Affordability, Financial Innovation, and the Start of the Housing Boom*

Jane K. Dokko
Brookings Institution

Benjamin J. Keys
Harris School of Public Policy
University of Chicago

Lindsay E. Relihan
The Wharton School
University of Pennsylvania

September 2015

Abstract

At their peak in 2005, more than sixty percent of all purchase loans originated in the United States contained at least one non-traditional financing feature. These features, which allowed borrowers easier access to credit through "teaser" interest rates, interest-only or negative amortization periods, and extended payment terms, have been the subject of much regulatory and popular criticism. In this paper, we create a novel county-level dataset to explore the relationship between rising house prices and non-traditional mortgage features. Using a break-point methodology, we find that although structural breaks in alternative financing and credit availability are correlated with house price movements, the timing of changes in alternative financing most frequently occurred after house price breaks. Our results are most consistent with the view that borrowers turned to these products in order to afford increasingly more expensive homes, rather than the availability of these products precipitating a trend-break in house prices.

*We thank Leonard Kiefer, Karen Pence, Amit Seru, Amir Sufi, and participants at the Bank of Korea, the Federal Reserve Bank of Chicago Bank Structure Conference, the Kreisman Initiative/Crain's Chicago Business Housing Research Forum, and the AREUEA mid-year meetings for helpful comments and suggestions. Keys thanks the Kreisman Initiative on Housing Law and Policy at the University of Chicago for support. Any remaining errors are our own. Contact: jdokko@brookings.edu, benkeys@uchicago.edu, lrelihan@wharton.upenn.edu.

I Introduction

The dominance of the 30-year fixed rate mortgage is one of the defining features of the United States housing market. For a brief period in the mid-2000s, however, this dominance was challenged by the popularity of non-traditional mortgage products that allowed borrowers easier access to credit through variable interest rates with teasers, extended payment terms, or interest only or negative amortization schedules. In effect, borrowers could pay less than 30-year fully amortizing monthly payments for some period of time and thus purchase homes of greater value. As Figure 1 shows, the share of mortgages with at least one "alternative financing feature" grew sharply during the years of the most rapid (and ultimately unsustainable) house price appreciation. At their peak in 2005, more than sixty percent of all purchase loans originated in the United States contained at least one alternative financing feature. Their coincidence with increasing house prices led many to conclude that these products were partly to blame for the housing boom. Consequently, their use since the housing bust has been almost nonexistent and many have called for permanent restrictions on mortgage contracts with these features.

In this paper, we explore the direction and magnitude of the relationship between rising house prices and alternative mortgage products. One possibility is that as house prices rose, borrowers flocked to non-traditional products to maintain affordability. In many instances, the rise in local house prices during the last decade was not matched by a rise in local incomes (Mian and Sufi 2009). In order for households at the extensive margin of home buying to purchase a home, the available mortgage contracts needed to be more affordable. Expanded access can generally be accomplished in three ways: a reduction in credit quality standards, lower down-payment requirements, or a reduction in the monthly payment. Many households face short-term liquidity constraints that restrict the resources they can devote to mortgage payments each month. We might therefore expect the reduction in mortgage payments afforded by alternative mortgage products to be a particularly important way for households to access housing services in an environment with high house prices.

However, the relationship between house prices and alternative mortgage products is more complicated. Borrowers may have used these alternative products to purchase more valuable homes in anticipation of a future rise in house prices. Such a relationship would suggest that the use of

alternative mortgage products creates negative externalities through speculation (as in Barlevy and Fisher 2011). In this case, there would be grounds for policymakers to restrict, or at least carefully monitor, alternative mortgage products in the interest of macroprudential regulation.

Despite previous research, the nature of the relationship between rising house prices and alternative mortgage products remains unclear for at least three reasons.[1] First, much of the research treats the housing boom as a single, national event and lacks both cross-sectional and time-series variation in the timing and size of local house price booms.[2] Second, without a clear exogenous shock to either house price growth or the use of alternative mortgage products, adequately addressing the simultaneity between house prices and mortgage products becomes extremely difficult. And third, concurrent changes in a local market, such as economic fundamentals, could confound the relationship between house prices and alternative mortgage products.

To address these three challenges, we construct a dataset with an unprecedented level of detail and precision. The data are at the county-by-month level, which allows for heterogeneity among local housing markets and fine measurement of changes within them. In addition, the loan level data from which we draw covers a large portion of the purchase market and a wide array of variables describing almost every possible feature of every loan. For 1,163 counties, we construct measures of house price growth, use of alternative mortgage products, credit supply, and economic fundamentals in each month from 1993 to 2007. This novel dataset gives us an unusual level of granularity in our study of the housing market and allows us to discern patterns that would be obscured at higher levels of data aggregation.

We then employ a break point randomization methodology based on the theory in Hansen (2000) and similar to that implemented by Ferreira and Gyourko (2011) and Charles et al. (2014). This method identifies the month in which each county's house price growth deviated most strongly from its prior trend. Each county's "break point" then serves as the start of the local house price boom. On average, we estimate that house price growth discontinuously increased by 6.5 percentage points at the start of a county's boom. This is an economically significant increase relative to the

[1] In addition, other studies debate over the role of investors and speculative activity, the role of subprime borrowers, and the degree to which changing economic fundamentals can explain the boom and bust. These studies include, but are not limited to, Haughwout et al. (2011), Amromin et al. (2010), Barlevy and Fisher (2011), Mian and Sufi (2009), Glaeser et al. (2010), Demyanyk and van Hemert (2011), Himmelberg et al. (2005), Ferreira and Gyourko (2011), Chinco and Mayer (2014), and Favilukis et al. (2013).

[2] A notable exception is Ferreira and Gyourko (2011).

average 2 percent house price growth prior to the start of the boom. However, we find significant heterogeneity in the timing and size of local house price booms across counties. Some break points occurred as early as 1993 and others as late as 2007, and jumps in house price growth range from 4 to 10 percentage points. Given such large heterogeneity, a purely national study could miss many of the important features that caused local house price booms to differ across time and place.

Our next step is to measure the change in the use of alternative mortgage products in the month in which house prices deviate most strongly from trend. We find discontinuous increases in the usage of variable rate, interest only, negative amortization, and extended term mortgages around the time of county-specific house price breaks. In addition to these individual features, we construct two new summary measures of the presence of alternative financing. First, we measure the share of loans in a given county with any alternative financing feature that allows the borrower to deviate from a fully amortizing 30-year fixed-rate mortgage. Second, we estimate a counterfactual payment that individual borrowers would have faced had their mortgage contract been for a 30-year fully amortizing loan. Using this counterfactual, we generate a measure of the "gap" between the 30-year fully amortizing payments and their observed payment.

We find that the prevalence of these alternative financing products and the estimated payment gap discontinuously widen around the time of the county-specific house price break. One remarkable example is the experience of Clark County, Nevada, which includes Las Vegas. Our methodology estimates that the Las Vegas housing boom began in February 2003. As shown in Figure 2, there is a clear difference in both the house price path and rate of house price appreciation on either side of the estimated breakpoint. In Las Vegas, we find that the rapid adoption of alternative mortgage products with lower monthly payments almost exactly coincides with the estimated start of the local housing boom (shown in Figure 3). Prior to the boom, 20 percent of purchase mortgage contracts had an alternative feature; by early 2004, 80 percent of contracts did so. These figures representing our empirical approach establish that non-traditional features of housing finance were directly linked to changes in house prices in some markets.

We then explore whether the supply of credit also experienced discontinuous changes around the estimated starts of local house price booms. We find that lenders increased their supply of credit by lending more to subprime borrowers while not denying significantly more loan applications and

permitting more leverage. The percent of loans made to owner-occupiers also fell slightly, pointing to a possible role for investors at the start of local booms (as in Haughwout et al. 2011 and Chinco and Mayer 2014). Consistent with a greater expansion of credit to subprime borrowers, underwriting standards and the percent of loans financed by the FHA decline at the start of booms, perhaps indicating that subprime lenders were taking a larger market share in low-income markets. At the same time, there is some evidence that market fundamentals were improving, as we find an increase in income. Taken together, these discontinuous changes suggest that the changes to credit supply are also closely linked to changes in house prices, and that at least some of the expansion of credit would have been justified by observable improvements in the local economy.

While these overall patterns are suggestive, we find that distinct differences emerge when we divide counties into those that experience early versus late house price breaks. The two decades over which our local house price booms occurred were characterized by very different conditions in the broader economy. We classify "early" counties as those with booms beginning before 2000 (many urban coastal counties such as San Francisco County, CA fall into this category) and "late" counties (such as Clark County, NV) as those with booms beginning 2000 and later.

Our results suggest that in counties with early house price booms alternative mortgage products and deteriorating underwriting standards did not play as large of a role in house price growth. Instead, increasing incomes appear to be a stronger factor in explaining early booms. We interpret this contrast as evidence that early house price booms may have been driven more by economic fundamentals rather than credit market conditions. Indeed, in the markets with later house price booms, we also document the strongest association between the start of house price booms and the use of alternative mortgage products. In these counties, our overall measures of alternative financing features and the payment gap substantially increase around the estimated break points. In later booming markets, we also find credit expansion to be closely associated with the start of local house price booms. The overall changes in credit supply discussed earlier are almost entirely driven by these late-booming housing markets.

In our final piece of analysis, we further explore the link between house prices and alternative mortgage financing in later house price booms. Our descriptive results show that the timing of changes in alternative financing are most likely to occur after the house price break. Thus, our

results are most consistent with the view that borrowers turned to these products in order to afford increasingly more expensive homes, rather than the availability of these products directly driving an acceleration in house price growth. In over two-thirds of counties, the break in financing options occurred after the break in house prices. In sum, the prima facie evidence seems most consistent with these product features as sequential responses to increasingly expensive 30-year fully amortizing mortgages: first through the use of variable rate loans with teaser rates, then interest-only or negative amortization payment schedules, and finally extended term mortgages (see Figure 4).

