or MBS that are not issued by the GSEs, has increased sharply to an all-time high of nearly 40 percent.\footnote{See Krainer (2006) for further discussion on the prevalence of alternative mortgages.}

3. A SIMPLE MODEL OF HOUSEHOLD CHOICE

Throughout this section, we often assume that income is not constant. Our motivation for emphasizing this assumption is summarized in Figure 4 which shows indexes of average wages by age and by educational attainment. What is striking in Figure 4 is the extent to which wages increase for individuals with a college education. For these individuals, income in the younger years can be far less than income in later years. For individuals with only a high-school education or less, real incomes grow much more slowly over time. Because there are such large differences in these income profiles, we will emphasize education in our empirical results.

To see the benefits of an innovation in mortgage design, consider a household with standard Cobb-Douglas preferences for a consumption good $c$ and a housing good $h$ with rental price $p$, assumed to be constant over time for simplicity.\footnote{See Brueckner (1984) for a similar theoretical analysis.} The household lives for two periods, receiving period income $y_1$ and $y_2$. If there are no credit constraints, the household chooses a consumption plan that ignores the timing of the arrival of income. That is, the household solves

\begin{align*}
\max_{c_1, c_2, h_1, h_2} & \quad c_1 + c_2 + h_1 + h_2 \\
\text{s.t.} & \quad c_1 + h_1 - y_1 = 0 \\
& \quad c_2 + h_2 - y_2 = 0 \\
& \quad c_1, c_2, h_1, h_2 \geq 0 \end{align*}

for an analysis of the possible consumer gains to using this and other flexible mortgage products. Campbell (2006) notes that historically consumers have been slow to demand financial products that would seemingly be welfare enhancing.
\[
\max_{c_1, c_2, h_1, h_2} \sum_{t=1}^{2} c_t^\theta h_t^{1-\theta},
\]

subject to:

\[
c_1 + c_2 + ph_1 + ph_2 = y_1 + y_2. \tag{1}
\]

The well-known solution to this problem is that total expenditures on housing \((ph_1 + ph_2)\) are equal to \(1 - \theta\) percent of total income \((y_1 + y_2)\) and housing consumption is equal in both periods. This example demonstrates two important properties commonly at work in consumer theory. First, optimizing households like to smooth expenditure shares across the available set of goods. Second, households like to smooth all types of consumption over time.

Now consider what happens if borrowers are not permitted to spend more on housing per period than their per period income. With these credit constraints in effect, equation (1) is replaced by

\[
c_1 + ph_1 = y_1, \tag{2}
\]

\[
c_2 + ph_2 = y_2. \tag{3}
\]

In this case, housing expenditures in the two periods, \(ph_1\) and \(ph_2\), are given by \((1 - \theta)y_1\) and \((1 - \theta)y_2\), respectively. The constant-expenditure shares property is preserved. However, consumption smoothing is no longer possible, and the household consumes less of everything in the first period if \(y_1 < y_2\). For housing, the value of the lost consumption is \(p(1 - \theta)(\frac{y_2 - y_1}{2})\).

Down payments, mortgages, and capital gains can be introduced into this simple framework by assuming that households must put up a constant fraction \(\delta\) of the per unit purchase price, \(q\), in the initial period. The constraints in this problem take the form

\[
c_1 + \delta q_1 h + m_1 \leq y_1, \tag{4}
\]
\[ c_2 + m_2 \leq y_2 + q_2 h, \quad (5) \]
\[ m_1 + m_2 = (1 - \delta)q_1 h, \quad (6) \]

where constraint (6) is a solvency constraint for the lender. Note also that the amount of housing, \( h \), is assumed to be fixed over the contract period. Taking mortgage payments as given, the first-order necessary conditions for an optimum include,

\[ \theta c_1^{\theta - 1} h^{1-\theta} = \lambda_1, \quad (7) \]
\[ \theta c_2^{\theta - 1} h^{1-\theta} = \lambda_2, \quad (8) \]
\[ (1 - \theta) h^{-\theta} (c_1^{\theta} + c_2^{\theta}) = \lambda_1 \delta q_1 - \lambda_2 q_2. \quad (9) \]

where the \( \lambda \)'s are Lagrange multipliers.

We can gain some insight into the magnitude of changes in consumer choices and overall utility by parameterizing the utility function and solving the first-order conditions in equations (7) to (9). In these examples, income is assumed to grow from 10 to 15 over the two periods. The per unit house prices increase from .25 to .3. The housing preference parameter \((1 - \theta)\) is set to .4.

In Figures 5a and 5b, we analyze how allocations and utility depend on \( \delta \), the down payment parameter. Mortgage payments are assumed to be constant over time in this example. As the down payment constraint is eased, housing consumption increases monotonically. Moving from a down payment rate of 20 percent to 10 percent results in a 24 percent increase in the quantity of housing purchased. As can be observed on the left-hand scale of Figure 5a, this increase in housing consumption also accompanies an increase in total lifetime utility. Not surprisingly, the easing of constraints makes households happier. However, the increase in housing consumption comes at the expense of non-housing consumption. Because the mortgage payment must be feasible in both periods, non-housing consumption is unevenly distributed towards the second period when the household has more income (see Figure 5b). The extent of this imbalance depends upon \( \theta \), which governs the expenditure share of housing. Higher values of \( \theta \) imply a greater reluctance to substitute non-housing for housing consumption. Households can never completely smooth their non-housing consumption unless they are allowed to borrow to make their mortgage payment.
In Figures 5c and 5d we study the effect of loosening the down payment constraint from 20 percent to 10 percent for different consumers, according to how much income they receive in period 2 relative to period 1. Total lifetime income is held constant in this exercise. A household with a high ratio, $y_2/y_1$, is meant to represent the two-period approximation to a household with high permanent income. In Figure 5c we observe a sharp, nonlinear increase in utility for high permanent income households as the down payment constraint is loosened. In Figure 5d we can tell that, for this parameterization of the model, this increase in utility is apparently due to a substantial increase in housing consumption made possible by the lower down payment constraint.

