TESTIMONY OF

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BEFORE

The U.S. Senate Committee on Banking, Housing, & Urban Affairs Hearing on
"Preserving Homeownership: Progress Needed to Prevent Foreclosures"

July 16, 2009

Chairman Dodd, Ranking Member Shelby, and distinguished members of the Committee, I thank you for your invitation to testify today. My name is Paul Willen, and I am one of the Senior Economists and Policy Advisors at the Federal Reserve Bank of Boston, which as you know is one of the twelve regional Reserve Banks in the Federal Reserve System. I would like to stress that the views I share with you today are mine, not necessarily those of the Federal Reserve Bank of Boston, the other Reserve Banks, or the Federal Reserve's Board of Governors.

In the time allotted today I plan to briefly summarize some key findings in the research that I and several talented co-authors have done over the last two years – findings that I think are particularly relevant to the issue of foreclosure prevention. I have also submitted a written statement to the committee, which contains more detail on our research, and which I respectfully request be accepted for the record.

I hope that my comments today and our broader research will be helpful to the Committee, as you consider the important issues that are the focus of this hearing.

The limited success of foreclosure prevention strategies undertaken to date results, at least partly, from reliance on theories about the causes of the crisis that – while intuitively appealing – are at odds with the data. In my remarks today I will focus on four facts from the data which contradict widely held beliefs about the causes of the crisis:

1. Resets of adjustable rate mortgages have not been the main driver of borrower payment problems.

2. Household life events like job loss and illness played a central role in the surge in foreclosures that started in 2007, even prior to the start of the recession.

3. Most borrowers who got subprime mortgages would not have qualified for a prime mortgage for that transaction.

4. The practice of securitization is not the main reason that lenders have failed large numbers of home mortgages. A more plausible explanation is that it is simply unprofitable for them to do so.[1]

[1]We use lender here to refer to the institution that provided funds (the bank or the investor in

I would respectfully submit that policies that ignore these facts - however well intentioned - will address some smaller problems while regrettably ignoring much more serious ones.

According to the conventional wisdom, large payment increases associated with the first reset of subprime adjustable rate mortgages led to large numbers of foreclosures. To test this in the data, researchers – including but not only my co-authors and me – have looked at a large sample of individual loan histories which provide information about both the expected payments owed by borrowers and whether borrowers made those payments. If resets were truly important, we would expect to see a dramatic increase in the likelihood that a borrower has trouble with his or her payment to coincide with the first reset of an adjustable-rate-mortgage. But we see no such relationship in the data and, in fact, the majority of borrowers who default on subprime adjustable rate mortgages start missing payments long before the rate increases with a reset.[2]

Part of the reason for the confusion about the resets is the widespread and, we have found, incorrect belief that rates on subprime ARMs spike dramatically at the reset. Our research reveals that in fact the so-called "teaser" rates on subprime mortgages were very high to begin with. Indeed the phrase "teaser rate" is something a misnomer as it was typically 3 percentage points higher than the rate on an equivalent prime mortgage. The bump in rates at the reset, which is typically tied to six month London Inter Bank Offered Rate (LIBOR), was only about 3 percentage points when LIBOR peaked in 2007, and the Fed Fund rate cuts in the fall of 2007 largely eliminated the reset as an issue entirely. Starting in 2008, most subprime mortgages saw no change in the rate at the reset. The fact that there was no improvement in loan performance corresponding to interest rate cuts suggests the limited scope of resets as a problem.

Allow me a point of clarification that is more than mere semantics. Some com-

the case of a securitized loan) or anyone representing their interests (including the servicer or the trustee).

[2]For details, see Panel C of Figure 6 in "Reducing Foreclosures," by Foote, C., K. Gerardi, L. Goette and P. Willen. NBER Working Paper 15063 and forthcoming in the *NBER Macro Annual*. June 2009. Attached.

mentators have erroneously equated subprime mortgages with alternative-mortgage products like so-called Option-ARMs. Option-ARMs, which allow borrowers to pay less than the interest on the loan, and make up for it by adding to the principal balance, were not generally marketed to subprime borrowers, and our investigation of the data suggests that the typical pool of subprime loans had no Option ARMs at all. In fact, the majority of problem subprime loans were fully-amortized loans and many of them were, in fact, fixed rate mortgages. Option ARMs have been and will continue to be a problem but they are not, nor have they ever been, the main source of problems in the mortgage market.

A second point. The conventional wisdom until very recently minimized the role of so-called "life events" like unemployment and illness in generating defaults on subprime mortgages. People argued that life-events could not explain the surge in defaults in 2007, because there was no underlying surge in unemployment or illness that year. But I believe that view reflects a misunderstanding of the interaction of house price depreciation and life events in causing default. Foreclosures rarely occur when borrowers have positive equity, for the simple reason that a borrower is almost always better off selling if they have to leave the house anyway. Thus, detrimental life events have no effect on foreclosures when prices are rising. Consider that in 2001, Massachusetts suffered a fairly severe recession which led to a big increase in delinquencies, but the number of foreclosures actually fell to a record low, as shown in the chart I have included with my testimony (Figure 1). But when home prices fall, some borrowers can no longer profitably sell, and then the income-disrupting life-events really take a toll. Thus we did not need to see a surge in life-events to get a surge in foreclosures, but rather a fall in house prices – which is exactly, and unfortunately, what we saw.

In understanding the role of unemployment in foreclosures, for example, one has to understand that large numbers of households suffer job losses – "separations," in the lingo of labor economics – even when the economy is doing well. Even in the summer of 1999, in the best labor market in a generation, 300,000 individuals filed new claims for unemployment insurance every week. Because house prices were rising rapidly,

few of these job losses ended in foreclosure. But the recession that started at the end of 2007 and worsened dramatically in the fall of 2008 has aggravated the problem. The separation rate has increased and importantly, the finding rate – the rate at which unemployed worked get new jobs – has fallen to record lows. While a recession certainly makes the foreclosure problem worse, it is not necessary to generate large numbers of employment-related foreclosures.

One key policy concern I see is the likelihood that the problem of negative home equity and job loss will persist even after the economy recovers. A borrower with negative equity is, unfortunately, somewhat like a patient with a weak immune system – shocks easily absorbed by a "healthy" homeowner can prove fatal to a homeowner with negative equity. To see this depicted, please note again Figure 1. In Massachusetts, house prices stopped falling in 1992 and a vigorous economic recovery started the following year; but we saw elevated foreclosure numbers for the next five years. The reason is, I believe, rather easily determined: homeowners who bought at the peak of the market in 1988 did not have positive home equity and the protection it brings from foreclosure until house prices fully recovered the 1988 peak in 1998.

My third point relates to the oft-made claim that many borrowers who used subprime mortgages were "steered" into subprime loans and, in fact, would have qualified for prime loans. Part of the problem here relates again to a misunderstanding of what a subprime loan is. What differentiates a subprime loan from a prime loan is not the loan itself – a subprime adjustable rate mortgage is no different from a prime adjustable rate mortgage – but rather the characteristics of the transaction: the size of the down payment, the ratio of the monthly payment to income, the credit history of the borrower, the level of documentation provided by the borrower, among other things.