Of course, the very existence of alternative mortgage products depends on the willingness of lenders to offer them. Although invented much earlier, these products were not much utilized until the late 1990s, at which point they became more attractive to lenders for several reasons. Advances in technology, including automated underwriting and better credit monitoring, made lenders more confident in their ability to assess the risk of such products (Gates et al. 2002). Financial liberalization and a deepening of the secondary market allowed lenders to not only make more mortgages, but pass on the riskiest to third parties (Keys et al. 2010; Rajan et al. 2015). Advances in contract theory also suggest that in healthy economies with rising house prices, lenders are more willing to make contracts with incomplete information (Bolton and Faure-Grimaud 2010; Tirole 2009; Piskorski and Tchistyi 2011). Our findings thus contribute to the literature on financial innovation by presenting evidence that the use of alternative mortgage products expanded most sharply in environments where prices were rising rapidly and less information was being collected on borrower quality.

Our results integrate a number of strands of recent literature on the determinants of the housing boom and the degree to which rising prices reflected justifiable credit supply expansions due to improving economic fundamentals or unjustified speculation (Ferreira and Gyourko 2011, Davidoff 2013). Such research points to the role of investors (Haughwout et al. 2011, Mayer and Chinco 2012) and the role of affordable and/or "exotic" mortgage products (Amromin, et al. 2013; Barlevy and Fisher 2011; Piskorski and Tchistyi 2011; Keys, et al. 2013). Experts are divided on whether these factors are a cause or consequence of rising prices, in part because of the challenge that, in many economic models, expectations of future price increases affect borrowers' and lenders'

behavior when mortgages are originated. On one side of the discussion, research finds that economic fundamentals and investor speculation contributed to the housing boom (Haughwout et al. 2011, Mayer and Chinco 2012, Ferreira and Gyourko 2011). Other sides of the literature find that alternative mortgage features can only arise in a speculative bubble (Barlevy and Fisher 2011) while others put forth that only minimal easing of lending standards occurred (Gyourko, Glaeser, and Gottlieb 2013). Many others are silent on whether alternative mortgage features contributed to or accelerated the housing boom (Amromin et al. 2013). In our paper, we find that the popularity of affordable mortgage products generally increased after structural breaks in house price appreciation, and that this was facilitated by an expansion of credit, providing support for the view that maintaining affordability and financial market liberalization were central determinants to the timing of house price increases, especially in late-booming markets.

In the next section, we describe our data and the construction of our novel measures of the use of alternative mortgage products. Section III presents a simple theoretical model to highlight the ways in which house prices and alternative mortgage products interact. Section IV describes our break point methodology and its application to house prices. In section V, we provide our results of our study for all counties and explore how those results change when we consider early- and late-booming counties separately. Section VI concludes and provides a brief policy discussion.

II Data and Measurement

The data used in our study are uniquely suited for studying the relationship between rising house prices and alternative mortgage products. Our house price indices cover an unusually large set of markets and include sales backed by a large range of loan types. These indices should, therefore, be more sensitive to purchases backed by alternative mortgage products, reducing possible measurement error. We also have the advantage of several nationally representative loan-level datasets with information on far more loan characteristics than are typically available. This allows us to measure with great precision the prevalence of alternative mortgage products for a large number of local markets. To our knowledge we are the first to construct such measures. Our access to private versions of this data also allow us to take measurements at a monthly frequency. This makes it much easier to pinpoint sharp changes in our variables and to follow the order in which they occur.

Our analysis uses data from three primary sources. The first is CoreLogic (CL), which provides our county-level house price indices. These indices are, for our purposes, preferable to others, such as those produced by the Federal Housing Finance Authority, which only include properties backed by government loans, or those produced by Case-Shiller, which are limited to a smaller set of markets. At the time of our analysis, CL produced 1,163 county-level house price indices for single-family detached properties using their repeat sales methodology. The indices start back as far as 1973 for some counties, but we limit our sample to 1993 (many indices begin in this year) and later. No indices are produced for counties that experience fewer than five sales in a least one month over their collection period. The sample counties cover over 80 percent of the US population. The remaining 20 percent consists of rural counties that experienced very little of the housing boom.

We also obtain loan-level records for first-lien non-agency (subprime and Alt-A) mortgages from CL and loan-level records for agency (mostly prime) mortgages from LPS Applied Analytics (LPS) covering 1990-2012. Both CL and LPS collect these records from a group of mortgage servicers. Their combined coverage of the mortgage market in the early 1990s is less than ideal, 20-40 percent, but grows with the addition of more servicers over time. The data after 2004 covers over 80 percent of the first-lien market. While the representativeness of our data in earlier years and compositional shifts over time are a concern, this data remains the best, if not only, source for detailed information on loan characteristics. Additionally, it is unlikely that changes in coverage are correlated with county-level structural breaks in house prices or our other market variables so our research design is, to a certain extent, able to overcome this particular limitation of the data. The sample is limited to purchase loans since we are interested in the actions of borrowers entering the market, rather than current owners who refinance or extract equity from their homes. Our measures for each county in each month of the share of loans with a variable rate, extended term, interest only, negative amortization, FHA, full documentation, and any alternative financing feature come from this combined dataset. In addition we also calculate average FICO scores, first-lien loan-to-value ratio, and the payment gap with this data.

We also use a separate, but overlapping, dataset that uses first-lien (except in the calculation of second-lien share) loan level data from the Home Mortgage Disclosure Act (HMDA) for 1990-2009. HMDA was passed by Congress in 1975 and requires every lender satisfying any of a broad list of

criteria to report every loan and a set of its characteristics to a central repository[3]. Because of this requirement, coverage for this dataset is near universal. Again, we limit ourselves to purchase loans. From this source, we obtain additional information on loan and borrower attributes not available in the CL and LPS data. The measures we calculate from HMDA for each county and month include percent of loan applications denied, percent subprime, second lien share of originations, percent owner-occupied, average debt-to-income ratio, and average borrower income.[4]

For both the combined CL/LPS dataset and the HMDA dataset, we construct our measures of housing market characteristics for each county and each month in the sample. We supplement this with county level income and employment statistics from the Census. This unique county-level dataset gives our analysis more granularity across three dimensions — the geographic level (county), time period (month), and mortgage-level detail — than any previous study along these lines.

We focus on the characteristics of the mortgage that would allow a borrower to pay less than the 30-year fully amortizing monthly payment. These characteristics include teaser variable rates, interest-only or negative amortization designs, and extended term contracts. In order to concisely summarize the value to the borrower of these types of contracts in relaxing the monthly payment constraint, we calculate two variables which we refer to as the percent of mortgages with any alternative financing feature and the average payment gap. The first is very straightforward; if a mortgage possesses a least one feature, such as negative amortization, then it is counted as having any alternative financing feature. For the second, a counterfactual monthly payment is constructed based on the payment that the borrower would have paid had they used a standard 30-year, fixed rate, fully amortizing contract at the prevailing PMMS rate in that month.[5] We define the difference between this estimated monthly payment and the borrower's actual monthly payment as the "monthly payment gap." As seen in the blue line in Figure 4, this variable hovers around zero, on average, until about 2003 after which it becomes negative until about 2007. Any

[3]The most important criteria include having assets below a low threshold and operating a branch within an MSA. For a full discussion of reporting requirements see `http://www.ffiec.gov/hmda/pdf/2013guide.pdf`.

[4]Subprime loans are identified by matching HMDA agency and lender codes with the subprime lender list created by HUD. According to Mayer and Pence (2009), this method should adequately capture the size of the subprime market. HMDA itself includes an indicator for "high-cost" loans in the later years of data, but this measure may not capture whether the loan is actually subprime (given the lack of data on creditworthiness).

[5]We conducted robustness tests using a risk-adjusted version of this estimated rate, using hypothetical FICO/LTV rate bins as one would find on a rate sheet. The results were largely unchanged (available upon request).

deviations from full amortization results in a negative monthly payment gap and indicates that the borrower is paying less on a monthly basis than he otherwise would have in the absence of these products. Positive values of the payment gap can arise if the borrower's estimated payment is larger, such as would be the case borrowers had shorter terms than 30 years.

We view the percent any alternative financing feature and the percent with a payment gap measures as useful not only for the purposes of this study, but more broadly for monitoring the mortgage market. As is clearly shown from Figure 1, the time series of the any alternative financing feature measure indicates quite strongly when borrowers and lenders began to use affordable mortgage products to help borrowers purchase homes. As the analysis will show later, the timing of the entrance of these products in different markets across the country is highly related to house price growth in the market.

III Theoretical Framework

Before our discussion of empirical methods, it is useful to discuss the optimization problem of a household that wishes to purchase a home and a potential lender. In doing so, we show that the relationship between alternative mortgage products and house prices is complex. High house prices may encourage borrowers to use alternative mortgage products to maintain affordability. But, borrowers may also drive up house prices through the use of these products if they use them to speculate through the purchase of more and/or larger homes. Our simple theoretical framework captures both of these effects.

A household considering a home purchase must trade off the benefit of housing consumption against other types of consumption. How much of each type of consumption they choose is dependent on not only their preferences, but also market conditions and expectations about market conditions over the period of time they will own the home. For example, in a market with rising house prices a household may buy a larger home than they would otherwise buy to take advantage of capital gains. This decision is further complicated by the need of most households to finance a home purchase through a mortgage. What types of mortgages are available and under what terms also plays a critical role in the consumption decision of households. A mortgage with a low interest rate period or an extended term will lower the monthly payment a borrower is required to make,

thereby allowing a household to purchase a home or a more expensive home.

The availability of funds to finance the purchase of a home is determined by lenders in the mortgage market. The amount they decide to lend to a household will depend in large part on the financial situation of that household (Agarwal, et al. 2011). Borrowers with lower incomes or credit scores will be restricted in the amount they are allowed to borrow because of their elevated default risk. The lender will also incorporate their own understanding of market conditions and expectations into their lending decisions. In a market with rising house prices, for instance, the value of loan collateral increases, so the lender might be more willing to lend to borrowers with more default risk under the expectation that a higher-valued collateral could be recovered. In addition, lenders may change their menu of mortgage options to maintain affordability for borrowers so that both the borrower and lender benefit from rising house prices. The degree to which lenders may alter their menu depends on how binding either down-payment or monthly-payment constraints are to borrowers.