So far we have assumed that a down payment constraint affects decisions only in that, conditional on a purchase, a household consumes less of its income than it would otherwise want to. If we were to specify a minimum amount of the housing good, $\bar{h}$ that can be purchased, then the down payment constraint can be much more important for people with initially low income. In the context of this simple model, households without the necessary income to get into the housing market do not consume any housing in the first period. If they have enough income to get into the market in the second period, the solution to their optimization problem is then the same as in a static problem: spend $\theta$ percent of their second-period income on consumption and $1 - \theta$ percent of their second-period income on housing. Thus, households are unable to smooth either type of consumption and also miss out on any house price appreciation over time.

In Figures 6a and 6b we perform the same basic exercise as above, only this time we fix the down payment rate at 15 percent of the purchase price (i.e., price per unit x quantity demanded) and study instead how allocations depend on the timing of the mortgage payment. Specifically, we consider the “tilt” of the mortgage, or the percentage of total payments that are made in the first period. As payments are shifted to the second period when the household has more income, housing consumption goes up, as does total lifetime utility. In this simplified example, the quantitative effect of changing the timing of mortgage payments is much larger than the effect of easing the down payment constraint; total housing consumption goes up by nearly a factor of 9.

\[^9\text{That is, households rent and derive utility less than that of owning the housing asset.}\]
of three. We see again that easing a housing market constraint results in a shift in non-housing consumption from period 1 to period 2.

In the empirical section to follow, we explore the main predictions of this simple model. As far as the down payment constraint is concerned, we expect to see two primary outcomes in the data. First, when the down payment constraint is loosened, previously constrained households would be expected to make changes along the extensive margin. Households should enter homeownership at a younger age. This prediction can be verified by exploring the changes in homeownership rates over time and relating these changes to demographics. Second, we expect to see households change consumption along an intensive margin. Previously constrained households will consume more housing and will exhibit higher expenditure shares on housing. This should be true for all households, regardless of demographics. Both of these effects, however, should be strongest among young households that might be expected to have the potential for high permanent income relative to current income.

The other type of innovation considered—allowing for greater flexibility in the timing of mortgage payments—should have the greatest impact on the timing of housing consumption. In the data we should observe a change in the slope of the payment-to-income profile (i.e., the ratio of payment-to-income for households of different ages). Without flexibility in the timing of mortgage payments, households will have steeply declining payment-to-income profiles as households “grow” into their mortgages. But if young households expect their incomes to rise in the future, they will desire a mortgage product that tilts payments to the future. Thus, the payment-to-income profile will flatten (become less negative) with access to these mortgage products. Since we know that the slope of the income profile is positively related to education, we expect the flattening of the payment-to-income profile to be strongest for college-educated households.

4. Empirical results

The models presented in the previous section generate a diverse set of predictions. As one of the important margins of housing adjustment from the consumer’s perspective is the rent-to-buy margin, our first set of results examines the change in the home ownership rate from 1994 to 2004. Then, focusing only on homeowners, we examine
how the share of income devoted to housing has increased over time. The final set of results explores the choice of mortgage characteristics by demographic groups.

4.1. **Changes in homeownership rates.** Our models illustrate how innovations in mortgage markets would increase demand for housing, and one manifestation of that increased demand would be an increase in the homeownership rate. Housing services, the variable in the consumer’s model, is difficult to measure fully. We assume that most households that become home owners are increasing their housing services from when they rented. As shown in Figure 7, the homeownership rate fluctuated within a tight range between 1970 and 1994. However, starting in 1994, the homeownership rate began a steady rise of five percentage points to 69 percent in 2004, and has since remained close to this elevated level. The 1994 to 2004 increase in the homeownership rate reflected an increase of 12 million homeowners.

Before discussing how innovations in mortgage markets could have spurred the increase in homeownership, we first briefly review some of the other potential causes of the increased homeownership rate. One factor behind the increase in the homeownership rate could have been the improvement in overall economic conditions, as the 1994-2004 period witnessed a period of above-average growth. However, there are several reasons to discount the improving economy story. First, although economic growth was strong overall during this period, it is also true that there was a recession. In spite of this downturn, the homeownership rate steadily increased. Further, as has been documented in numerous studies, gains in real income were largely confined to the upper tail of the income distribution during this time period (see Autor, Katz, and Kearney 2005), and, as we show and discuss below, the homeownership rate increased rapidly for the low to middle income groups. Finally, looking over a longer time period (back to the 1960s), changes in the homeownership rate do not correlate closely with economic cycles.

Another reason ownership rates could have increased is in response to demographic change. For instance, the median age of the population has been increasing as the

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10 For more comprehensive discussions on the increase in the home ownership rate, see Bostic and Surrette (2000), Gabriel and Rosenthal (2005), and Li (2005).

11 Another economic factor that could have resulted in increased home ownership could have been an increase in the relative supply of housing. However, overall prices for housing increased steadily and the stock of housing grew at a fairly steady pace, as shown in Figure 7. Therefore, it is unlikely that the homeownership rate increased because of a positive supply shock to housing.
baby boomers work their way up the age scale; if older people are more likely to be home owners, then the increase in the home ownership rate could simply reflect changing demographics. Table 1 shows the change in the homeownership rate by various demographic breakdowns for 1994 and 2004 using the Current Population Survey (CPS) outgoing rotation panel in conjunction with the Residential Vacancy and Homeownership Survey.\footnote{To perform the demographic analysis, demographic characteristics have to be chosen for a household. Most research relies on the head of household as indicated in the CPS. In Table 1, we use this definition as well.} As discussed in other research and shown in Table 1, homeownership rates increased between 1994 and 2004 for nearly every demographic sub-group; the rate increased for the young, as well as the old, the college educated and the high school educated, and so on.

To be more precise about the role of changing demographics, we decompose the change in the homeownership rate into the change attributable to changes in demographics and into changes in the propensity in home ownership for each demographic group. We use the procedure proposed by Fairlie (2005) that follows the spirit of Blinder-Oaxaca decompositions. Our model of homeownership contains controls for age, education, income, race, number of children, number of prime-age adults, and the number of senior citizens in the household. The Fairlie decompositions suggest that changes in the demographic distribution between 1994 and 2004 account for less than 20 percent of the increase in the home ownership rate; that is, most of the increase in the home ownership rate is attributable to increased propensity in home ownership by each demographic slice of the population.