Careful analysis of the data shows that the vast majority of borrowers who took out subprime loans could not have qualified for prime loans. We looked at a large sample of subprime mortgages in New England in 2007 and defined a prime loan as a loan to an owner-occupant, with a loan-to-value ratio of 90% or less, full documentation of income and assets, a borrower FICO scores of 620 or higher, and a monthly payment

that was less than 45% of monthly income. Only 9.6% of the mortgages identified as subprime met these criteria. Furthermore, that subset of prime-qualifying buyers got mortgages with characteristics very similar to prime mortgages available at the time – 65% had fixed interest rates and the average initial interest rate for these loans was 6.7%.[3]

It should be clear that borrowers may well have been steered into transactions that required subprime loans. For example, a real estate agent may have convinced them to buy an expensive house or a mortgage broker may have encouraged them to do a cash-out refinance that in either case required a loan that no prime lender would approve given their income and credit history. But conditional on the actual transaction, there is no evidence right now that borrowers who used subprime loans could have qualified for a prime loan. The evidence typically cited to make the claim that borrowers were steered is that over the period 1999 to 2006, the fraction of borrowers who used subprime loans but had FICO scores typically associated with prime mortgages increased sharply, going from about 35% to 70% in our data. What this evidence fails to take into account is that over that same period, all the other characteristics of the loans deteriorated sharply: the average LTV for a subprime borrower with 660 FICO went from 82% to 95%.[4]

My fourth and final comment today relates to foreclosure prevention strategies. Foreclosures are bad for homeowners, but they are also bad for lenders, which typically recover less than half the principal owed to them. So it seems natural to think that borrowers and lenders could work together to arrive at some happy medium in which the borrower gets to stay in his or her home and the lender continues to receive payments, albeit smaller ones. In our most recent paper, we find that such renegotiation is extremely rare. Through careful statistical work using a dataset with 29 million active residential loans, we were able to look at borrowers in the year after they became seriously delinquent. Our main finding is that lenders are reluctant to

[3]For details, see attached, Foote, C., K. Gerardi, L. Goette and P. Willen. "Just the Facts: An initial analysis of the subprime crisis." 2008. *Journal of Housing Economics*, 17(4):291-305.

[4]See Figure 7 of Foote, C., K. Gerardi, L. Goette and P. Willen (2008), attached.

renegotiate loans: only about 3 percent of the seriously delinquent borrowers in our sample received payment reducing loan modifications in the year subsequent to their first 60-day delinquency.[5]

A leading explanation for this relative paucity of renegotiation is the view that since most loans are securitized now, the fragmented ownership and contractual complexity inherent in such transactions makes it difficult for borrower and lender to come to a mutually beneficial agreement. But our data does not support this theory. We find servicers equally reluctant to modify loans, whether they are owned in portfolio or serviced on behalf of securitization trusts.

We argue that a more plausible explanation for the unwillingness of lenders to renegotiate is that it simply isn't profitable. The reason is that lenders face two risks that can make modification a losing proposition. The first, which has been recognized as an issue by many observers and researchers, is "redefault risk" – the possibility that the borrower who receives a modification will default again, and thus the modification will have only served to postpone foreclosure and increase the loss to the investor as house prices fall and the home itself (the collateral) quite possibly deteriorates. The second risk, which has been largely ignored but I believe is no less important, and arguably more, is "self-cure risk" – the possibility that the borrower would have repaid the loan without any assistance from the lender. About a third of the borrowers in our large sample are current on their mortgages or prepay a year after they become sixty days delinquent. An investor would view assistance given to such a borrower as "wasted" money.

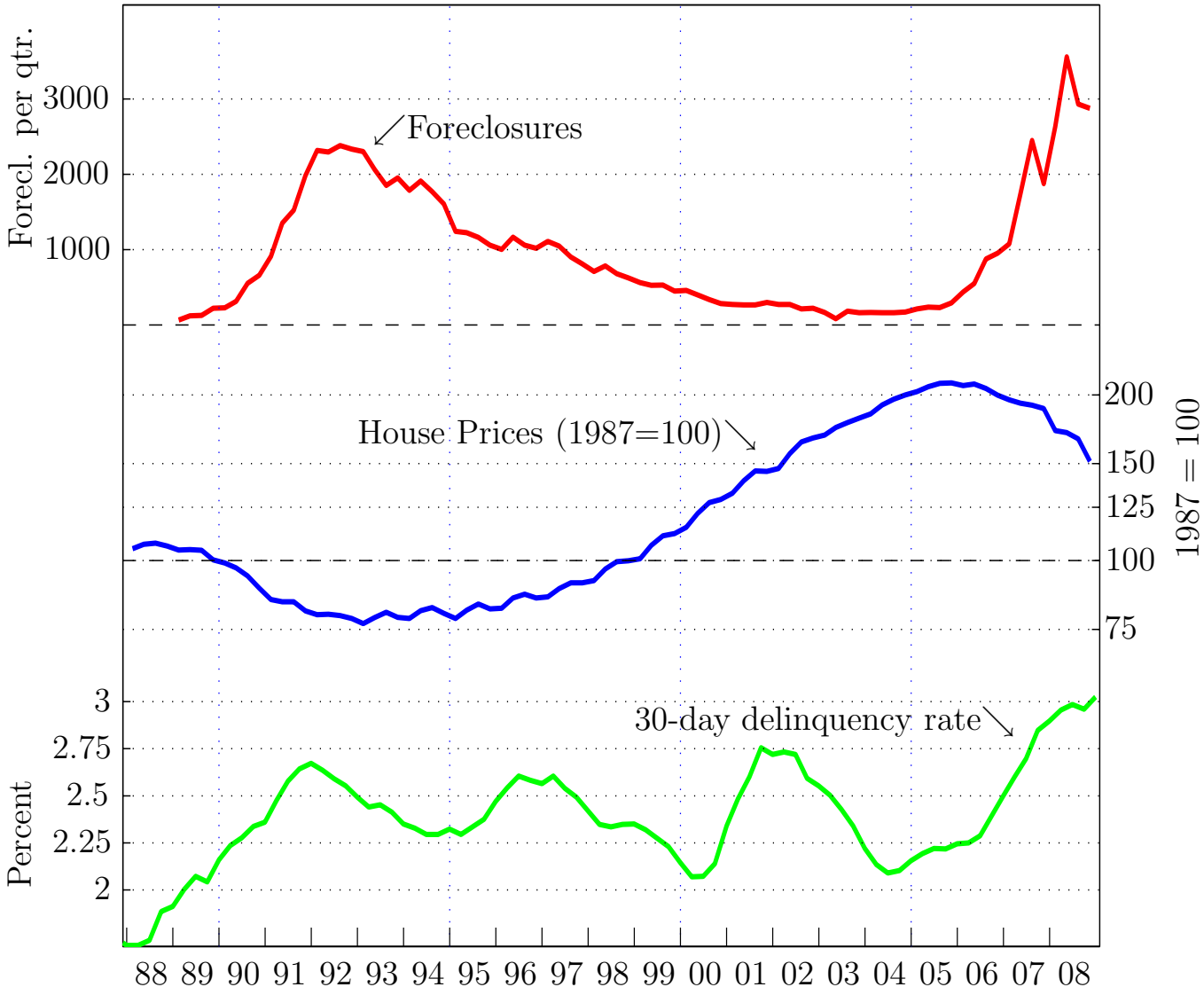
Let me conclude by saying that my observation, rooted in our investigation of the data, that servicers and investors may find modification unprofitable should not be misconstrued as suggesting that modification is not desirable for society at large and the economy. The private net present value and the social net present value of a modified loan may well be very different. An investor may have an urgent need for cash that leads it to find the short-term payoff of a foreclosure far more attractive

[5]See attached, Adelino, M., K. Gerardi and P. Willen. "Why Don't Lenders Renegotiate More Home Mortgages? Redefaults, Self-Cures and Securitization." FRBB PPDP 09-04, July 2009.

than the uncertain longer-term (but potentially larger) payoff from a modified loan.

We hope that these empirical findings about the crisis add important, and perhaps unexpected, insights to your work as policymakers. Thank you again for the opportunity to appear before you today. I would of course be happy to address any questions you might have.

Figure 1: Massachusetts House Price Growth, Foreclosures and Delinquencies, January 1989 to December 2008



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REDUCING FORECLOSURES: NO EASY ANSWERS

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Working Paper 15063
http://www.nber.org/papers/w15063

NATIONAL BUREAU OF ECONOMIC RESEARCH
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June 2009

The views in this paper are our own and not necessarily those of the Federal Reserve Banks of Boston or Atlanta. the Federal Reserve System, or the National Bureau of Economic Research. Andreas Fuster provided both first-rate research assistance and excellent comments and suggestions. We would like to thank, without implicating, Daron Acemoglu, Larry Cordell, Jeff Fuhrer, Eileen Mauskopf, Christopher Mayer, Atif Mian, James Nason, Julio Rotemberg, and Hui Shan for helpful comments and suggestions. We are also grateful for the help that Mark Watson and Kevin Shruhan provided us in working with the LPS data. Any remaining errors are our own.