We outline a simple framework to illustrate these ideas, adapted from Piskorski and Tchistyi's (2013) model of an optimal contract for forward-looking borrowers and lenders. We abstract from important frictions, such as foreclosure discounts and limits on the supply of loanable funds, in order to focus on the relationship between house price expectations, income, and mortgage contract decisions (Campbell, et al. 2011). We assume that a household purchases a home with a mortgage at time $t = 0$ and maximizes lifetime utility. The utility of a household depends on the consumption of housing services, a composite good, and end of life wealth: $u_t = \sum_{t=0}^{T} U_t(c_t, \gamma H) + W_T$, where c_t is the composite good, γ is the flow of services from a house of size H, and W_T is end of life wealth. The household has income w_t and faces a budget constraint in each period $c_t + p_t + s_t \leq w_t$, where p_t is the mortgage payment and s_t is savings at time t. The size of the payment will depend on the size of the home purchased at $t = 0$, the interest rate, the mortgage term, and the size of the down payment. The household is allowed to default at any time and receives a reservation utility from that point forward. On the lender side, we imagine a risk neutral lender with unlimited capital who wants to maximize the revenue from a stream of payments p_t discounted at rate r: $v_t = \sum_{t=0}^{T} \frac{p_t}{(1+r)^t}$. If a borrower defaults, the lender takes possession of the home and sells it at market price.

Given conditions at $t = 0$ and expectations about future conditions, a household and a lender

will form a contract that maximizes their expected utility. In this framework, it is not necessary for the borrower's and lender's expectations to be identical, but they should each have expectations such that gains from the contract will be positive. How those gains from trade are divided between the borrower and lender are not modeled here. When income rises, both the borrower and the lender will be more willing to increase the size of the contracted house: the borrower because housing is a normal good and the lender because higher incomes are associated with lower default risk. But it is not only this type of economic fundamental that can change the parties' willingness to contract over a house of size H. The expectation of future high house prices will allow borrowers to take on larger homes, even if their credit quality and income remains unchanged, because lenders can expect larger revenue from foreclosure sales. In order to access this revenue, lenders may be willing to offer non-traditional mortgage products that maintain affordability for such borrowers.

While this framework abstracts from many issues, it highlights the important mechanisms by which households and lenders determine equilibrium mortgage prices and characteristics in an environment with rising house prices. This model can also help explain how competing theories on the cause and effect for rising house prices might both be true. Households with better income prospects will bid up market prices and other households will need to maintain affordability if they choose to stay in the market. Unfortunately, we are not aware of any natural experiment that would allow us to fully disentangle cause and effect. We must, therefore, rely on second best methods that can still provide evidence on which theory best fits the data. In the next section, we describe how our event study methodology around the timing of local house price breaks can be used to establish the typical order of events in the housing market and thus gain an understanding of the mechanics of the house price boom.

IV Methodological Framework

We are primarily concerned with studying changes in local housing markets at the start of their house price booms. This, of course, requires a definition of the start of a house price boom. Unfortunately, no clear definition exists since considerable uncertainty characterizes the empirical work in the literature to identify booms (Himmelberg et al. 2005, Case and Shiller 2003, Mayer 2011). Our approach is to identify the start of a county's housing boom by using a break point

randomization methodology that selects the month in which 12-month house price appreciation rates first deviate most sharply from prior trends. We assume that this large deviation indicates that the forces driving local house prices changed in some fundamental way. This follows the approach taken by Hansen (2000) and applied to metropolitan housing markets by Ferreira and Gyourko (2011) and Charles et al. (2014).

For each county c and month m, we run regressions over all possible breakpoints $\lambda*_{c,m}$ of the form:

$$\delta P_{c,m} = \alpha_c + \beta_c \mathbf{1}[\lambda_{c,m} \geq \lambda*_{c,m}] + \epsilon_{c,m} \tag{1}$$

In the sample for each county, we only include the months up to and including the month with the largest 12-month change in house prices. This ensures our methodology chooses the structural break associated with the boom in house prices, rather than a break associated with the later bust. Practically, this usually involves running somewhere between 60 and 150 regressions (one for each month observed for a given county from the beginning of the data to the house price peak) for the 1,163 counties with an available house price index from CL. From each regression, we recover the sum of squared errors, $S(\lambda_{c,m})$ and identify the structural breakpoint in house price growth as:

$$\lambda*_{c,m} = argmin(S(\lambda_{c,m})) \tag{2}$$

We exclude any county for which this chosen break point is not significant at the 5 percent level. This leaves us with 832 counties in our final sample.

After recovering the month in which house price growth deviates most from trend, what we call the start of the local housing boom, we use this date to estimate the magnitude of house price appreciation, namely the β_c in the regression where $\lambda_{c,m} = \lambda*_{c,m}$. We then analyze a wide range of mortgage and borrower attributes and housing market conditions to explore whether these other factors significantly change during the year in which house prices jump. We run regressions of the form:

$$Y_{c,m} = \alpha_c + \beta\lambda *_{c,m} + \nu_1 m + \nu_2 m^2 + \epsilon_{c,m} \tag{3}$$

Our regression specifications include county fixed effects α_c, a quadratic in calendar time m, and controls for county level income. ur dependent variables $Y_{c,m}$ include the use of specific types of alternative mortgage products, our aggregate measures of alternative mortgage product use, and the availability of credit. The β coefficients tell us whether these other characteristics changed significantly in the month in which house prices began to boom. The inclusion of county fixed effects is important to the extent that counties' time-invariant characteristics explains both the timing of house price breaks and how the attributes of mortgages and borrowers change around the house price break. For example, Amromin et al. (2013) argue that borrowers using mortgages with alternative features tend to have higher income and more education. Because these borrowers geographically segregate along these dimensions that also matter for housing markets, it is important to estimate the relationship between house prices and mortgage features within counties. Controlling for calendar time helps us control for the underlying trends in mortgage and borrower characteristics so that the estimated relationship between house price breaks and these attributes is independent of these trends.

These regressions are closely linked to the consumer and lender optimization problem discussed in the theoretical framework. If consumers primarily used alternative mortgage products to keep payments within their monthly budget constraint, $c_t + p_t + s_t \leq w_t$, after the initial acceleration in house prices, then we would expect their use to be uncorrelated with our house price breaks. Alternatively, if consumers used these products to access more housing services, γH, or end of period wealth, W_T, then we would expect their increased use by consumers to be concurrent with the house price breaks.

In addition to our main set of regressions, we extend the analysis in Ferreira and Gyourko (2011) by running breakpoint estimations on additional variables besides house prices. Importantly, we are interested in when various housing and mortgage market characteristics experience a significant deviation from the prior trend. This extension allows us to assign a degree of Granger-style causality. For example, if house price appreciation changes discontinuously in a period before the discontinuous change in the percent of originations that are subprime, we may infer that the percent subprime does not "Granger cause" accelerated house price growth. More simply, the use of subprime loans is unlikely to have "caused" the local house price boom if house prices accelerated

before the widespread use of subprime loans.

There are several caveats to this approach that we wish to point out. First, other break point studies typically split their sample into two parts, one which they use to estimate the break point and another to estimate the size of the jump. In doing so, some issues related to endogeneity can be ameliorated. We are unable to do this because we take our house price indices as given, rather than calculated directly, because we obtain already constructed house prices from CoreLogic. In addition, the number of loans in any given county is small enough that splitting our sample to first construct a $Y_{c,m}$ variable and then to estimate a break would leave us with little statistical power. Second, our methodology only allows for a single break point when it may be that some markets experienced multiple structural changes in the path of house prices. For example, many counties in California experienced a housing boom related to the technology sector in the late 1990s in addition to a boom in the mid-2000s. We use the strongest single break and do not allow for multiple breaks since it is not clear which counties this would apply to ex ante and such an arbitrary split may only serve to confuse the results.

V Results

V.A House Price Booms and Alternative Mortgage Financing

Our first set of results show the estimates of the beginning of local house price booms, defined as the period in which the rate of house price growth deviated most strongly from prior trend. Figure 5 shows the estimates for four counties in our sample plotted against their county house price indices and 12-month house price appreciation rates. It is readily apparent that for these four counties our estimation procedure does an excellent job at picking the month in which house prices began to boom. For other counties with less smooth house price indices or multiple boom periods, the break point is not as obvious to the naked eye. Still, we believe this methodology is the best approach for systematically choosing the start of local house price booms.

Figure 7 provides a histogram showing the distribution of these breaks across time for all our counties and their average magnitude. Each bar spans six months. There are several interesting features of the distribution. First, the majority of house price breaks take place between 1998

and 2005, with pronounced spikes at the beginning and end of this range. The 1998 spike closely coincides with the tech boom in California and the Northeast, while the spike around 2005 occurs well after what we usually think of as the "beginning" of the national housing boom. Second, some local house price breaks are estimated to take place at the very extreme ends of our sample period, with some occurring as early as 1993 and as late as 2007. This heterogeneity immediately questions the notion of a national house price boom (see, e.g., Ferreira and Gyourko 2012; Mian and Sufi 2009).

The magnitude of the initial house price break also varies across time with the largest breaks occurring after 2005. The red dots in Figure 6 give the average magnitude of the jump in house prices for house price breaks that occurred in that period. In counties with house price breaks, the average looks fairly steady over time at roughly 6 percentage points. This average then rises dramatically and appears to peak around 2005 to approximately 10 percentage points. Table 1 shows the precise estimates of the average size of the breaks in our sample. We find that although house prices jumped an average of 6.5 percentage points at the start of the local boom across all time periods, early counties jumped an average of 6 percentage points and late counties an average of 7 percentage points. This suggests that the forces driving later breaks may have been somewhat different from those driving earlier breaks, a proposition we explore in detail below.

As seen in Figure 8, counties with structural breaks in house prices before 2000 – shown in gray – are situated along the coasts, with some clusters around other major population centers such as Minneapolis and Chicago. Meanwhile, counties with later breaks – shaded in black – are more dominant farther away from the coasts. A second noticeable feature is the dispersion of house price shocks from major city centers to outlying areas. This pattern has been documented elsewhere (for example, see DeFusco et al. 2012) and is an interesting area for future research. Such a pattern may also lend support to the hypothesis that booms in late-breaking counties were driven by households' search for affordable housing outside urban cores.