Our models are consistent with the results in Table 1 in several ways. First, with the increased access to credit (in part by the use of credit scoring), households that had poor credit and would have been denied access to mortgages in the past would now be able to obtain credit. Second, also through the credit scoring channel, down payment requirements would be reduced, and that would assist the younger households that are traditionally cash constrained. Finally, households with steep expected earnings profiles may be able to purchase their desired home earlier by using financing instruments that have payments that increase over time; that is, households where the head is college educated. The households headed by younger people enjoyed the largest increase in ownership; according to our models, it is this group that may have faced the largest relaxation in borrowing constraints. Further down in Table 1
are results by age and education. As mentioned in the model section, we examine education because the curvature of lifetime earnings profiles varies tremendously by educational attainment. Within the younger groups (households where the head is less than 40), it is the college educated that have increased their homeownership rates the fastest.

The results in Table 1 hold up to more formal analysis. Models of home ownership were estimated with the variables presented in Table 1 (age, education, income, etc..) and other controls include number of children, prime age adults, and seniors. The models were estimated where all of the independent variables were interacted with year (1994 or 2004). The number of estimated parameters is therefore large and we do not present them here. When simultaneously controlling for a wide variety of variables, the demographic groups that enjoyed the largest statistical increase in home ownership are those groups shown in Table 1, namely the young and higher-educated.

4.2. Housing costs as a share of income. Our models suggest several reasons why households would increase their lifetime expenditures on housing. For instance, recall that the easing of down payment constraints increased the demand for housing for all households that were not able to equate lifetime expenditures on housing with the share $1-\theta$ of lifetime income, where $1-\theta$ is the weight on housing consumption in the per-period utility function. To examine the changes in household spending on housing, we construct various housing costs-to-income ratios, where housing costs are mortgage payments or total housing costs (which, in addition to mortgage payments, include utilities, property taxes, home insurance, condo fees, and other regularly occurring costs associated with homeownership that are collected in the American Housing Survey (AHS)).\textsuperscript{13} There are several micro-level data sets with some measure of housing costs and income, including the Panel Survey of Income Dynamics, the Survey of Consumer Finance, the Consumer Expenditure Survey, and the AHS. Although each data set possesses its own advantages, we focus on the results from the AHS for several reasons. The first reason is that the AHS has a larger sample than the other surveys. The second reason is that the AHS has some geographic detail, which, as we explain further below, could potentially be important for identification. Finally, the

\textsuperscript{13}As stated earlier, we also would want a measure of the flow of housing services. Unfortunately, direct measures of these flows are not available. That is one reason why our models focus on expenditure shares and not just the consumption of housing services.
AHS has a wealth of information about the home, the demographics of its occupants, and the way the home is financed.

We use observations from the AHS in the odd-numbered years between 1997 and 2005. We limit the sample from 1997 onward because the data are consistent over this time and edit flags are available. We use only those observations for which mortgage payments were reported, at least 50 percent of salary income is not imputed, and the households were homeowners. All observations used in estimation are weighted by the sample weights provided by the AHS. In our analysis, we focus on the ratio of total housing costs to income, though we also examine the ratio of mortgage costs to income. Before delving into models where these two measures are the dependent variables, Figures 8a and 8b present the kernel densities of these two measures over our sample period. As can be seen with both measures, there is a rightward shift in these unconditional distributions by several percentage points. For the mortgage-to-income ratio, Figure 8b, there is a mass point at zero in all years, though that mass point diminishes by several percentage points over time.

A series of basic models using these two measures as dependent variables is presented in Table 2. The estimated models differ according to the sets of controls used. In nearly all of the models, we include year fixed effects to examine the change in the ratio of housing costs to income over time for the mean household. To ensure that the year dummy results do not arise from changing demographics, we include variables that measure basic information about the household, including educational attainment, and the number of children, prime age adults, and elderly in the household. Further, we include a set of five age dummies for the head of household (20-29, 30-39, 40-49, 50-59, and 60-69).\textsuperscript{14}

Columns 1-5 in Table 2 report results from a variety of specifications where the dependent variable is mortgage payment-to-income. Columns 6-10 mirror columns 1-5, but the dependent variable is total housing costs. Because the dependent variable is left-censored at zero (especially for the mortgage payment dependent variable), we use a Tobit maximum likelihood model for all of our results.\textsuperscript{15} The first column reports the estimates from a model that includes only year dummies and column 2

\textsuperscript{14}Households headed by individuals 70 years old or older are excluded.

\textsuperscript{15}The likelihood of having no mortgage has decreased over our sample period. Using the controls used in Table 2, the expected probability of having no mortgage has fallen by over 4 percentage points between 1997 and 2005.
reports the results for year dummies and basic demographic controls. As discussed above, the homeownership rate rose considerably during the sample period, resulting in a potential change in sample. To control for the possibility that the time dummies may be influenced by the influx of new homeowners, the model reported in column 3 includes the number of years the family has been living in the home and the number of years squared.\footnote{Our results are robust to a wide variety of other specifications that control for new homeowners.} Finally, columns 4 and 5 include dummy variables for the metropolitan statistical area (MSA); column 5 drops those observations where the MSA is not reported while column 4 codes those observations as their own unique MSA.

In terms of the coefficients on the year dummies, all of the models show that the share of income devoted to housing has increased several percentage points from 1997 to 2005, and this result is robust to numerous specifications. For the mortgage-to-income variable, the increase between 1997 and 2001 is similar in magnitude to the increase from 2001 to 2005. For the total housing cost variable, the increase in the earlier years is less than the increase in later years; overall, the increase in total housing costs increased about 0.8 percentage points less than mortgage housing costs. The general result that the share of income devoted to housing has increased is consistent with the results we have found using other data sets, such as the Survey of Consumer Finances, the Panel Survey of Income Dynamics, and the Consumer Expenditure Survey.