Reducing Foreclosures: No Easy Answers
Christopher Foote, Kristopher Gerardi, Lorenz Goette, and Paul Willen
NBER Working Paper No. 15063
June 2009
JEL No. R2

ABSTRACT

This paper takes a skeptical look at a leading argument about what is causing the foreclosure crisis and distills some potential lessons for policy. We use an economic model to focus on two key decisions: the borrower's choice to default on a mortgage and the lender's subsequent choice whether to renegotiate or "modify" the loan. The theoretical model and econometric analysis illustrate that "unaffordable" loans, defined as those with high mortgage payments relative to income at origination, are unlikely to be the main reason that borrowers decide to default. In addition, this paper provides theoretical results and empirical evidence supporting the hypothesis that the efficiency of foreclosure for investors is a more plausible explanation for the low number of modifications to date than contract frictions related to securitization agreements between servicers and investors. While investors might be foreclosing when it would be socially efficient to modify, there is little evidence to suggest they are acting against their own interests when they do so. An important implication of our analysis is that the extension of temporary help to borrowers suffering adverse life events like job loss could prevent more foreclosures than a policy that makes mortgages more "affordable" on a long-term basis.

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1 Introduction

One of the most important challenges now facing U.S. policymakers stems from the tide of foreclosures that now engulfs the country. There is no shortage of suggestions for how to attack the problem. One of the most influential strands of thought contends that the crisis can be attenuated by changing the terms of "unaffordable" mortgages. It is thought that modifying mortgages is not just good for borrowers in danger of losing their homes but also beneficial for lenders, who will recover more from modifications than they would from foreclosures. Proponents of this view, however, worry that without government intervention, this win-win outcome will not occur. Their concern is that the securitization of mortgages has given rise to contract frictions that prevent lenders and their agents (loan servicers) from carrying out modifications that would benefit both borrowers and lenders.

In this paper, we take a skeptical look at this argument. Using both a theoretical model and some loan-level data, we investigate two economic decisions, the borrower's decision to default on a mortgage and the lender's choice between offering a loan modification and foreclosing on a delinquent loan. We first study the "affordability" of a mortgage, typically measured by the DTI ratio, which is the size of the monthly payment relative to the borrower's gross income.[1] We find that the DTI ratio at the time of origination is not a strong predictor of future mortgage default. A simple theoretical model explains this result. While a higher monthly payment makes default more likely, other factors, such as the level of house prices, expectations of future house price growth and intertemporal variation in household income, matter as well. Movements in all of these factors have increased the probability of default in recent years, so a large increase in foreclosures is not surprising. Ultimately, the importance of affordability at origination is an empirical question and the data show scant evidence of its importance. We estimate that a 10-percentage-point increase in the DTI ratio increases the probability of a 90-day-delinquency by 7 to 11 percent, depending on the borrower.[2] By contrast, an 1-percentage-point increase in the unemployment rate raises this probability by 10-20 percent, while a 10-percentage-point fall in house prices raises it by more than half.

[1] DTI ratio stands for "debt-to-income" ratio. A more appropriate name for this ratio is probably "payment-to-income" ratio, but we use the more familiar terminology. Throughout this paper, we define DTI as the ratio of mortgage-related payments to income, rather than all debt payments; this is sometimes called the "front end" DTI.

[2] As explained below, these estimates emerge from a duration model of delinquency that are based on instantaneous hazard rates. So, the statement that an 10-percentage-point increase in DTI increases the probability of 90-day delinquency by 7 percent means that the DTI increase multiplies the instantaneous delinquency hazard by 1.07, not that the DTI increase raises the probability of delinquency by 7 percentage points.

The fact that origination DTI explains so few foreclosures should not surprise economists, given the mountain of economic research on the sources and magnitude of income variation among U.S. residents. The substantial degree of churning in the labor market, combined with the trial-and-error path that workers typically follow to find good job matches, suggests that income today is an imperfect predictor of income tomorrow. Consequently, a mortgage that is affordable at origination may be substantially less so later on, and vice versa.

We then address the question of why mortgage servicers, who manage loans on behalf of investors in mortgage-backed securities, have been unwilling to make mass loan modifications. The evidence that a foreclosure loses money for the lender seems compelling. The servicer typically resells a foreclosed house for much less than the outstanding balance on the mortgage, in part because borrowers who lose their homes have little incentive to maintain them during the foreclosure process.[3] This would seem to imply that the ultimate owners of a securitized mortgage, the investors, lose money when a foreclosure occurs. Estimates of the total gains to investors from modifying rather than foreclosing can run to $180 billion, more than 1 percent of GDP. It is natural to wonder why investors are leaving so many $500 bills on the sidewalk. While contract frictions are one possible explanation, another is that the gains from loan modifications are in reality much smaller or even nonexistent from the investor's point of view.

We provide evidence in favor of the latter explanation. First, the typical calculation purporting to show that an investor loses money when a foreclosure occurs does not capture all relevant aspects of the problem. Investors also lose money when they modify mortgages for borrowers who would have repaid anyway, especially if modifications are done *en masse*, as proponents insist they should be. Moreover, the calculation ignores the possibility that borrowers with modified loans will default again later, usually for the same reason they defaulted in the first place. These two problems are empirically meaningful and can easily explain why servicers eschew modification in favor of foreclosure.

Turning to the data, we find that the evidence of contract frictions is weak, at least if these frictions result from the securitization of the loan. Securitization agreements generally instruct the servicer to behave "as if" it owned the loan in its own portfolio, and the data are consistent with that principle. Using a dataset that includes both securitized and non-securitized loans, we show that these two types of loans are modified at about the same rate. While there is room for further empirical work on this issue, these results minimize the likely importance of contract-related frictions in the modification decision. Even though

[3] An even more important reason that lenders rarely recover the full balance of the mortgage is that the borrower owed more on the home than the home was worth. Below, we show that negative equity is a necessary condition for foreclosure; people rarely lose their homes when they enjoy positive equity.

it may be in *society's* interest to make modifications (because of the large externalities from foreclosure), it may not be in the *lender's* interest to do so, whether or not this lender is an investor in a mortgage-backed security or a portfolio lender.[4]

Our skepticism about the arguments discussed above is not meant to suggest that government has no role in reducing foreclosures. Nor are we arguing that the crisis is completely unrelated to looser lending standards, which saddled borrowers with high-DTI mortgages, or interest rates that reset to higher levels a few years into the loans.[5] Rather, we argue that a foreclosure-prevention policy that is focused on high-DTI ratios and interest-rate resets may not address the most important source of defaults. In the data, this source appears to be the interaction of falling prices and adverse life events, such as job loss.

The remainder of this paper is organized as follows. Section 2 outlines a simple model of the default decision that helps organize ideas about potential sources of the foreclosure crisis. Section 3 shows that, as would be implied by the simple model, the affordability of a mortgage at origination as measured by DTI is not a strong predictor of mortgage default, especially compared with other variables that reflect income volatility and falling house prices in a fundamental way. Section 4 adapts the model to encompass the decision of the lender to offer a modification, and then provides evidence that securitization contracts are not unduly preventing modifications. Section 5 concludes with some lessons for foreclosure-reduction policy that are suggested by our results.

2 Affordability and Foreclosure: Theory

One of the most commonly cited causes of the current foreclosure crisis is the mass origination of unaffordable or unsustainable mortgages. Ellen Harnick, the senior policy counsel for the Center for Responsible Lending, characterized the crisis this way when she recently testified before Congress:

> The flood of foreclosures we see today goes beyond the typical foreclosures of years past, which were precipitated by catastrophic and unforeseen events such as job loss, divorce, illness, or death. The current crisis originated in losses triggered by the unsustainability of the mortgage itself, even without any changes in the families' situation, and even where the family qualified for, but was not offered,

[4] A foreclosure imposes externalities on society when, for example, a deteriorating foreclosed home drives down house prices for the entire surrounding neighborhood.