With our estimates of the starts of local house price booms in hand, we then analyze how changes in the use of alternative mortgage products coincided with these starts. The first two columns of Table 2 show the average change in the use of alternative mortgage products across counties in the same period as the local house price break. The first column includes county fixed effects and and

the second column adds controls for calendar time. The results between these two columns are very stable, suggesting that controls for county and calendar time appear to be orthogonal to the timing of the house price break, so we focus on the more conservative results with the full set of controls in column 2. The results show a statistically significant increase of 2.7 percentage points in the use of variable rate loans and a 0.7 percentage point rise in negative amortization loans. Our aggregate measures of any alternative financing feature and the payment gap show a statistically significant increase of 3.1 and 2.5 percentage points, respectively. The overall results suggest that the use of alternative mortgage products interacted with house prices in a meaningful way. Some of the results in Table 2 are presented graphically in Figure 11.

However, the story becomes more nuanced when we split counties according to their early- versus late-breaking status. Columns 4 and 6 of Table 2 repeat the same exercise as column 2 for these two groups, respectively. Column 4 shows that in early-breaking counties, the increase in most alternative mortgage products was of smaller magnitude and, in some cases, statistically insignificant. The share with any alternative financing features increases approximately 1.2 percentage points, mostly accounted for by a rise in the share with an adjustable-rate mortgage. Interestingly, the percent of loans that are interest-only decreases. In contrast, column 6 shows that late-breaking counties are driving up the results in column 2. The percent of variable rate mortgages increased by almost 6 percentage points and the percent of interest only mortgages increased by 3.7 percentage points. Our two summary measures also increased, with the percent of mortgages with any alternative financing feature increasing by 6.5 percentage points and the percent with a payment gap increasing by 4.0 percentage points. Comparing the estimated jumps for early- and late-breaking counties to the levels reported in Table 5 suggests that, even in percentage terms, late-breaking counties generally experienced larger changes.

V.B Structural Breaks in Alternative Mortgage Financing and Granger Causality Tests

We then apply the same break point estimation technique to our aggregate measures of use alternative mortgage products. This approach estimates at what time the use of these products accelerated in different local markets. The results are presented graphically in Figure 9 and Figure

10. As is evident, the overwhelming majority of counties with a structural break in the percent with any alternative financing feature and percent with a payment gap experienced that break between 2003 and 2005. This timing coincides with the previously mentioned spike in local house price breaks around 2005. However, the lack of a economically significant correlation along the rest of the distribution again suggests that alternative mortgage products played a minor role in early house price booms. Instead they became a factor only when most of the country was already experiencing accelerated house price growth. This then begs the question of what other housing market conditions were changing at the time of early house price breaks. The expansion of credit to new borrowers is one possibility that we can analyze with our data.

The results in Table 3 explore how credit conditions were changing in the overall market and in our split between early- versus late-breaking counties. All estimates reflect controls for county fixed effects and calendar time. The overall results in column 1 show a statistically significant increase of 1.1 percentage points in the percent of mortgages going to subprime borrowers and a decrease of 1.5 percentage points in the percent of mortgages originated by the FHA. This suggests that lenders were extending more subprime credit to low-quality borrowers and crowding out FHA lending to these borrowers. There is also evidence that more credit was extended to borrowers of all types: the share of originations made up of second liens increased by 0.5 percentage points. Because the primary motivation for these mortgages is to keep the amount of the first lien within the conforming loan limit, this suggests that more borrowers are exceeding this limit as they accessed mortgage credit. Finally, we also find that the average income of mortgage loan applicants jumped by just over $3,000, suggesting that not all of the observed growth in credit supply was purely speculative, as borrowers with higher incomes and better job prospects generally receive more credit.

In columns 2 and 3, we repeat this exercise for early- versus late-breaking counties. For early-breaking counties, we find that denial rates edged up 0.4 percentage points but that, nevertheless, the share of subprime borrowers increased 1.1 percentage points and the average FICO score dropped 5.5 points. These results suggest that for some subset of early-breaking counties, subprime borrowers and declining credit quality may have played an important role at the start of the local house price boom. The most striking result from early-breaking counties is the both economically and statistically significant increase in borrower incomes of approximately $5,300. This result

could owe to either rapid income growth or the entry of high-income borrowers to the local market, and either would suggest improving economic fundamentals at the start of the housing boom in early-breaking counties.

For late-breaking counties, the supply of credit appears to change somewhat more significantly at the start of local house price booms. The percent of mortgage applications denied decreased by 0.4 percentage points and the percent of mortgages originated by the FHA decreased by 1.8 percentage points. They also experience a change in their borrower mix. In addition to an increase in subprime borrowers, more loans go to investors, as indicated by the 1.7 percentage point decrease in the share of loans indicating owner-occupancy. There is also a 3.8 percentage point decrease in loans made with full documentation, perhaps reflecting lenders' willingness to make riskier loans. And there is also a large and statistically significant increase of 1.3 percentage points in the share of originations accounted for by second liens. However, the rise in income is somewhat lower in late-breaking counties at $3,100 than in early counties (and less so in real terms). Though some of the increase in credit supply could be explained by improvements in income, it is unlikely that a smaller jump in income could justify the larger expansion of credit supply in counties with late house price breaks.

Moreover, we find that the rise in the subprime share is not large enough to fully account for the increase in the use of alternative financing features. Specifically, comparing the magnitudes of the estimated jumps in the share of borrowers with alternative financing and the share that is subprime (Tables 2 and 3), we find that the former is larger than the latter. Counties with late house price breaks show a larger difference between the rise in the subprime share (Table 3) and the rise in the use of alternative financing (Table 2). This result corroborates previous research that finds that prime borrowers turned to "non-traditional" mortgage products during the housing boom and adds to the literature by documenting that the shift in the behavior of prime borrowers was larger in counties with late house price breaks (Amromin et al. 2011).

In short, the results presented thus far point to a role for alternative mortgage products to facilitate affordability, particularly in markets with later house price booms. These markets feature larger increases in alternative financing features and the payment gap but do not show a correspondingly large increase in income. Moreover, late-breaking counties experience a more significant

deterioration in borrower credit quality. To lend further support to this narrative, we provide additional analysis to examine whether the proliferation of alternative financing features and deterioration in borrower credit quality precede the house price boom and could thus be driving the jump in house prices.

To explore this possibility, in Table 4 we present the timing of structural breaks in the various financing variables as compared to the structural breaks in house prices. These results are based on the same methodology used to identify the timing of house price breaks so for each financing variable, we run a series of regressions to identify the period in which the use of these products deviates most sharply from its trend. The rightmost column of the table shows that while most counties experienced a break at some point in these financing variables. But, as seen in the first three columns, the vast majority of counties experience such breaks after the break in house prices. For example, 86 percent of counties experience a break in the share of loans with any alternative financing feature and 62 percent of these counties experience such breaks after the house price break. In other words, nearly three-quarters (or 72 (= 62/86) percent) of the breaks in any alternative financing feature occur after the house price break. Similarly, 67 (= 53/70) percent of the breaks in the payment gap occur after the house price break.

At a minimum, the results in Table 4 suggest that the use of alternative financing features did not systematically precede the start of local house price booms. Our preferred interpretation – that is, the one that best fits the data – of the results in Table 4 in light of our other evidence is that the use of alternative mortgage products was largely a response of households trying to maintain affordability in an environment of rising house prices. For other explanations, the estimates in Table 4 provide additional requirements that explanations of the housing boom must incorporate, including why trend breaks in alternative financing features generally follow the period in which house prices start to boom but for the response of households. Another requirement lies in identifying the variables that are omitted from our analysis but would explain the sequence in which house prices and then alternative financing "jump." Among the many narratives put forth in the literature, we are unaware of an alternative that would fit the evidence we have presented.

VI Conclusion

In this paper, we attempt to disentangle the timing of the use of alternative mortgage products and the timing of house price growth during the housing boom. To do so, we leverage newly integrated mortgage databases with information on the precise timing of mortgage contracts, and use transparent methods to identify the timing of the introduction and growth of the use of these alternative products. In this unique time period, alternative mortgage products were surprisingly commonly used. We find that in many local housing markets, house prices boomed well before substantial use of alternative mortgage products, suggesting that expanded access to credit occurred in response to binding down-payment and monthly-payment constraints on the part of borrowers. Moreover, consistent with this interpretation, we find that the use of alternative mortgage products cannot be fully accounted for by the increase in the share of subprime borrowers.

Our separate analysis of early- versus late-booming counties shows the importance of treating the housing boom as a local, heterogeneous event. Counties with the start of their house price booms before 2000 show relatively smaller changes in the composition of mortgage activity but the gains in income in these markets, however, are both statistically and economically significant. This result complements the findings of Ferreira and Gyourko (2011) and supports the view that the initial house price boom was driven by economic fundamentals. In contrast, late-breaking counties seem to be those where the acceleration of house prices, use of alternative mortgage products, and the expansion of credit are most closely linked. Furthermore, our evidence suggests that alternative mortgage products were more often a tool for borrowers to maintain affordability rather than to speculate on rising house prices.

Our work has particularly focused on the start of local house price booms, rather than their evolution over time. An important and nascent body of research focuses on how a boom changes into a "bubble" in which prices become unmoored from market fundamentals (see, e.g. Mayer 2011). Our narrative regarding how high house prices led borrowers to use alternative mortgage products to maintain affordability ignores the feedback effects of these products during the bubble period. This remains a topic for future research.

In the wake of the crisis, regulators have placed significant limitations on a number of the alternative mortgage features discussed in this paper by excluding them from the definition of a

"Qualified Mortgage" for regulatory purposes. As laid out by the Consumer Financial Protection Bureau (CFPB) in their January 2013 report, lenders will no longer be able to underwrite a qualified mortgage loan based on a "teaser" rate in determining ability to pay, and cannot contain interest-only, negative amortization, or extended term features.[6] As we have shown, whether restricting these contract features will have an impact on the formation and magnitude of housing price cycles in the future depends crucially on the context of the use of these features. Although these rules have only recently come into effect, the consequences of limiting these products will likely reduce credit access for some households, while guiding others into more standard contracts. What impact these changes in credit access have on house prices going forward is also a promising area of future research.