In terms of the demographic controls, we generally find that higher educated households tend to spend a smaller share of their income on housing, as do households with persons over the age of 60. The opposite is true of households with more than one prime age adult. Perhaps not surprisingly, the mortgage payment-to-income ratio falls as age increases. Households whose heads are of age 60 to 70 pay about 7 percentage points less in mortgage payments relative to income than households in their 20s. As a robustness check, we estimated the models separately by year and found that the coefficients on the demographic variables were little changed over time.\footnote{Recall that one of the implications of the model section was that the share of income devoted to housing is becoming more constant over time. Unfortunately, discerning a flattening of the profile is difficult to discern using a data set that only spans eight years. To make more definitive statements as to whether payment-age profiles have changed shape, we would need to have data for a sufficient period of time after the changes in mortgage markets have taken place. Our results so far are limited to suggesting that more is being spent on housing for all age groups.} Although these demographic controls are interesting in and of themselves, our main
motivation for including them is to ensure that our results for the time dummies do not arise from demographic changes in the sample.

One of the results from the model section was that households that face binding financial constraints are those households that will benefit the most from financial innovations. Taking this logic a step further, lower income households are more likely to face finance constraints than higher income households. To examine how the share of income devoted to housing varies by income, Table 3 reports models estimated separately for each income quintile. The two groups that experienced the largest increases over time are the two lowest income quintiles, where the increase in housing expenditure share increased by approximately 3-1/2 percentage points from 1997 to 2005. By contrast, the sample that makes up the highest income quintile increased their share of income to housing by only 1-1/2 percentage points.

The model section also highlighted how households may benefit from mortgage innovations by educational attainment, which is related to the steepness in income profiles. Table 4 shows the results by educational attainment; both groups–those with high school or less and those with some college or more–witnessed similar increases in the share of income devoted to housing costs. When the models are estimated by income quintile interacted with educational attainment (not shown), the lower income groups in both educational categories witnessed the largest increases in housing costs-to-income ratios.

4.3. Possible alternative explanations. The increased expenditure shares on housing could arise for reasons other than those suggested by our models. In particular, over the period we examine, house prices increased sharply and steadily. If people expectation larger future price gains, then the user cost of capital falls. All other things held constant, this would translate into an increase in demand for housing. Another possible reason for increased expenditure shares on housing could arise from expectations that future income will be higher, leading to increased spending on housing and on other goods as well. Alternatively, there may be other reasons why expenditures on all major categories increased relative to incomes, resulting in a lower overall savings rate. We investigate each of these possible explanations in turn.

---

18The sample sizes in Table 3 are skewed to the higher income quintiles because the income quintiles are computed using the entire AHS sample, which includes renters. Renters tend to have lower incomes than homeowners. The results are robust to if the quintiles were computed using only homeowners.
Although house prices have gone up significantly over the past decade (as shown in Figure 7), the price changes were less than uniform across the country. In particular, several locations along the Atlantic and Pacific coasts have seen tremendous increases in house prices, but there are many other areas, especially in the south, where the increase in home price appreciation has been much more muted. Figure 9 shows the kernel density of house price appreciation from 2000 to 2005 for the MSAs in our sample; the data come from OFHEO. The main point we wish to make is that there is tremendous variation across regions in terms of house price changes. The AHS data are grouped into one of four quartiles based on the change in home prices, and then the models are estimated separately for each group.\textsuperscript{19} The results are presented in Table 5. As a baseline, column 1 presents the model estimates from the entire sample and replicates the results in Table 2. The change in expenditure shares varies somewhat across regions, but not systematically with the degree of local housing market conditions. However, if expectations for house price appreciation are influenced not by local conditions but instead by national conditions (which we find unlikely), then the results in Table 5 do not rule out the possibility that increased expectations of appreciation could be partly responsible for increased expenditures shares on housing.

Another possible explanation for our results is that spending shares on all goods increased, perhaps as a reflection of increased future income expectations. After all, the aggregate savings rate fell considerably during our sample period. To examine this hypothesis, we examined information from the Consumer Expenditure Survey (CES). Relative to the AHS, the CES does not contain geographical information or detailed information on costs associated with the servicing of property debt. However, an advantage of the CES is that it does contain information on expenditures other than housing costs. We compute several expenditure share measures using these data from 1991 to 2003 and run regressions similar to those using the AHS data. The results are presented in Table 6. In the first column we show results from a regression of spending relative to income that excludes housing on a set of year dummies and

\textsuperscript{19} We examined the price change for a number of different periods, and our results are robust to the time period examined. 
\textsuperscript{20} Several of the models run in Table 2 control for MSA in that a dummy variable is used for all time periods. This dummy variable will pick up mean differences in housing expenditures-to-income by region but will not capture changes in housing expenditures-to-income by region.
demographic characteristics for households that are homeowners. Between 1994 and 2003, there appears to be a slight decrease in the share of income devoted to non-housing consumption. The second column shows the same basic regression but where the dependent variable is the share of income going to mortgage payments. Roughly speaking, the decrease in the share of income going to other consumption goods is matched by the increase in income going to housing. This result is interesting in that it suggests that the increase in expenditures for housing did not come directly out of saving but instead out of consumption of other goods.\textsuperscript{21}

4.4. Mortgage and demographic characteristics. The empirical sections above examined homeownership and the share of income devoted to housing of homeowners. In this section, we examine the choice of mortgage characteristics. Recall that according to our model, younger, cash-constrained households with steep expected income profiles would be more likely to opt for mortgages with low initial payments. One way households can reduce their mortgage payments, at least for a time, is to finance their housing consumption with mortgage products that have relatively low introductory interest rates.

The AHS data contain limited information about the primary mortgage of homeowners, including the interest rates for the primary and secondary mortgages. Using this information, we construct an average mortgage interest rate where the interest rates are weighted by the value of the mortgage. We then examine the relationship between interest rates and demographic characteristics, and those results are presented in Table 7. Before discussing the results, an important omitted variable in our models is credit quality. Given the importance of this variable, the results in Table 7 have to be viewed with greater skepticism than the results in the previous tables. With that caveat in mind, the results in Table 7 are consistent with our models.