[5] For a discussion of the role of looser lending standards, see Mian and Sufi (2009) and Dell'Ariccia, Igan, and Laeven (2009).

a loan that would have been sustainable.[6]

The claim that the foreclosure crisis results from unaffordable or unsustainable loans has been endorsed by a number of influential policy analysts.[7] But the concept of "unaffordability" is rarely defined precisely. To economists, something is unaffordable if it is unattainable under any circumstances, even temporarily. For example, an economist might say: "For me, the penthouse apartment at the Time Warner Center in New York is unaffordable ($50 million when finished in 2004)." But a non-economist might say, "For me, the dry-aged ribeye at Whole Foods ($19.99 a pound) is unaffordable." The problem is that, for most Americans, a regular diet of ribeye steaks is attainable; a consumption bundle that includes two pounds of ribeye every night is not impossible for most families. They do not choose this bundle because of relative prices: the tradeoff between the ribeye and other consumption is unappealing (for example, the family might prefer a new car). In this case, economists, if they were being precise, would say that the ribeye was "affordable" but "too expensive." Along the same lines, economists might argue that an unaffordable mortgage is one that is really too expensive, in the sense that the benefits that come with making payments on the mortgage no longer outweigh the opportunity costs of doing so. In the next subsection, we build a simple model of these benefits and costs in order to evaluate what makes a borrower decide that a mortgage is unaffordable and thus to default on it. In describing this model, we will use the common usage definition of "affordable," though we really mean "too expensive."

2.1 A simple model

Assume a two-period world ($t = 1, 2$), with two possible future states, good and bad. The good state occurs with probability α_G, while the bad state occurs with probability α_B (where $\alpha_B = 1 - \alpha_G$). In the first period, the value of the home is P_1 with a nominal mortgage balance of M_1. In this period, the borrower decides between making the mortgage payment, a fraction m of the mortgage balance M_1, and staying in the home, or stopping payment and defaulting. Because this is a two-period model, we assume that in the second

[6] Harnick (2009), p. 5.

[7] A recent report from the Congressional Oversight Panel of the Troubled Asset Recovery Program (hereafter denoted COP) states that "[t]he underlying problem in the foreclosure crisis is that many Americans have unaffordable mortgages" (COP report, p. 16). The report adds that the unaffordability problem arises from five major factors: (1) the fact that many mortgages were designed to be refinanced and cannot be repaid on their original terms, (2) the extension of credit to less creditworthy borrowers for whom homeownership was inappropriate, (3) fraud on the part of brokers, lenders, and borrowers, (4) the steering of borrowers who could qualify for lower cost mortgages into higher priced (typically subprime) mortgages, and (5) the recent economic recession.

period the borrower either sells the home or defaults on the mortgage. If the good state occurs, the price of the house in the second period is P_2^G, while if the bad state occurs, the price is P_2^B. We will assume that $P_2^B < M_2$, where M_2 is the remaining nominal mortgage balance in the second period.

The first key insight of the model is that if equity is positive, the borrower will never default on the house. Selling dominates foreclosure when equity is positive because the borrower has to move out either way and the former strategy yields cash while the latter does not. Exactly what constitutes positive equity is a bit tricky empirically. Borrowers have to pay closing costs to sell the house and may be forced to accept a lower price if they sell in a hurry. Thus, the balance of the mortgage may be slightly less than the nominal value of the home, but with these extra expenses factored into the equation, the borrower may not have positive equity to extract.

The empirical evidence on the role of negative equity in causing foreclosures is overwhelming and incontrovertible. Household-level studies show that the foreclosure hazard for homeowners with positive equity is extremely small but rises rapidly as equity approaches and falls below zero. This estimated relationship holds both over time and across localities, as well as within localities and time-periods, suggesting that it cannot result from the effect of foreclosures on local-level house prices.[8]

Because default does not occur if $P_1 \geq M_1$, we focus on the case where $M_1 > P_1$. The decision for the borrower is whether or not to make the periodic mortgage payment mM_1. The cost of making the payment is the payment amount, net of the rent that the borrower would have to pay for shelter in the event of default. The benefit to the borrower includes the option in the next period to sell the house at a profit in the good state where $P_2 > M_2$, or the option to default in the bad state and lose nothing. We assume that the decision to default costs the borrower some amount Λ next period, which can be interpreted as some combination of guilt, shame, and reduced access to future credit. Under these conditions, we can collapse the default decision into the following inequality:[9]

$$\text{Default} \Leftrightarrow \frac{\alpha_G(P_2^G - M_2) + \Lambda}{mM_1 - rent_1} < 1 + r. \tag{1}$$

The basic point here is that a borrower views the mortgage payment (or more precisely the excess of the mortgage payment over his rent) as an investment in a security that pays off in the next period as long as the value of the house exceeds the strike price, which is the

[8]See Sherlund (2008), Danis and Pennington-Cross (2005), and Deng, Quigley, and Order (2000) for default regressions. See Gerardi, Shapiro, and Willen (2007) for an exhaustive discussion of the identification issues in the study of house prices and foreclosure.

[9]For details on a very similar model, see Foote, Gerardi, and Willen (2008).

outstanding balance on the mortgage. If the return on the investment exceeds the alternative investment, here assumed to be the riskless rate, then the borrower stays in the home. If instead the return falls short, then the borrower decides that the riskless asset is a better investment and defaults.

Thus far, income appears to play no role in the default decision. In this sense, our model follows the traditional option-theoretic analyses of the mortgage default decision, in which the mortgage is viewed as a security priced by arbitrage, and household income is irrelevant.[10]

The problem with the model described above is that it gives no role to individual heterogeneity, except potentially through differences in Λ. According to the model, all borrowers living in similar houses with similar mortgages should default at roughly the same time. Yet, in the data, we observe enormous heterogeneity in default behavior across otherwise similar households. Moreover, there is a pattern to this heterogeneity: households that suffer income disruptions default much more often than households that do not; younger homeowners default more often; and households with few financial resources default more often.

To address these limits, we make two small changes to the model. If we assume that housing is a normal good, households that suffer permanent reductions in income will prefer less housing, and thus their alternative rent payment will fall. So we allow rent to vary by individual household, denoting it $rent_i$. But, more significantly, we introduce borrowing constraints. Borrowing constraints mean that the relevant interest rate is no longer "the" riskless rate but the household's shadow riskless rate. Under the assumption of log utility and exponential discounting, this rate equals:

$$1 + r_i = (1 + \delta_i)^{-1} \left(\mathrm{E} \left[\frac{c_{i,1}}{c_{i,2}} \right] \right)^{-1}$$

where $c_{i,t}$ is consumption of household i at time t and δ_i is a household-specific discount rate. Then we can re-write equation (1) as:

$$\text{Default} \Leftrightarrow \frac{\alpha_G(P_2^G - M_2) + \Lambda}{mM_1 - rent_i} < 1 + r_i. \tag{2}$$

This model can shed light on the question of what really constitutes an unaffordable mortgage. A mortgage is unaffordable if the marginal rate of transformation between current and future consumption implied by the mortgage falls short of the marginal rate of

[10] See Kau, Keenan, and Kim (1994), for example.

substitution. What makes a mortgage "unaffordable," that is, too expensive?

1. **Low house price appreciation.** A higher probability of price appreciation (higher α_G) increases the expected return to staying in the house. In this sense, our treatment is similar to the standard user cost calculation in the literature, whereby increased house price appreciation lowers the cost of owning a home.[11]

2. **High monthly payments.** All else equal, higher m makes the mortgage less attractive. This is consistent with the views expressed in the quote that opened in this section: Many families, for one reason or another, took on mortgages with high payments that are likely to dissuade them from keeping their mortgage current. Typically, the burden of a mortgage's payments at origination is measured by the DTI ratio. Thus, analysts who believe that this type of unaffordability is at the heart of the crisis often support proposals designed to lower DTI ratios on a long-term basis.

3. **Permanent and transitory shocks to income.** Permanent shocks lower $rent_i$. Also, *if* the borrower is constrained, then a transitory shock that leads to a lower level of income will lead to high consumption growth and thus a high shadow riskless rate, which makes staying less attractive. The quote that opens this chapter expresses the view that income shocks were important drivers of foreclosure in the past, but that these shocks are less important today. However, if income shocks are in fact the most important source of distress in the housing market, then a policy that grants troubled borrowers substantial but temporary assistance could be effective. Temporary assistance may not help borrowers facing permanent income shocks, but it would help borrowers undergoing transitory setbacks.