[6]See the CFPB report on ability to repay rules and qualified mortgages: `http://files.consumerfinance.gov/f/201301_cfpb_ability-to-repay-rule_what-it-means-for-consumers.pdf`

VII References

Agarwal, Sumit, Brent W. Ambrose, Souphala Chomsisengphet, and Chunlin Liu, "Asymmetric Information in Dynamic Contract Settings: Evidence from the Home Equity Credit Market," Journal of Money, Credit, and Banking, 43(4), 2011.

Amromin, Gene, Jennifer Huang, Clemens Sialm, and Edward Zhong. "Complex Mortgages." Federal Reserve Bank of Chicago Working Paper no. 2010-17, November 2010.

Barlevy, Gadi, and Jonas D. M. Fisher. "Mortgage Choices and Housing Speculation." Federal Reserve Bank of Chicago Working Paper no. 2010-12, Revised: June 2011.

Bolton, Patrick, and Antoine Faure-Grimaud. "Satisficing Contracts." Review of Economic Studies 77(3): 937-971, July 2010.

Campbell, John, Stefano Giglio, and Parag Pathak. "Forced Sales and House Prices." American Economic Review, 101(5): 2108-31, August 2011.

Case, Karl E., and Robert J. Shiller. "Is There a Bubble in the Housing Market?" Brookings Papers on Economic Activity, No 2., 2003.

Charles, Kerwin K., Erik Hurst, and Matthew J. Notowidigdo. "Housing Booms, Labor Market Outcomes, and Educational Attainment." Working Paper, April 2014.

Chinco, Alex and Chris Mayer. "Misinformed Speculators and Mispricing in the Housing Market." NBER Working Paper No. 19817, January 2014.

Davidoff, Thomas. "Supply Elasticity and the Housing Cycle of the 2000s," Real Estate Economics 41, no. 4 (2013): 793 - 813.

DeFusco, Anthony, Wenjie Ding, Fernando Ferreira, and Joseph Gyourko. "The Role of Contagion in the Last American Housing Cycle." Wharton Working Paper, 2012.

Demyanyk, Yuliya and Otto Van Hemert. "Understanding the Subprime Mortgage Crisis." Review of Financial Studies 24, no. 6 (2011): 1848-1880.

Favilukis, Jack, David Kohn, Sydney Ludvigson, and Stijn Van Nieuwerburgh. "International Capital Flows and House Prices: Theory and Evidence." in E. Glaeser and T. Sinai, eds., Housing and the Financial Crisis, University of Chicago Press / NBER, 2013.

Ferreira, Fernando and Joseph Gyourko. "Anatomy of the Beginning of the Housing Boom: U.S. Neighborhoods and Metropolitan Areas, 1993-2009." Wharton Working Paper, August 2011.

Gates, Susan Wharton, Vanessa Gail Perry, and Peter M. Zorn. "Automated Underwriting in Mortgage Lending: Good News for the Underserved?" Housing Policy Debate, 13(2), 2002.

Glaeser, Edward L., Joshua D. Gottlieb, and Joseph Gyourko. "Can Cheap Credit Explain the Housing Boom?" NBER Working Paper No. 16230, July 2010.

Hansen, Bruce E. "Sample Splitting and Threshold Estimation." Econometrica 68 (2000): 575-603.

Haughwout, Andrew, Donghoon Lee, Josephy Tracy, and Wilbert van der Klaauw. "Real Estate Investors, the Leverage Cycle, and the Housing Market Crisis." Federal Reserve Bank of New York Staff Report no. 514, September 2011.

Himmelberg, Charles, Chris Mayer, and Todd Sinai. "Assessing High House Prices: Bubbles, Fundamentals, and Misperceptions." Journal of Economic Perspectives 19, no. 4 (2005): 67-92.

Keys, Benjamin J., Tanmoy Mukherjee, Amit Seru, and Vikrant Vig. "Did Securitization Lead to Lax Screening? Evidence from Subprime Loans." Quarterly Journal of Economics, 125(1), February 2010.

Keys, Benjamin J., Tomasz Piskorski, Amit Seru, and Vikrant Vig. "Mortgage Financing in the Housing Boom and Bust." in E. Glaeser and T. Sinai, eds., Housing and the Financial Crisis, University of Chicago Press / NBER, 2013.

Piskorski, Tomasz, and Alexei Tchistyi. "Stochastic House Appreciation and Optimal Mortgage Lending." Review of Financial Studies 24, no. 5 (May 2011): 1407-1446.

Mayer, Christopher. "Housing Bubbles: A Survey." Annual Review of Economics, 3: 559-77, 2011.

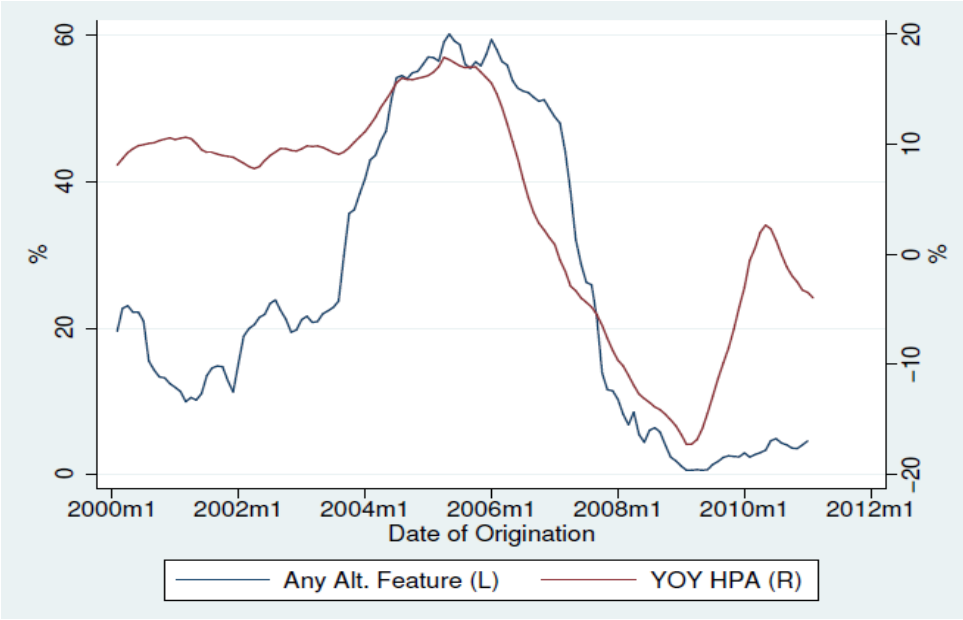
Mayer, Chris, and Karen Pence. "Subprime Mortgages: What, Where, and to Whom?" in Glaeser, Edward L. and John M. Quigley, eds., Housing Markets and the Economy: Risk, Regulation, and Policy. Cambridge, MA: Lincoln Institute of Land Policy, 2009.

Mian, Atif and Amir Sufi. "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis." Quarterly Journal of Economics 124, no. 4 (2009): 1449-1496.

Rajan, Uday, Amit Seru, and Vikrant Vig. "The Failure of Models that Predict Failure: Distance, Incentives, and Defaults." Journal of Financial Economics, 115(2), pp. 237-260, February 2015.

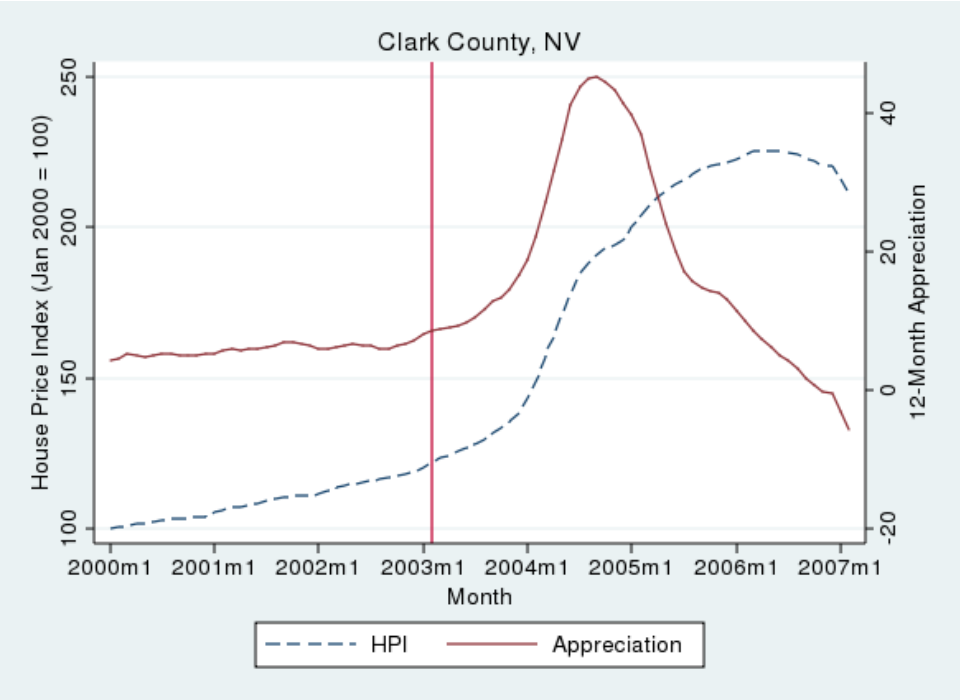
Tirole, Jean. "Cognition and Incomplete Contracts." American Economic Review, 99(1): 265-294, March 2009.

Figure 1: Share of Loans Originated with Any Alternative Financing Features and National House Prices



Note: The figure shows the fraction of purchase loans originated in a given month with any alternative financing feature (the blue line, and left y-axis), as well as year-over-year house price appreciation at the national level (the red line, and corresponding right y-axis). The alternative financing features are those that reduce the monthly payment relative to a fully amortizing 30-year fixed rate mortgage payment: teaser variable rate, extended term, interest-only, or negative amortization. See text for details.