The first three columns of Table 7 are probit models where the dependent variable equals one if the average interest rate is in the lowest quintile for a year. The first column shows the results for the entire sample and the second and third columns

\textsuperscript{21}There are several reasons why our results can be consistent with the decline in the national savings rate. First, the regressions in Table 6 represent the mean household whereas the national savings rate, in essence, weights households by income. As we saw previously, higher income households did not increase their housing expenditures as a share of income by as much as lower income households. Further, the decrease in the official national savings rate stems, in part, from an increase in health care expenditures. In the official statistics, employer contributions also go towards consumption, which reduces the savings rate.
estimate the models separately by whether households are in the bottom or top half of the income distribution. In addition to the controls used in Tables 2-6, the controls in Table 7 also include dummy variables for the income decile of the household; it is hoped that these controls may be correlated with the unobserved credit quality of households.

The first three columns of Table 7 show that households headed by individuals with at least some college education are more likely to be in the lowest interest rate quintile. However, this result may be tainted from a positive correlation between education and credit quality that is not captured by the income deciles. The remaining rows of the table show the coefficients for the age dummies; in all three columns, younger households are more likely to have lower interest rates on their mortgages. This result is somewhat surprising as credit quality is likely to be inversely related to age. Comparing columns 2 and 3, we find that the age profile of interest rates is greater for lower income households than for higher income households. Again, lower income households are more likely to face the constraints addressed in our model, and therefore may be more responsive to mortgage instruments that offer initially low interest rates. A slightly different specification for the interest rate models are contained in columns 4-6 of Table 7 which show results from OLS models when the dependent variable is the interest rate. The OLS results are qualitatively very similar to the probit results.\footnote{We also examined other observable characteristics of the mortgage, such as whether the mortgage is adjustable or not. Unfortunately, the AHS data do not provide other information on how and when the interest rate is adjustable. For instance, a traditional 10-1 ARM would be coded the same as a 1-year ARM that offered a low initial teaser rate.}

5. Conclusion

Over the last decade there have been several innovations in mortgage markets, such as the lowering of down payment requirements, the increased flexibility in repayment schedules, and the reduction of costs associated with extracting equity from homes. We develop a model that generates testable implications of how these innovations would affect household behavior. For instance, the lowering of down payment requirements should result in homeownership increasing, especially for young people who are traditionally cash constrained. In fact, we show that between 1994 and 2004, the homeownership rate for young people rose sharply. Our model predicts that lower
down payments and more flexible mortgage payment schedules should lead to higher housing consumption for previously constrained households. Empirically we document that households have increased the share of their income devoted to housing by a substantial margin. The result is robust to the changing composition of households and also to location; the share of income devoted to housing costs has increased markedly in markets regardless of what happened to housing prices in those markets. Finally, we find that young educated households have dramatically increased their housing expenditures between 1995 and 2005, but appear to be financing these expenditures with mortgages that have relatively low interest rates. We interpret this finding to be suggestive that these households may be financing their increased housing consumption with alternative, flexible mortgage products.
References


Table 1: Home Ownership Rates by Demographic Groups, 1994 to 2004

<table>
<thead>
<tr>
<th></th>
<th>Rates by year</th>
<th></th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of head of household</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>26.6</td>
<td>33.2</td>
<td>6.6</td>
</tr>
<tr>
<td>30-39</td>
<td>55.8</td>
<td>61.8</td>
<td>6.0</td>
</tr>
<tr>
<td>40-49</td>
<td>70.5</td>
<td>74.1</td>
<td>3.6</td>
</tr>
<tr>
<td>50-59</td>
<td>77.8</td>
<td>79.6</td>
<td>1.8</td>
</tr>
<tr>
<td>60+</td>
<td>77.9</td>
<td>81.4</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Education (in years of schooling) of head of household</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>61.3</td>
<td>64.1</td>
<td>2.8</td>
</tr>
<tr>
<td>13 or more</td>
<td>66.6</td>
<td>72.9</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>Age and education of head of household</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>25.4</td>
<td>30.0</td>
<td>4.6</td>
</tr>
<tr>
<td>13 or more</td>
<td>27.7</td>
<td>35.6</td>
<td>7.9</td>
</tr>
<tr>
<td>30-39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>50.2</td>
<td>52.0</td>
<td>1.8</td>
</tr>
<tr>
<td>13 or more</td>
<td>60.4</td>
<td>67.9</td>
<td>7.5</td>
</tr>
<tr>
<td>40-49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>63.6</td>
<td>66.1</td>
<td>2.5</td>
</tr>
<tr>
<td>13 or more</td>
<td>75.8</td>
<td>79.6</td>
<td>3.8</td>
</tr>
<tr>
<td>50-59</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>73.4</td>
<td>73.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>13 or more</td>
<td>82.5</td>
<td>83.7</td>
<td>1.2</td>
</tr>
<tr>
<td>60+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 years or less</td>
<td>75.3</td>
<td>78.2</td>
<td>2.9</td>
</tr>
<tr>
<td>13 or more</td>
<td>83.4</td>
<td>86.0</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>Income quartile of family income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st quartile</td>
<td>41.2</td>
<td>44.7</td>
<td>3.5</td>
</tr>
<tr>
<td>2nd quartile</td>
<td>58.6</td>
<td>63.8</td>
<td>5.2</td>
</tr>
<tr>
<td>3rd quartile</td>
<td>72.9</td>
<td>78.5</td>
<td>5.6</td>
</tr>
<tr>
<td>4th quartile</td>
<td>87.1</td>
<td>91.1</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Source: Current Population Survey and authors' calculations
### Table 2: Maximum Likelihood Models of Housing Costs as a Percent of Income