4. **Low financial wealth.** A borrower with little financial wealth is more likely to be constrained and thus more likely to have a high shadow riskless rate.

2.2 Monthly payments, income, and affordability

Once we recognize the role that unforecastable income shocks can play in foreclosure, we can further divide the concept of affordability into what we will call *ex ante* and *ex post* affordability. A loan is *ex post* unaffordable if the borrower decides to default on it. A loan is *ex ante* unaffordable if the probability that it will become *ex post* unaffordable exceeds some threshold. To decide whether a loan is *ex ante* affordable, an underwriter or policymaker needs to forecast the evolution of stochastic variables like income, payments,

[11] See Poterba (1984) and, more recently, Himmelberg, Mayer, and Sinai (2005).

and house prices, and then choose some threshold probability of *ex post* unaffordability. In this section, to clearly convey our points, we consider an extreme model, in which *ex post* affordability depends entirely on the ratio of monthly payments to income, the DTI ratio. Thus, our forecasting model will involve only the required monthly payment and the borrower's income.

To forecast income, we follow the macro literature and assume that changes to the logarithm of a borrower's labor income y_t consist of a predictable drift term α_t, a transitory (and idiosyncratic) shock ε_t, and a permanent shock η_t:

$$y_t = \alpha_t + y_{t-1} + \varepsilon_t + \eta_t.$$

We use estimates from Gourinchas and Parker (2002) for the process for the "average person" in their sample and assume that the borrower is 30 years old.

For the monthly payments, we assume that either they are constant, or they follow the typical path of a 2/28 adjustable-rate mortgage (ARM). A 2/28 ARM is a common subprime mortgage that has a fixed payment for the first two years, after which the payment is determined by the so-called fully indexed rate, typically hundreds of basis points over the six-month London interbank offered rate (Libor).[12] We assume that the initial rate is 8.5 percent (the average initial rate for a sample of 2/28 ARMs originated in 2005) and that the first adjustment occurred in 2007, when the six-month Libor was 5.25 percent. A spread over Libor of 600 basis points was typical during this period and would imply a fully indexed rate of 11.25 percent, which generates a payment increase of roughly one-third. We focus on the 2/28 ARMs because they were, by far, the most common type of subprime loan and have accounted for a hugely disproportionate share of delinquencies and foreclosures in the last two years. Other loans, like option ARMs, allow for negative amortization and have far higher payment shocks at reset, but were rarely marketed to subprime borrowers, and thus, have not accounted for a large share of problem loans so far.

Table 1 shows some basic results. The first key finding is that the threshold for *ex post* affordability must be much higher than the threshold for *ex ante* affordability. If one sets them equal, then about 70 percent of borrowers will end up with unaffordable mortgages at some point in the first three years, even without resets. This is important because it means that one cannot decide on *ex ante* affordability by using some *a priori* idea of what is a reasonable amount to spend on housing. In other words, if spending one third of one's income on housing is considered too much (as low-income housing studies often claim), then one has to set the *ex ante* criterion well below 33 percent of income.

[12] This spread is determined by the risk characteristics of the borrower.

The second finding is that resets are of only limited importance. Many commentators have put the resets at the heart of the crisis, but the simulations illustrate that it is difficult to support this claim. The payment escalation story is relevant if we assume that there is no income risk *and* that the initial DTI is also the threshold for *ex post* DTI. Then loans with resets become unaffordable 100 percent of the time and loans without resets never become unaffordable. But adding income risk essentially ruins this story. If the initial DTI is also the threshold for *ex post* DTI, then, with income risk, about 70 percent of the loans will become unaffordable even without the reset. The reset only raises that figure to about 80 percent. If, on the other hand, we set the *ex post* affordability threshold well above the initial DTI, then the resets are not large enough to cause *ex post* affordability problems. The only scenario in which the reset makes a significant, quantitative impact is when we set the initial DTI very low and the threshold for *ex post* affordability very high. In this case the likelihood of default roughly doubles with resets.

The third finding is that setting the right initial DTI can help reduce foreclosures if the *ex post* affordability criterion is sufficiently high, but this finding is very sensitive to the assumption about income volatility. The first column of Panel C shows that if the *ex post* criterion is 50 percent, then loans with 31 percent DTI at origination become unaffordable only about 16 percent of the time, whereas those with 50 percent DTI do so roughly 70 percent of the time. The problem here is that the troubled borrowers who obtain subprime loans or who need help right now are unlikely to have the baseline parameters from Gourinchas and Parker (2000). If we assume that they have a standard deviation of transitory shocks twice as large as average, then column 4 shows that the benefits of low DTI are much smaller.Going from 38 percent DTI to 31 percent DTI only lowers the number of borrowers who will face *ex post* unaffordability by 30 percent from 54 percent to 38 percent. Put another way, if our goal is "sustainable" mortgages, neither 31 percent nor 38 percent would fit that definition.

3 Affordability and Foreclosure: Evidence

In this section we perform an empirical analysis of the potential determinants of default identified in the previous section, including falling house prices, labor income shocks, and high DTI ratios. Because a loan that is prepaid is no longer at risk of default, we also investigate prepayments in a competing risks framework.

3.1 Data

The data used in this paper come from loan-level records, compiled by LPS Applied Analytics, Inc., from large loan-servicing organizations.[13] This dataset has fields for key variables set at the time of each loan's origination, including the amount of the loan, the appraised value and location of the property that secures the loan, whether the loan is classified as prime or subprime, whether the loan is a first or second lien, and whether the loan is held in portfolio or has been packaged into a mortgage-backed security (MBS). We can also observe a host of interest-rate variables, such as whether the loan is fixed-rate or adjustable-rate and the manner in which the interest rate changes in the latter case. Additionally, the performance of each loan can be monitored over time. For each month in which a given loan is in the data, we know its outstanding balance, the current interest rate, and the borrower's payment status (that is, current, 30-, 60-, or 90-days delinquent, in foreclosure, etc.). We also know whether a loan ended in payment, prepayment, or default.

As of December 2008, the LPS dataset covered nearly 60 percent of active residential mortgages in the United States, representing about 29 million loans with a total outstanding balance of nearly $6.5 trillion.[14] Nine of the top 10 servicers in the U.S. are present in our data, including Bank of America/Countrywide and Wells Fargo. Cordell, Watson, and Thomson (2008) write that because the LPS data come from large servicers (who now dominate the servicing market), the unconditional credit quality of the average loan in the LPS data is probably lower than that of a randomly sampled U.S. mortgage, because smaller servicers are more prevalent in the prime market. However, when assessing the representativeness of the LPS data, it is important to note that we can tell whether a loan in the data is prime or subprime.[15] Additionally, we usually have access to other variables reflecting risk, including the borrower's credit (that is, FICO) score, loan-to-value at origination, etc. This allows us to condition on several factors affecting loan quality.

One of the strengths of the LPS dataset is that it is one of the few loan-level databases that include both conforming prime loans and subprime loans. Table 2 lists the numbers of prime and subprime loans in the data, disaggregated by the investors for whom the servicers are processing payments and the seniority of the mortgage (first lien, second lien,

[13] The dataset was originally created by a company called McDash Analytics; LPS acquired McDash in mid-2008. Among housing researchers, the dataset is still generally called the "McDash data." The description of the LPS dataset in this section draws heavily from Cordell, Watson, and Thomson (2008). The dataset was purchased in late 2008 by a consortium that included the Board of Governors of the Federal Reserve System and eight regional Federal Reserve Banks.

[14] Because of the size of the data (about 600 gigabytes), we never took possession of it when performing our analysis. Instead we downloaded random samples of various size from the servers of the Federal Reserve Bank of Kansas City.

[15] Subprime loans are defined by the servicers themselves as loans with a grade of either "B" or "C."

etc.). About 33 percent of the mortgages in the dataset are held in the securities of Fannie Mae, with another 22 percent held in Freddie Mac securities. Around 18 percent of the loans are held in "private securitized" pools; these are the loans that are also covered by the well-known LoanPerformance dataset.[16]A little less than 10 percent of the loans in the LPS data are held in the portfolio of the servicer itself.