Figure 2: Estimated House Price Break for Clark County, NV

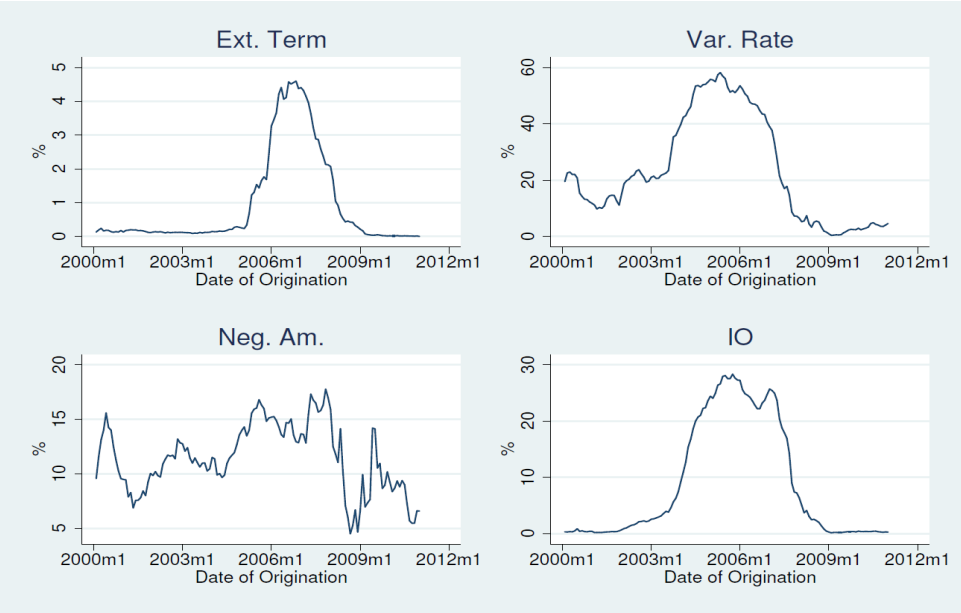


Note: The figure shows the timing of the estimated house price break in Clark County, NV, which is where Las Vegas is located. House price break is estimated using a break-point methodology described in the text. The figure shows both the level of house prices (the blue dashed line, and the left y-axis) and the 12-month appreciation rate (the red line and corresponding right y-axis). The vertical line represents the month in which the house price break occurred.

Figure 3: Use of Alternative Mortgage Products in Clark County, NV

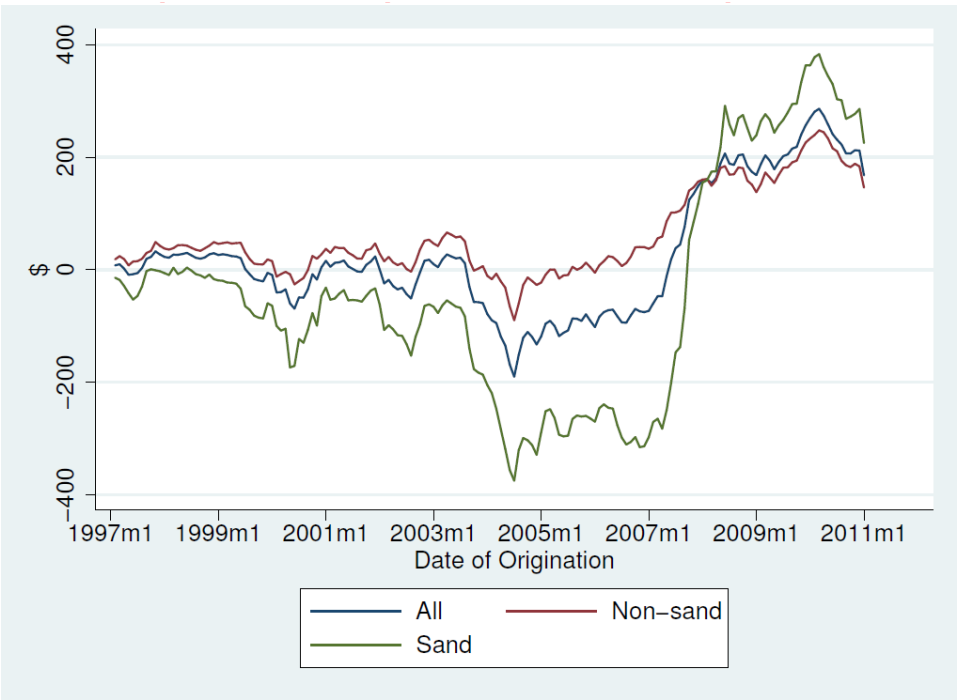
Note: The figure shows the fraction of purchase loans with a "payment gap," or any deviation from the fully amortizing 30-year fixed-rate mortgage payment (left panel), and the share with any alternative financing feature (right panel) in Clark County, NV (Las Vegas). The vertical line in each figure represents the month of the estimated house price break for Clark County.

Figure 4: Time Series of New Originations with Alternative Financing Features



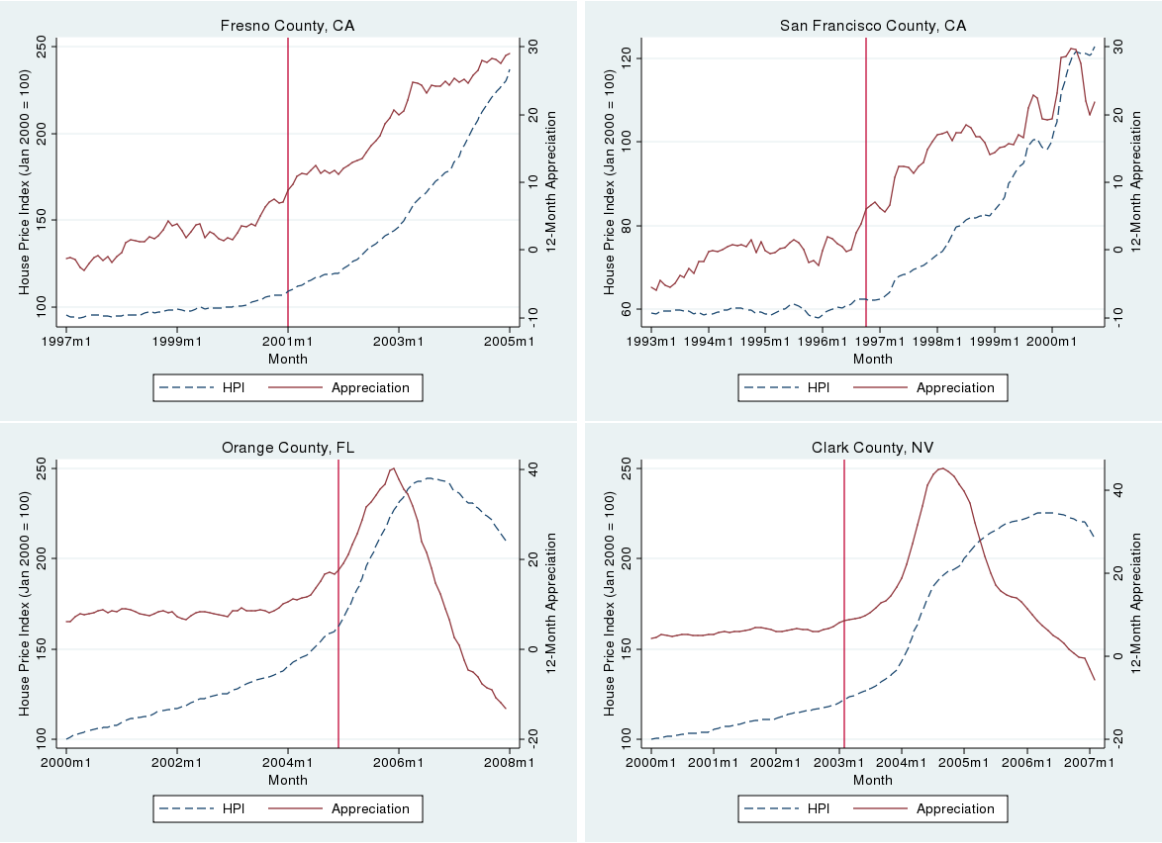
Note: The figure shows the time series of the fraction of purchase loans with each of four alternative financing features: extended term (top left), variable rate (top right), negatively amortizing contract (bottom left), and interest-only contract (bottom right). See text for additional details.

Figure 5: Time Series of Payment Gap Measure, by Sand and non-Sand States



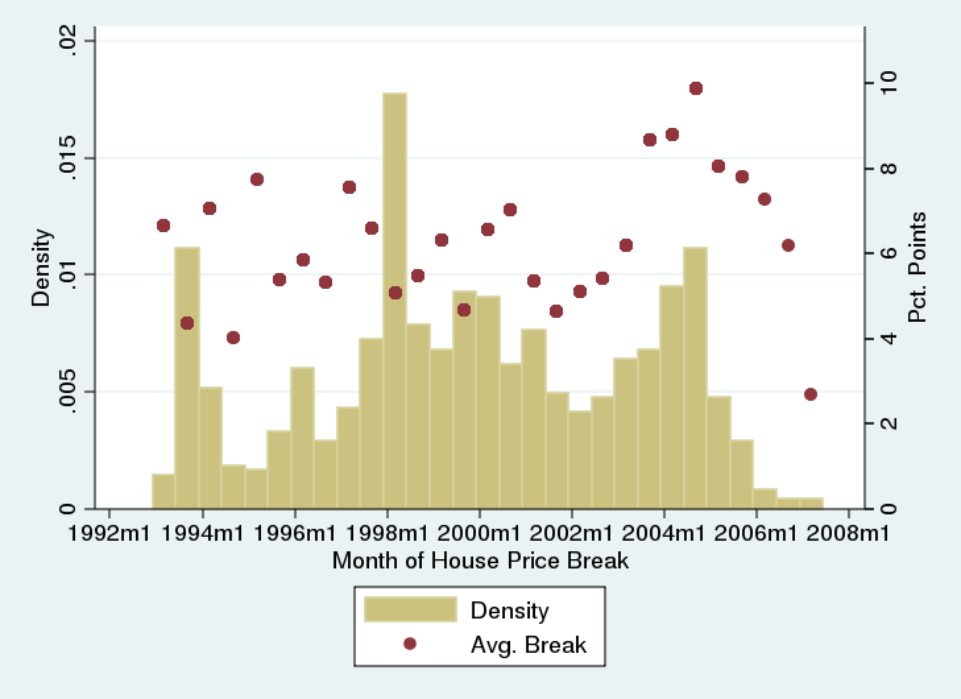
Note: The figure plots the time series of the "payment gap" measure, which represents the average deviation from the fully amortizing 30-year fixed-rate mortgage payment in each month. The figure shows a dramatic widening of the gap, especially in sand states, beginning in 2004. At the peak of alternative mortgage features, purchase mortgage borrowers paid nearly $400 per month less than they would have if the only available contracts were 30-year fixed-rate mortgages.