<table>
<thead>
<tr>
<th>Year dummies (1997 omitted)</th>
<th>Primary and second mortgage payments as a percent of income</th>
<th>Total housing costs as a percent of income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>1999</td>
<td>0.352</td>
<td>0.356</td>
</tr>
<tr>
<td></td>
<td>(0.189)*</td>
<td>(0.187)*</td>
</tr>
<tr>
<td>2001</td>
<td>1.837</td>
<td>1.872</td>
</tr>
<tr>
<td></td>
<td>(0.186)**</td>
<td>(0.184)**</td>
</tr>
<tr>
<td>2003</td>
<td>2.057</td>
<td>2.195</td>
</tr>
<tr>
<td></td>
<td>(0.185)**</td>
<td>(0.183)**</td>
</tr>
<tr>
<td></td>
<td>(0.185)**</td>
<td>(0.183)**</td>
</tr>
</tbody>
</table>

Education of head of household (=1 if some college or more, =0 otherwise)  
-0.487       0.196     -0.007            -1.172    -1.628        -1.960        -2.087        -4.130
(0.123)**   (0.122)   (0.122)            (0.197)** (0.113)** (0.112)** (0.113)** (0.188)**

Age of head of household dummies (less than 30)
30<=Age<=39
-0.850       0.114     -1.117            -1.660    -2.064        -1.060        -2.307        -2.844
(0.230)**   (0.232)   (0.225)** (0.361)** (0.219)** (0.221)** (0.216)** (0.355)**
40<=Age<=49
-1.612       0.830     -1.823            -2.305    -2.963        -0.552        -3.197        -3.840
(0.224)**   (0.235)** (0.220)** (0.353)** (0.213)** (0.223)** (0.210)** (0.346)**
50<=Age<=59
-3.158       0.260     -3.378            -4.444    -3.782        -0.458        -4.026        -4.450
(0.237)**   (0.252)   (0.232)** (0.369)** (0.222)** (0.238)** (0.220)** (0.359)**
60<=Age<=69
(0.371)**   (0.383)** (0.364)** (0.549)** (0.335)** (0.349)** (0.331)** (0.515)**

Number of children  
0.960       0.919     0.924            1.065     1.251         1.214         1.232         1.379
(0.057)**   (0.056)** (0.056)** (0.085)** (0.054)** (0.053)** (0.053)** (0.083)**

Number of prime age adults  
(0.086)**   (0.085)** (0.085)** (0.121)** (0.079)** (0.079)** (0.079)** (0.116)**

Number of elderly adults  
-0.969       -0.799    -1.482            -1.189    -1.528        -1.352        -1.986        -1.484
(0.205)**   (0.203)** (0.202)** (0.286)** (0.184)** (0.182)** (0.182)** (0.267)**

Years living in the house  
-0.278       -0.047
(0.048)**   (0.045)**

Years living in the house, squared  
-0.013       -0.002
(0.003)**   (0.003)

SMSA dummies  
Yes, SMSA=9999
No, SMSA=9999
Constant  
0.292       4.389     5.536            9.452     11.277        20.107        30.935        31.977
(0.148)*   (0.354)** (0.358)** (6.127) (6.086)+ (0.124)** (0.326)** (0.330)** (5.802)** (5.868)**

Observations  
72443       72443     72443            72443     31020        72443        72443        72443
31020

Notes: Standard errors in parentheses, all models estimated by maximum likelihood. All data from the American Housing Survey.  
+ significant at 10%; * significant at 5%; ** significant at 1%
Table 3: Maximum Likelihood Models of Total Housing Costs as a Percent of Income by Income Quintiles (1-lowest, 5=highest)

<table>
<thead>
<tr>
<th>Year dummies (1997 omitted)</th>
<th>All Observations</th>
<th>Income quintile (1=lowest, 5=highest)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>-0.253</td>
<td>-1.275</td>
<td>0.054</td>
<td>0.020</td>
<td>-0.985</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.863)</td>
<td>(0.436)+</td>
<td>(0.297)</td>
<td>(0.218)</td>
<td>(0.183)**</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>0.863</td>
<td>1.665</td>
<td>1.234</td>
<td>1.070</td>
<td>-1.295</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.835)**</td>
<td>(0.435)**</td>
<td>(0.292)**</td>
<td>(0.217)**</td>
<td>(0.180)**</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>1.184</td>
<td>1.057</td>
<td>1.310</td>
<td>1.320</td>
<td>0.247</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.169)**</td>
<td>(0.837)**</td>
<td>(0.426)**</td>
<td>(0.290)**</td>
<td>(0.215)**</td>
<td>(0.179)</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>2.702</td>
<td>3.448</td>
<td>2.703</td>
<td>2.451</td>
<td>1.455</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.859)**</td>
<td>(0.426)**</td>
<td>(0.294)**</td>
<td>(0.215)**</td>
<td>(0.178)**</td>
<td></td>
</tr>
</tbody>
</table>

Education of head of household (=1 if some college or more, =0 otherwise)
-1.653
(0.113)**
(0.559)**
(0.279)**
(0.181)**
(0.151)**
(0.154)**

Age of head of household dummies (less than 30 omitted)
30<=Age<=39
-2.076
(0.223)**
(0.999)*
(0.478)**
(0.340)**
(0.287)
(0.331)

40<=Age<=49
-2.966
(0.215)**
(0.961)*
(0.473)+
(0.332)
(0.281)
(0.323)**

50<=Age<=59
-3.770
(0.226)**
(0.996)*
(0.499)**
(0.352)**
(0.293)**
(0.325)**

60<=Age<=69
-5.630
(0.341)**
(1.411)**
(0.764)**
(0.567)**
(0.458)**
(0.434)**

Number of children
1.262
(0.256)**
(2.306)
(1.512)
(0.989)
(0.960)
(0.802)

Number of prime age adults
-3.350
(0.295)**
(1.648)
(0.159)
-0.350
-0.545
-0.061

Number of elderly adults
1.543
(0.187)**
(3.248)
(0.694)
-0.057
0.004
0.694

Constant
31.067
(0.324)**
(7.538)
(2.359)
(14.249)
(14.757)
(14.027)
(11.359)

Observations
72438
7537
11637
15254
18212
19798

Notes: Standard errors in parentheses, all models estimated by maximum likelihood. All data from the American Housing Survey. + significant at 10%; * significant at 5%; ** significant at 1%
Table 4: Maximum Likelihood Models of Total Housing Costs By Educational Attainment