While the LPS dataset now covers more than half of the U.S. mortgage market, coverage was not as extensive in earlier years. The LPS dataset has grown over time as new servicers have been added, with a substantial spread in coverage of the market in 2005 (when most of our samples begin). Whenever a new servicer is added to the dataset, that servicer's existing portfolio is incorporated into the dataset. Future loans from that servicer are added a month or two after the loans close. This pattern has the potential to introduce unrepresentative loans into the data, because loans that stay active for many years (and thus are likely to be added when their servicers enter the LPS data) are a nonrandom sample of all loans. One way to ameliorate potential problems of left-censoring is to analyze only those loans that enter the data within the year that the loans were originated.[17] A separate issue is the fact that not all servicers collected the exact same variables, so the preponderance of missing data changes over time. Unfortunately, DTI is recorded for only about half the loans in the sample, as shown in Table 3. On one hand, this is disheartening, because an analysis of DTI is a prime goal of this section. On the other hand, the sample is sufficiently large that we do not want for observations. Moreover, the fact that DTI is so spottily recorded — especially in comparison to the FICO score — indicates that investors and servicers place little weight on it when valuing loans. This is, of course, what the model of section 2 would predict. A final concern about the LPS data is that we do not know whether there are other loans on the property that secures any given loan. Thus, given some path of local house prices, we are able to construct an ongoing loan-to-value ratio for any loan in the dataset, but we cannot construct a *combined* loan-to-value ratio for the borrower on that loan. We are therefore unable to calculate precise estimates of total home equity.[18]

[16]The dataset from LoanPerformance FirstAmerican Corp. includes loans that were securitized outside of the government-sponsored agencies, Fannie Mae and Freddie Mac. It therefore includes loans that are subprime, Alt-A, and non-conforming (that is, jumbo loans). The coverage of private securitized loans is broader in the LoanPerformance data than it is in LPS, as LoanPerformance has about 90 percent of the private-label market.

[17]Most loans in our sample were included in the data one or two months after origination.

[18]For a borrower with only one mortgage, the loan-to-value ratio on his single mortgage will, of course, be his total loan-to-value figure. However, we are unable to know whether any particular borrower in the data has more than one mortgage.

3.2 Affordability and origination DTI: Results from duration models

To learn how different risk characteristics and macroeconomic variables affect loan outcomes, we run Cox proportional hazard models for both defaults and prepayments.[19] In this context, the proportional hazard model assumes that there are common baseline hazard functions that are shared by all loans in the data. The model allows for regressors that can shift this hazard up or down in a multiplicative fashion. The specific type of proportional hazard model that we estimate, the Cox model, makes no assumption about the functional form of the baseline hazard. Rather, the Cox model essentially "backs out" the baseline hazard after taking account of the effects of covariates. The baseline hazards for both potential outcomes (default and prepayment) are likely to be different across the two types of loans (prime and subprime), so we estimate four separate Cox models in all. We define default as the loan's first 90-day delinquency, and our main estimation period runs from 2005 through 2008. In this section, we use a random 5 percent sample of the LPS data.

The results of these models should not be interpreted as causal effects. If we see that borrowers with low loan-to-value ratios (LTVs) default less often (and we will), we cannot tell whether this arises because of something about the loan or something about the borrowers likely to choose low-LTV mortgages. Even so, a finding that DTI at origination is not a very strong predictor of default would undermine the claim that unaffordable mortgages are a more important cause of default than income shocks and falling prices.

Table 4 presents summary statistics of the loan-level characteristics that are included in the proportional hazard models. The average DTI at origination for prime loans in our sample is 35.1 percent, while the mean DTI for subprime loans is about 5 percentage points higher. Subprime loans also have generally higher LTVs and lower FICO scores. Figure 1 provides some additional detail about these risk characteristics by presenting the entire distributions of DTIs, LTVs, and FICO scores. While the distribution of prime DTIs is somewhat symmetric, the distribution of DTIs for subprime loans is strongly skewed, with a peak near 50 percent. Another interesting feature of the data emerges in the bottom row of panels, which presents LTVs. For both prime and subprime loans, the modal LTV is 80 percent, with additional bunching at multiplies of five lying between 80 and 100. Recall that in the LPS data, an LTV of 80 percent does not necessarily correspond to 20 percent equity. This is because the borrower may have used a second mortgage to purchase the home (or may have taken out a second mortgage as part of a refinance). Unfortunately, there is no way to match loans to the same borrower in the LPS dataset, nor is there a flag to denote

[19] For details about hazard models, see Kiefer (1988).

whether any given loan is the only lien on the property. The large number of 80-percent LTVs, however, strongly suggests that these loans were accompanied by second mortgages. Thus, in our empirical analysis, we include a dummy variable that denotes whether the particular loan has an LTV of exactly 80 percent.[20]

In addition to loan-specific characteristics, the Cox models also include the cumulative changes in statewide house prices and county-level unemployment rates that have occurred since the loan was originated.[21] Figures 2 and 3 present the distributions for these data; unlike the figures for DTI, FICO, and LTV, each loan in the sample contributes a number of monthly observations to each of these two figures. Figure 2 shows that the distribution of price changes is skewed toward positive changes. In part, this reflects the large number of loans originated in the early years of the sample (2005–2006), when house prices were rising. In our empirical work we allow positive price changes to have different effects than negative price changes.[22]

Finally, we also include a number of interactions among risk characteristics and macro variables. These interactions play an important role, given the strong functional form assumption embedded in the proportional hazard model. Denote $h(t|\mathbf{x_j})$ as the hazard rate for either a default or a prepayment, conditional on a vector of covariates $\mathbf{x_j}$. The proportional hazard assumption is

$$h(t|\mathbf{x_j}) = h_0(t)\exp(\mathbf{x_j}\beta_\mathbf{x}),$$

where $h_0(t)$ is the shared baseline hazard and β_x represent coefficient estimates. Because $\exp(\beta_1 x_1 + \beta_2 x_2)$ equals $\exp(\beta_1 x_1)\exp(\beta_2 x_2)$, there is in a sense a multiplicative interaction "built in" to the proportional hazard assumption. Entering various interactions directly ensures that interactions implied by the estimated model are not simply consequences of the functional form assumption. Of course, as with any regression, the presence of interactions makes interpretation of the level coefficients more difficult, because the level coefficients will now measure marginal effects at zero values of the other variables. Hence, we subtract 80 from the loan's LTV before entering this variable in the regressions. In this way, a value of zero in the transformed variable will correspond to the most common value of LTV in the data. We transform DTI by subtracting 35 for prime loans and 40 for subprime loans, and

[20] For ease of interpretation, we define this variable to equal one if the borrower does *not* have an LTV of 80 percent.

[21] Obviously, county-level house prices would be preferable to state-level prices, but high-quality, disaggregated data on house prices are not widely available. Our state-level house prices come from the Federal Housing Financing Authority (formerly the OFHEO price index).

[22] Because of the importance of negative equity in default, the difference between a price increase of 10 percent and an increase of 20 percent may be much less consequential for a loan's outcome than whether the house price declines by 10 or 20 percent. However, recall that we cannot figure total equity in the house, because we do not observe all mortgages.

we transform FICO by subtracting 700 for prime loans and 600 for subprime loans.