Figure 6: Sample Counties with Structural House Price Break



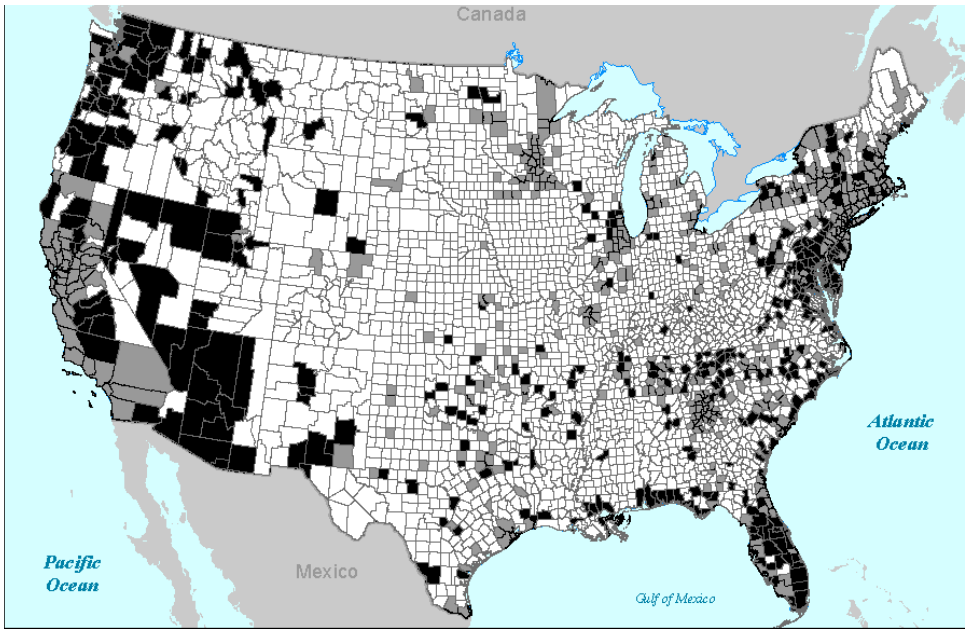
Note: The figure shows the timing of structural house price breaks in four counties: Fresno County, CA (top left), San Francisco County, CA (top right), Orange County, FL (bottom left), and Clark County, NV (bottom right). Structural breaks estimated using break-point methodology described in the text. Each panel shows both the house price index (blue dashed line) and 12-month appreciation rate (red line).

Figure 7: Distribution of Structural House Price Breaks and Average Magnitude of Break



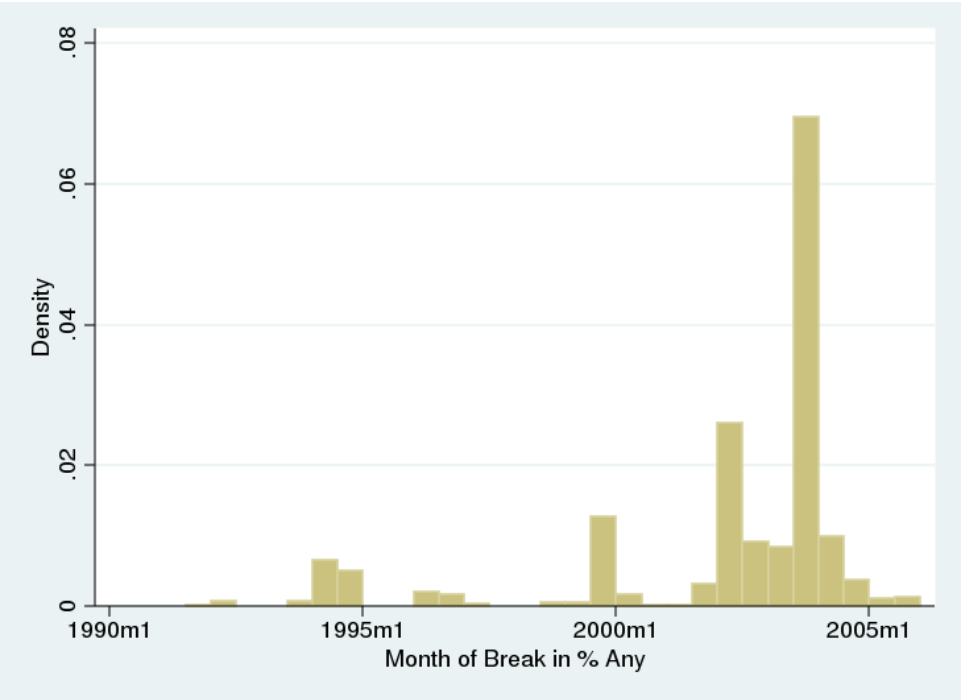
Note: The figure presents the distribution of the timing of each county's structural house price break. Structural breaks estimated using break-point methodology described in the text. The red dots represent the average magnitude of house price break in each period, indicating that later house price breaks were larger than earlier breaks (see right y-axis).

Figure 8: Location of Counties with Structural House Price Break



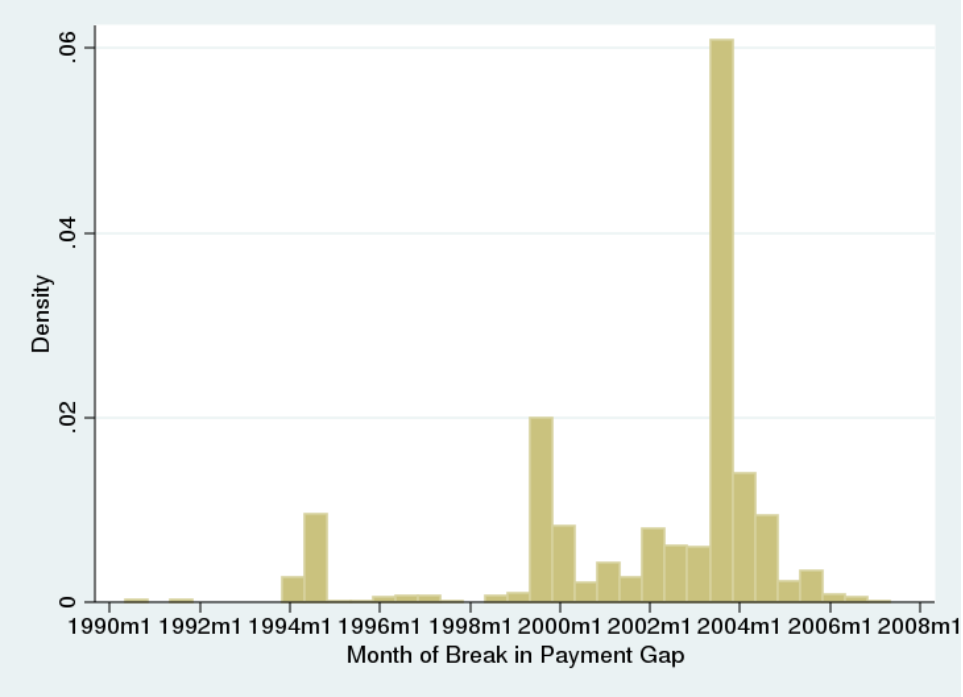
Note: The figure provides a map of the counties with structural house price breaks. Structural breaks estimated using break-point methodology described in the text. Gray-shaded counties had earlier breaks, whereas black-shaded counties had later breaks. White counties either had no estimated house price break or had insufficient data.

Figure 9: Distribution of Month of Structural Break in "Percent with Any Alternative Financing Feature"