<table>
<thead>
<tr>
<th>Year dummies (1997 omitted)</th>
<th>(1) All</th>
<th>(2) High school or less</th>
<th>(3) Some college or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>-0.261</td>
<td>-0.235</td>
<td>-0.287</td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.306)</td>
<td>(0.208)</td>
</tr>
<tr>
<td>2001</td>
<td>0.849</td>
<td>1.518</td>
<td>0.443</td>
</tr>
<tr>
<td></td>
<td>(0.171)**</td>
<td>(0.305)**</td>
<td>(0.204)*</td>
</tr>
<tr>
<td>2003</td>
<td>1.166</td>
<td>1.420</td>
<td>0.991</td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.306)**</td>
<td>(0.201)**</td>
</tr>
<tr>
<td>2005</td>
<td>2.683</td>
<td>2.934</td>
<td>2.505</td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.312)**</td>
<td>(0.201)**</td>
</tr>
</tbody>
</table>

Education of head of household (=1 if some college or more, =0 otherwise)  
-1.626  
(0.113)**

Age of head of household dummies (less than 30 omitted)

<table>
<thead>
<tr>
<th>Age</th>
<th>(1) All</th>
<th>(2) High school or less</th>
<th>(3) Some college or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>30&lt;=Age&lt;=39</td>
<td>-2.065</td>
<td>-1.651</td>
<td>-2.203</td>
</tr>
<tr>
<td></td>
<td>(0.219)**</td>
<td>(0.406)**</td>
<td>(0.256)**</td>
</tr>
<tr>
<td>40&lt;=Age&lt;=49</td>
<td>-2.961</td>
<td>-2.385</td>
<td>-3.100</td>
</tr>
<tr>
<td></td>
<td>(0.213)**</td>
<td>(0.394)**</td>
<td>(0.250)**</td>
</tr>
<tr>
<td>50&lt;=Age&lt;=59</td>
<td>-3.779</td>
<td>-3.198</td>
<td>-3.956</td>
</tr>
<tr>
<td></td>
<td>(0.222)**</td>
<td>(0.415)**</td>
<td>(0.259)**</td>
</tr>
<tr>
<td>60&lt;=Age&lt;=69</td>
<td>-5.642</td>
<td>-4.784</td>
<td>-5.984</td>
</tr>
<tr>
<td></td>
<td>(0.335)**</td>
<td>(0.581)**</td>
<td>(0.411)**</td>
</tr>
<tr>
<td>Number of children</td>
<td>1.253</td>
<td>1.683</td>
<td>0.998</td>
</tr>
<tr>
<td></td>
<td>(0.054)**</td>
<td>(0.096)**</td>
<td>(0.064)**</td>
</tr>
<tr>
<td>Number of prime age adults</td>
<td>-3.319</td>
<td>-3.225</td>
<td>-3.391</td>
</tr>
<tr>
<td></td>
<td>(0.079)**</td>
<td>(0.138)**</td>
<td>(0.096)**</td>
</tr>
<tr>
<td>Number of elderly adults</td>
<td>-1.529</td>
<td>-1.717</td>
<td>-1.367</td>
</tr>
<tr>
<td></td>
<td>(0.184)**</td>
<td>(0.309)**</td>
<td>(0.228)**</td>
</tr>
<tr>
<td>Constant</td>
<td>30.927</td>
<td>28.003</td>
<td>28.326</td>
</tr>
<tr>
<td></td>
<td>(0.326)**</td>
<td>(0.482)**</td>
<td>(0.310)**</td>
</tr>
<tr>
<td>Observations</td>
<td>72438</td>
<td>25939</td>
<td>46499</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses, all models estimated by maximum likelihood. All data from the American Housing Survey.  
+ significant at 10%; * significant at 5%; ** significant at 1%
<table>
<thead>
<tr>
<th>Year dummies (1997 omitted)</th>
<th>All observations</th>
<th>Region (1=lowest house price appreciation, 4=highest house price appreciation)</th>
<th>SMSA not defined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1999</td>
<td>-0.261</td>
<td>-0.033</td>
<td>1.211</td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.493)</td>
<td>(0.501)*</td>
</tr>
<tr>
<td>2001</td>
<td>0.849</td>
<td>0.660</td>
<td>1.621</td>
</tr>
<tr>
<td></td>
<td>(0.171)**</td>
<td>(0.489)</td>
<td>(0.492)**</td>
</tr>
<tr>
<td>2003</td>
<td>1.159</td>
<td>1.620</td>
<td>2.444</td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.485)**</td>
<td>(0.491)**</td>
</tr>
<tr>
<td>2005</td>
<td>2.683</td>
<td>3.031</td>
<td>3.536</td>
</tr>
<tr>
<td></td>
<td>(0.170)**</td>
<td>(0.488)**</td>
<td>(0.495)**</td>
</tr>
<tr>
<td>Education of head of household (=1 if some college or more, =0 otherwise)</td>
<td>-1.626</td>
<td>-2.448</td>
<td>-3.375</td>
</tr>
<tr>
<td></td>
<td>(0.113)**</td>
<td>(0.332)**</td>
<td>(0.355)**</td>
</tr>
<tr>
<td>Age of head of household dummies (less than 30 omitted)</td>
<td>1.253</td>
<td>1.340</td>
<td>1.267</td>
</tr>
<tr>
<td>30&lt;=Age&lt;=39</td>
<td>(0.054)**</td>
<td>(0.148)**</td>
<td>(0.158)**</td>
</tr>
<tr>
<td>40&lt;=Age&lt;=49</td>
<td>-3.319</td>
<td>-4.052</td>
<td>-3.853</td>
</tr>
<tr>
<td></td>
<td>(0.079)**</td>
<td>(0.222)**</td>
<td>(0.227)**</td>
</tr>
<tr>
<td>50&lt;=Age&lt;=59</td>
<td>-1.529</td>
<td>-3.091</td>
<td>-1.047</td>
</tr>
<tr>
<td></td>
<td>(0.184)**</td>
<td>(0.576)**</td>
<td>(0.521)**</td>
</tr>
<tr>
<td>60&lt;=Age&lt;=69</td>
<td>-2.065</td>
<td>-2.813</td>
<td>-3.454</td>
</tr>
<tr>
<td></td>
<td>(0.219)**</td>
<td>(0.597)**</td>
<td>(0.646)**</td>
</tr>
<tr>
<td>Number of children</td>
<td>-2.961</td>
<td>-4.216</td>
<td>-4.054</td>
</tr>
<tr>
<td></td>
<td>(0.213)**</td>
<td>(0.581)**</td>
<td>(0.627)**</td>
</tr>
<tr>
<td>Number of prime age adults</td>
<td>-3.779</td>
<td>-4.172</td>
<td>-5.355</td>
</tr>
<tr>
<td></td>
<td>(0.222)**</td>
<td>(0.609)**</td>
<td>(0.653)**</td>
</tr>
<tr>
<td>Number of elderly adults</td>
<td>-5.642</td>
<td>-4.713</td>
<td>-8.458</td>
</tr>
<tr>
<td></td>
<td>(0.335)**</td>
<td>(0.980)**</td>
<td>(0.964)**</td>
</tr>
<tr>
<td>Constant</td>
<td>30.927</td>
<td>33.434</td>
<td>36.569</td>
</tr>
<tr>
<td></td>
<td>(0.326)**</td>
<td>(0.914)**</td>
<td>(1.001)**</td>
</tr>
<tr>
<td>Observations</td>
<td>72438</td>
<td>7952</td>
<td>8212</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses, all models estimated by maximum likelihood. All data from the American Housing Survey. + significant at 10%; * significant at 5%; ** significant at 1%
Table 6: Maximum Likelihood Models of Expenditures as a Percent of Income Using the Consumer Expenditure Survey, 1994-2003