Figure 4 graphs the baseline default hazards for both prime and subprime loans. The subprime default hazard (dotted line) is much higher than the hazard for prime loans (note the different vertical scales on the figure). There is an increase in the subprime default hazard shortly after 24 months, a time when many loans reset to a higher interest rate. At first blush, this feature of the subprime default hazard would appear to lend support to oft-made claims that unaffordable resets caused the subprime crisis. Recall, however, that a hazard rate measures the instantaneous probability of an event occurring at time t among all subjects in the risk pool at time $t-1$. While the default hazard shows that the default probability rises shortly after 24 months, the subprime prepayment hazard, graphed in Figure 5, shows that prepayments also spiked at the same time. The surge in prepayments means that the relevant pool of at-risk mortgages is shrinking, so that the *absolute number* of subprime mortgages that default shortly after the reset is rising to a much smaller extent than the hazard rate seems to imply. Thus, our results are not inconsistent with other research that shows that most subprime borrowers who defaulted did so well before their reset date.[23]

Table 5 presents the coefficients from the Cox models. The model for prime defaults (first column) generates a significantly positive coefficient for the DTI ratio: .0105, with a state-clustered standard error of .0009. When working with proportional hazard models, it is common to report results in terms of "hazard ratios," $\exp(\beta_j)$, the multiplicative shift in the baseline hazard engendered by a unit change in the regressor of interest. The DTI coefficient in the prime default regression generates a hazard ratio of $\exp(0.0105) \approx 1.0105$, indicating that a one-percentage-point increase in DTI shifts the default hazard up by 1.05 percent.[24] While statistically significant, the effect is small as a practical matter. Recall that Table 4 showed that the standard deviation of DTI in the prime sample is 13.8 percentage points, so a one-standard-deviation increase in DTI for prime borrowers results in a hazard ratio of $\exp(13.8 \cdot 0.0105) \approx 1.156$. This effect can be compared to the effect of decreasing a borrower's FICO score by one standard deviation. The FICO coefficient in the first column (–.0124) has about the same absolute value as the DTI coefficient, but the standard deviation in FICO scores is much greater (61.6 points). Thus, a one-standard-deviation drop in the FICO score results in a hazard ratio of $\exp(-61.6 \cdot -0.0124) \approx 2.147$.

Other coefficients in the first column also have reasonable signs and magnitudes. More defaults are to be expected among loans with high LTVs as well as loans with LTVs that

[23] See Sherlund (2008), Mayer and Pence (2008), and Foote, Gerardi, Goette, and Willen (2008).

[24] Because of the way we transformed our variables, this marginal effect corresponds to a prime borrower with a 700 FICO score, a DTI of 35, and an LTV of 80 percent.

are exactly 80 percent (and which thus suggest the presence of a second mortgage). The unemployment rate enters the regression with a large coefficient (.2068), so that a one-percentage-point increase in the unemployment rate results in a hazard ratio of about 1.23. House-price changes also enter significantly, though there is little evidence for different coefficients based on the direction of the price change (both the positive-change and negative-change coefficients are close to –.058).[25] These estimates indicate that a 10-percentage-point increase in housing prices shifts the hazard down by about 44 percent. When evaluating the effect of these macroeconomic coefficients on defaults, it is important to recall the earlier qualifications about identification. An exogenous increase in delinquencies may increase housing-related unemployment and cause housing prices to fall. Nevertheless, it is gratifying to see that the results of the model are consistent with other work that shows a direct causal effect of prices on default in ways that are immune to the reverse-causation argument (Gerardi, Shapiro, and Willen (2007)).

The second column of the table presents the estimates from the subprime default model.[26] As in the prime column, all of the individual-level risk characteristics enter the model significantly. And, as before, movements in FICO scores have a more potent effect on default than movements in DTI, though the difference is not as extreme. For subprime borrowers, a one standard-deviation increase in DTI results in a hazard ratio of $\exp(.0072 * 11.1) = 1.083$. This percentage change is smaller than the corresponding shift for prime mortgages, but recall that the baseline default hazard for subprime mortgages is also much higher. In any case, for subprime loans, the effect of raising DTI by one standard deviation is still smaller than the effect of lowering FICO by one standard deviation, shifting the baseline hazard up by about 21 percent rather than 8.3 percent.

We ran a number of robustness checks to ensure that the small DTI coefficients we obtained are accurate reflections of the underlying data. In principal, these coefficients could be biased down for two reasons. First, when DTI is recorded noisily, or when borrowers give inaccurate representations of their incomes in order to qualify for loans, then measurement error will attenuate the DTI coefficients toward zero. To see how much this matters in practice, we ran the default regressions on fully documented loans only. The DTI coefficients in both the prime and subprime default regressions became even smaller when we did so. We then estimated on the model only using prime loans held by Fannie Mae or Freddie Mac. Again, the prime DTI coefficient becomes smaller.[27] A second, more serious potential

[25] Negative price changes are entered as a negative numbers, not as absolute values.

[26] The level coefficients for LTV, FICO, and DTI now correspond to marginal effects for a subprime borrower with a 600 FICO score, an LTV of 80 percent, and a 40 percent DTI.

[27] The subprime coefficient became slightly larger, rising from 0.0072 to 0.0127, but Fannie and Freddie hold only about 12 percent of the subprime loans in our regression sample.

source of downward bias arises because we cannot link separate mortgages taken out on the same house. Thus the DTI coefficients in our models reflect the onerousness of first mortgage only. One imperfect way of addressing this issue is to throw out loans that are likely to have second mortgages — specifically, the mortgages for which the LTV on the first lien is exactly equal to 80 percent. Our DTI coefficients again become smaller when we do so. However, better data is needed to fully address the role that DTI plays in default when more than one mortgage is present.

Turning back to the baseline estimates, two additional results from the default regressions are consistent with the idea that idiosyncratic income risk is an important determinant of mortgage outcomes. First, among subprime borrowers, the effect of DTI on the likelihood of default is smaller for borrowers with high FICO scores. The coefficient on the interaction of FICO and DTI in the second column is significantly negative (–.000055, with a standard error of .000017). Thus, for a subprime borrower with a 700 FICO score, the total marginal effect of an increase in DTI on his default probability is only .0017, an effect that is insignificantly different from zero.[28] The fact that high-FICO borrowers in the subprime pool are better able to tolerate high DTIs suggests that these borrowers may have been able to make good predictions of their future incomes and of the likely variation in these incomes. These borrowers may have desired high-DTI mortgages that were unattractive to prime lenders, so they entered the subprime pool. A second set of results pointing to the importance of income volatility is the coefficients on the unemployment–FICO interactions. These coefficients are significantly negative in both the prime and subprime regressions, indicating that the ARMs of high FICO borrowers are generally hurt more severely, in percentage terms, by increases in the aggregate unemployment rate. If idiosyncratic income variation among high-FICO borrowers is relatively low, then it is perhaps not surprising that their mortgages are relatively more sensitive to aggregate fluctuations.

Results from the prepayment regressions are presented in the third and fourth columns of Table 5. Prime borrowers tend to refinance somewhat more quickly out of high-DTI mortgages, while DTI has an insignificant effect on subprime prepayment. Of particular note in both regressions is the strong effect that house prices have on prepayment. The coefficients on all price terms are positive, indicating that higher prices encourage prepayment and lower prices reduce it. The effect of price declines on subprime refinancing is particularly strong.

Figure 6 puts the pieces together by simulating the number of monthly defaults under various assumptions about loan characteristics, house prices, and unemployment. To do this,

[28] To see this, note that a 700 FICO score corresponds to a score of 100 in our transformed FICO metric for subprime borrowers. Thus, the relevant DTI coefficient for a 700-FICO borrower is the level coefficient on DTI (.0072) plus 100 times the interaction of DTI and FICO (–.000055). This sum approximately equals .0017.

we first shift the baseline hazards for both default and prepayment to be consistent with the assumptions and the coefficient estimates from the model. We then calculate what these adjusted hazards would imply for the size of an initial risk set of 100 loans.[29] Multiplying the risk set in a given month times the hazard of either defaults or prepayments gives the total number of the 100 original loans that are expected to default or prepay in that month. Panel A of Figure 6 presents the data for prime defaults. The solid line assumes a baseline case of no changes in house prices or unemployment along with the baseline DTI value (35 percent for prime loans). The dashed line just above it assumes that DTI is 45 rather than 35. As one would expect from the modest size of the coefficient in the first column of Table 5, increasing DTI has a modest effect on monthly defaults. The next lines return DTI to 35 but either raise the unemployment rate by 2 percentage points or reduce housing prices by 10 percent. These assumptions have a much larger positive effect on prime defaults than the assumption of higher DTI. Falling house prices also strongly discourage prime prepayments, as shown in Panel B.