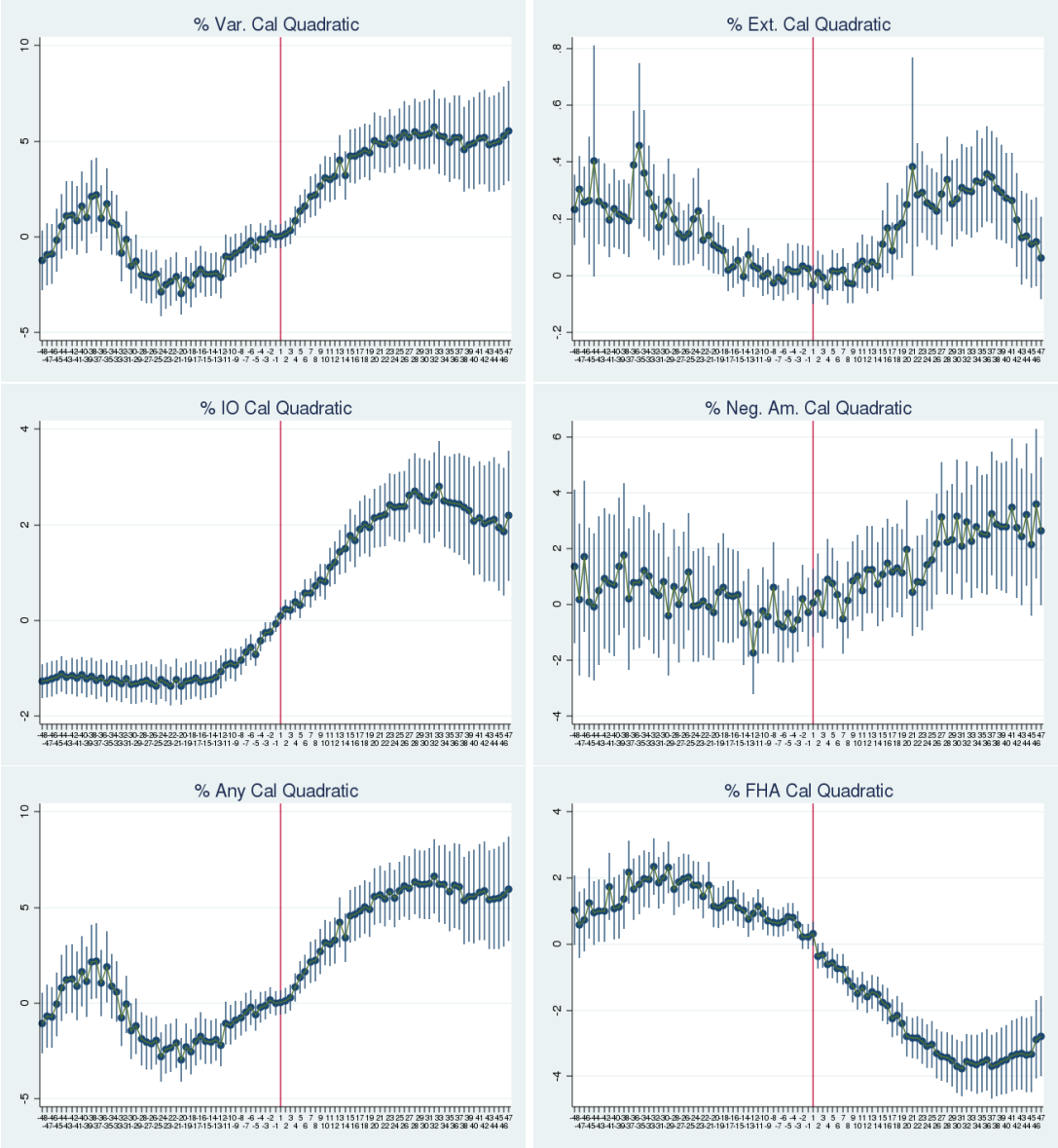
Note: This figure presents the distribution of the timing of structural breaks in the share of purchase originations with any alternative financing feature. See text for details of break-point methodology.

Figure 10: Distribution of Month of Structural Break in "Payment Gap"



Note: This figure presents the distribution of the timing of structural breaks in the share of purchase originations with a "payment gap," or deviation in monthly payment from a fully amortizing 30-year fixed-rate mortgage payment. See text for details of break-point methodology.

Figure 11: Event Study Figures around House Price Structural Breaks



Note: The figure shows event study figures (where time=0 is the month of the structural break in house prices. See text for details of break-point methodology. The variables plotted are percent variable rate (top left), percent extended term (top right), percent interest-only (middle left), percent negative amortization (middle right), percent with any alternative financing feature (bottom left), and percent FHA (bottom right). Each figure plots four years (48 months) before and after the estimated house price break. Dashed lines represent 95 percent confidence intervals. Event study specifications include county fixed effects and a quadratic in calendar time, see text for details on event study methodology.

Table 1: Magnitude of Break in House Price Growth Rate around County-Specific Structural Break Points

	Overall		"Early" Counties		"Late" Counties	
House Price Growth	10.9	5.3	6.8	3.2	15.5	11.1
	(0.30)	(0.27)	(0.15)	(0.16)	(0.54)	(0.55)
County FE?	Y	Y	Y	Y	Y	Y
Calendar Time Controls?	N	Y	N	Y	N	Y

Note: The table presents coefficients from an event study regression of the change in house prices around the timing of the estimated structural break in house prices. Estimates are the percentage point difference in the annual growth rate of house prices in year of the house price break relative to the previous year. Quadratic controls for calendar time used. "Early" signifies counties with house price break prior to 2000. Standard errors clustered at the county level are in parentheses. Source: Authors' calculations using CoreLogic data.

Table 2: Changes in Mortgage Financing around House Price Structural Breaks

	Overall		Early		Late	
% Variable Rate	3.0	2.7	1.8	1.2	4.3	5.5
	(0.42)	(0.42)	(0.56)	(0.58)	(0.61)	(0.66)
% Extended Term	0.2	0.2	0.0	0.1	0.5	0.4
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)
% Interest Only	1.8	1.2	0.1	-0.4	3.6	3.7
	(0.20)	(0.20)	(0.03)	(0.07)	(0.37)	(0.40)
% NegAm	0.1	0.7	0.0	0.8	0.3	0.3
	(0.26)	(0.32)	(0.43)	(0.47)	(0.30)	(0.44)
% Any	3.6	3.1	1.8	1.2	5.4	6.5
	(0.41)	(0.42)	(0.60)	(0.58)	(0.59)	(0.65)
% with "Payment Gap"	3.1	2.5	2.1	2.3	4.2	4.0
	(0.29)	(0.32)	(0.42)	(0.46)	(0.40)	(0.48)
County FE	Y	Y	Y	Y	Y	Y
Calendar Time Controls	N	Y	N	Y	N	Y

Note: The table presents coefficients from an event study regression of the change in mortgage financing features in a county relative to the timing of the estimated structural break in house prices. Estimates are the percentage point difference in each mortgage financing feature in year of the house price break relative to the previous year. Quadratic controls for calendar time used. "Early" signifies counties with house price break prior to 2000. Standard errors clustered at the county level in parentheses. Source: Authors' calculations using HMDA, LPS Applied Analytics, Bureau of Labor Statistics, and CoreLogic data.

Table 3: Changes in Credit Availability and Underwriting around House Price Structural Breaks

	Overall	Early	Late
% Denied	0.0	0.4	-0.3
	(0.17)	(0.23)	(0.26)
% Subprime	1.1	1.1	1.8
	(0.18)	(0.20)	(0.32)
% FHA	-1.5	-0.1	-3.9
	(0.14)	(0.19)	(0.23)
% Full Doc	-1.8	-0.6	-3.8
	(0.43)	(0.71)	(0.50)
FICO	-2.6	-5.5	0.0
	(0.66)	(1.16)	(0.64)
1st Lien Loan-to-Value	-0.4	-0.1	-0.7
	(0.09)	(0.14)	(0.10)
Second Lien Share of All Originations	0.5	0.1	1.3
	(0.08)	(0.08)	(0.13)
% Owner-occupied	-0.8	-0.3	-1.7
	(0.16)	(0.25)	(0.22)
Debt to Income Ratio	0.0	-0.01	0.01
	(0.00)	(0.00)	(0.00)
Income	3.3	5.3	3.1
	(0.50)	(0.65)	(0.71)
County FE	Y	Y	Y
Calendar Time Controls	Y	Y	Y

Note: The table presents coefficients from an event study regression of the change in credit availability and underwriting in a county relative to the timing of the estimated structural break in house prices. Estimates are the percentage point difference in each mortgage financing feature in year of the house price break relative to the previous year. All estimates include county fixed effects and quadratic controls for calendar time. "Early" signifies counties with house price break prior to 2000. Robust standard errors in parentheses. Source: Authors' calculations using HMDA, LPS Applied Analytics, Bureau of Labor Statistics, and CoreLogic data.

Table 4: Timing of Structural Breaks in Mortgage Financing Variables Relative to House Price Structural Breaks

	With Respect to House Price Break			with
	Before	Same	After	estimated
Variable Rate Break	22.2	3.2	59.5	84.9
Extended Term Break	6.5	1.4	73.0	80.9
"Any" Break	20.4	3.4	61.9	85.7
"Payment Gap" Break	22.6	3.8	52.8	79.2
FHA Break	10.3	0.1	54.7	65.1
2nd Lien Break	1.7	0.4	76.6	78.7
Denied Break	5.2	1.0	60.2	66.4

Note: The table shows whether structural breaks in mortgage financing variables occur before, concurrently, or after estimated structural breaks in house prices in a given county. First three columns do not necessarily sum to 100 percent in a given row because counties do not always have an estimated break in other variables. Sample consists of counties experiencing a house price break. Source: Authors' calculations using HMDA, LPS Applied Analytics, Bureau of Labor Statistics, and CoreLogic data.

Table 5: Summary Statistics for Pooled Sample of Counties

	Overall	Early	Late
HPA	7.6	6.2	9.3
	(5.2)	(4.1)	(5.8)
% Variable Rate	17.0	11.5	21.3
	(13.8)	(9.7)	(15.0)
% Extended Term	0.2	0.2	0.2
	(0.6)	(0.6)	(0.7)
% Interest Only	2.6	0.2	4.4
	(6.6)	(1.1)	(8.3)
% Negative Amortization	8.7	7.5	9.6
	(11.7)	(12.3)	(11.0)
% Any	17.5	11.7	21.8
	(14.3)	(9.8)	(15.6)
% with "Payment Gap"	14.2	9.6	19.2
	(14.4)	(13.5)	(13.7)
% Denied	16.4	17.9	15.0
	(10.0)	(11.4)	(8.2)
% Subprime	4.7	3.0	6.4
	(4.3)	(3.2)	(4.6)
% FHA	14.8	15.8	13.7
	(9.9)	(10.3)	(9.5)
% Full Doc	68.7	69.3	68.2
	(16.7)	(19.2)	(14.4)
FICO	695.0	695.3	694.8
	(25.6)	(31.4)	(20.1)
LTV Ratio	83.8	82.8	84.7
	(4.6)	(5.1)	(4.1)
2nd Lien Share of All Originations	6.5	5.0	7.9
	(4.6)	(3.6)	(5.0)
Income (in 1000s)	72.2	67.4	76.9
	(27.5)	(26.1)	(27.9)

Note: The table presents summary statistics for all counties with an estimated structural break in house prices. Values are county-month averages, with standard deviations in parentheses. Sample consists of county-months in the year before and after the county experiences a house price break. Source: Authors' calculations using HMDA, LPS Applied Analytics, Bureau of Labor Statistics, and CoreLogic data.