<table>
<thead>
<tr>
<th>Year dummies, 1994 omitted</th>
<th>(1) Total spending ex. housing costs</th>
<th>(2) Mortgage payments</th>
<th>(3) Total housing costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>0.372 (1.071)</td>
<td>1.036 (0.535)*</td>
<td>1.278 (0.692)*</td>
</tr>
<tr>
<td>1999</td>
<td>-2.289 (1.064)*</td>
<td>1.391 (0.531)**</td>
<td>0.958 (0.687)</td>
</tr>
<tr>
<td>2001</td>
<td>-1.857 (1.100)*</td>
<td>1.662 (0.552)**</td>
<td>1.378 (0.714)*</td>
</tr>
<tr>
<td>2003</td>
<td>-2.633 (1.274)*</td>
<td>2.070 (0.636)**</td>
<td>2.158 (0.823)**</td>
</tr>
<tr>
<td>Constant</td>
<td>45.212 (1.704)**</td>
<td>21.655 (0.850)**</td>
<td>34.873 (1.100)**</td>
</tr>
<tr>
<td>Demographic controls¹</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>4599</td>
<td>4524</td>
<td>4524</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.03</td>
<td>0.05</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%

¹ Demographic controls include number of income earners and children in the household, 5 age range dummies for the head of household, and 1 dummy variable for the education level of the head of household.
Table 7: Interest Rates on Mortgages and Demographic Characteristics

<table>
<thead>
<tr>
<th>Demographic controls</th>
<th>Expected change in probability from a probit model of a household being in the bottom quintile of interest rates</th>
<th>OLS coefficients of the interest rate on the primary and second mortgages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All households</td>
<td>Household below median income</td>
</tr>
<tr>
<td>Head of household has some college education</td>
<td>0.023  (0.004)**</td>
<td>0.018  (0.006)**</td>
</tr>
<tr>
<td>Age of head of household dummies (less than 30 omitted)</td>
<td>0.028 - 0.035 (0.007)**</td>
<td>-0.019 - 0.030 (0.007)**</td>
</tr>
<tr>
<td>30&lt;=Age&lt;=39</td>
<td>0.036 - 0.040 (0.007)**</td>
<td>-0.030 - 0.030 (0.007)**</td>
</tr>
<tr>
<td>40&lt;=Age&lt;=49</td>
<td>0.033 - 0.057 (0.007)**</td>
<td>-0.017 - 0.030 (0.007)**</td>
</tr>
<tr>
<td>50&lt;=Age&lt;=59</td>
<td>0.027 - 0.051 (0.011)*</td>
<td>-0.014 - 0.030 (0.010)*</td>
</tr>
<tr>
<td>60&lt;=Age&lt;=69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Demographic controls include the same variable reported in tables 2-6, dummy variables for income decile, and dummy variables for SMSA.

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Figure 1: Ratio of Refi Index to Mortgage Bank Employment Index

Source: MBAA and BLS
Figure 2: Costs of Adjustable Rate Mortgages

Source: Freddie Mac
Figure 3

Percent of Total Mortgage-Backed Securities In Private Conduits

Source: Board of Governors
Figure 4: Mean Income Profiles by Age and Education

Results from tobit models of the log of wage income on a fourth-degree polynomial of age for each of three education groups. The models were estimated using data on full-time workers from the 2000 decennial census.
Figure 5a: Allocations and Utility as Function of Down Payment Rate

Figure 5b: Consumption Allocations
Figure 5c
% change in Utility Associated with Change in Down Payment Constraint

Utility following change from $\delta=20\%$ to $\delta=10\%$

Figure 5d
% Changes in Consumption and Housing Consumption
Change from $\delta=20\%$ to $\delta=10\%$
Figure 6a: Allocations and Utility as function of Mortgage Tilt

Figure 6b: Timing of Consumption as Function of Mortgage Tilt
Figure 7: Home Ownership Rates and Changes in Real House Prices and the Housing Stock

Source: BEA, Census, and OFHEO.
Figure 8a: Kernel Densities of Total Housing Costs as a Percent of Income for Home Owners, by Year

Figure 8b: Kernel Densities of Mortgage Costs as a Percent of Income for Home Owners, by Year

Source: American Housing survey (various years) and authors' calculations
Figure 9
Distribution of MSA House Price changes 2000-2005