The bottom two panels of Figure 6 present the results for subprime loans. In Panel C, we see a small uptick in defaults between 24 and 30 months, presumably due to the interest-rate resets on subprime 2/28 mortgages. This increase, however, is smaller than the bulge in the baseline hazard at about this time, because the risk set has been significantly reduced by prepayments. Panel C also shows the nearly imperceptible effect of higher DTI. Here, the experiment is raising DTI from the baseline subprime value of 40 percent to 50 percent. As with prime defaults, the effect of this increase is small relative to the effect of unemployment and house prices. Finally, Panel D shows that falling house prices have particularly severe effects on the prepayments of subprime loans.

The patterns displayed in Figure 6 are consistent with a large role for income volatility in mortgage defaults discussed in section 2. Higher unemployment rates increase defaults, as more people are likely to lose jobs and become liquidity constrained during recessions. Falling housing prices also raise defaults, because they increase the likelihood that a homeowner who receives a negative income shock will also have negative equity, and will thus be unable to sell his home for enough to repay the mortgage. This interaction of income shocks and falling prices is sometimes called the "double-trigger" model of default, because it claims that defaults occur when two things happen at the same time: the borrower suffers some adverse life event while he also has negative equity in his home.

[29] For example, if both the default and prepayment hazards have been adjusted upwards by the implied assumptions on covariates and coefficient estimates, then the risk set will be whittled more quickly away by defaults and prepayments.

3.3 Affordability and falling prices: Quantifying "walk-away" defaults

The previous subsection showed that high levels of origination DTI are not predictive of high default rates, especially in comparison to variables like FICO scores and features of the macroeconomic environment like falling house prices and rising unemployment. Our preferred interpretation of this pattern is that falling prices lead to negative equity, which can lead to default and foreclosure when a borrower receives a large negative income shock. However, as the model of section 2 shows, housing prices have a direct effect on the affordability of a home that does not involve income volatility. A lower probability of future price appreciation (lower α_G) raises the user cost of owning a home and makes default more likely. If there is no hope that the price of the house will ever recover to exceed the outstanding balance on the mortgage, the borrower may engage in "ruthless default" and simply walk away from the home. Kau, Keenan, and Kim (1994) show that optimal ruthless default takes place at a negative-equity threshold that is well below zero, due to the option value of waiting to see whether the house price recovers.[30] Once the default threshold has been reached, however, default remains optimal if no new information arrives.

Of course, we cannot observe the expectations of individual homeowners to see whether their defaults coincide with extremely gloomy forecasts of future house prices. However, we can exploit a particular feature of the ruthless default model to get a rough upper bound on how many people are walking away from their homes. If the ruthless default model is a good characterization of the data, then delinquent borrowers should simply stop making payments, never to resume again. There is no reason for a ruthless defaulter to change his mind and start making payments once more (unless his expectation of future house prices suddenly improves). On the other hand, if income volatility is interacting with falling prices to produce double-trigger defaults, then we should see delinquent borrowers cycling through various stages of delinquency as various shocks to their incomes are realized and they struggle to keep their homes. In the LPS data, we observe each borrower's monthly delinquency status so we can compare the number of "direct defaults" to the number of "protracted defaults." The fraction of 90-day delinquencies that arise via direct defaults will be an upper bound on the importance of walk-away defaults, because some people may have suffered particularly severe declines in income and had to stop making payments abruptly, even though they wanted to keep their homes.

To set the stage for this analysis, we first present so-called "roll rates," which measure the

[30] The presence of this option value explains why negative equity is a necessary but not sufficient condition for default.

likelihood that a borrower in one stage of delinquency will transition into another. Figure 7 graphs these rates for borrowers who start a month in different delinquency stages.[31] Panel A considers people who begin a month in current status. Since January 2001, about 1 to 2 percent of current borrowers have become 30 days delinquent each month. Interestingly, the number of people rolling from current to 30 days delinquent has only recently exceeded the levels of the 2001 recession, even though foreclosures have been far higher than they were then. Another interesting pattern in this panel is that the current-to-30-day roll rate was low in 2004 and 2005, when many supposedly unaffordable mortgages were originated. Panel B considers borrowers who begin the month 30 days late. A fairly constant 40 percent of these borrowers make their next payment to remain 30 days late the next month. Until 2007, about 40 percent of borrowers who were 30 days late made two payments to become current again, with the remaining 20 percent failing to make a payment at all and thereby becoming 60 days late. In the past few months, however, more persons who were 30 days late are rolling into 60-day status, considered the start of serious delinquency. Panel C shows that the fraction of 60-day delinquencies that roll into 90-day status has risen sharply over the past two years, with corresponding declines in the fractions of borrowers making two or three payments. Yet the fraction of 60-day delinquencies making one payment to remain 60 days late has remained fairly constant. Finally, Panel D analyzes borrowers who begin the month 90 days late. This is a somewhat absorbing state, because there is no formal 120-day status.

The main takeaway from Figure 7 is that many people who are delinquent have no desire to stay that way. Many people who are seriously delinquent come up with two or three payments in an attempt to climb out of the status, or manage one payment so as not to slide further down. Still, these graphs do not answer the precise question of how many people who become 90 days delinquent simply stopped making payments. We define this type of direct default as a 90-day delinquency that satisfies three requirements:

- The borrower is current for three consecutive months, then registers a 30-day, a 60-day, and a 90-day delinquency in succession during the next three months;
- The borrower had never been seriously delinquent before this six-month stretch;
- The borrower never becomes current or rolls down to 30-day or 60-day status after this stretch.

Panel A of Table 6 lists the fraction of direct defaults for the entire United States, starting in 2003. These rates differ by the year that the mortgage is originated and the

[31] As was the case with the duration models, the roll rates are based on a random 5 percent sample of the LPS data.

year in which the default occurred. Among all 2003–2008 mortgages that defaulted in 2008, fewer than half, 41.6 percent, were direct defaults. This percentage was higher for loans made at the height of the housing boom, as 44.6 percent of 2005 mortgages defaulting in 2008 were direct defaults. This is consistent with the idea that mortgages likely to have the largest amounts of negative equity are the most likely to ruthlessly default. But among these mortgages, fewer than half simply stopped making payments, and even this fraction is an upper bound on the true fraction of ruthless defaults.[32] Panel B Table 6 uses data from four states that have had particularly severe price declines and thus are more likely to have ruthless defaulters.[33] As we would expect, the share of direct defaulters is higher in these states, reaching 55.1 percent in 2008. The 2008 fraction of direct defaults in the remaining 47 states (including DC) is less than one-third, as seen in Panel C.

To sum up, falling house prices are no doubt causing some people to ruthlessly default. But the data indicate that ruthless defaults are not the biggest part of the foreclosure problem. For the nation as a whole, less than 40 percent of homeowners who had their first 90-day delinquency in 2008 stopped making payments abruptly. Because this figure is an upper bound on the fraction of ruthless defaults, it suggests ruthless default is not the main reason why falling house prices have caused so many foreclosures.

4 Foreclosure and Renegotiation

A distressing feature of the ongoing foreclosure crisis is the seeming inability of the private market to stop it. A lender typically suffers a large loss when it (or its agent) forecloses on a house. On the surface, it would appear that the lender would be better off modifying any delinquent loan in the borrower's favor and taking a small loss, as opposed to refusing a modification, foreclosing on the mortgage, and suffering a large loss. Lender behavior is especially perplexing if high DTI ratios are causing the crisis. Surely making the mortgage affordable by reducing a borrower's DTI to 38 or 31 percent is preferable to foreclosure for the lender as well as the borrower. Given this apparent puzzle, a number of analysts have argued that the securitization of mortgages into trusts with diffuse ownership is preventing "win-win" modifications from taking place. In this section, we provide an alternative explanation for why modifications are rare. We then consult the LPS dataset and the historical record to see how the different explanations square with the data.

[32] It is also important to point out that right-censoring may be inflating these numbers a little, since some of the borrowers who we identify as direct defaulters in the last 3 months of the data, may make a mortgage payment in the future.

[33] The states are Arizona, California, Nevada, and Florida.

4.1 The renegotiation-failure theory

Lenders often take large losses on foreclosed homes, which are typically sold for much less than the outstanding balances of the defaulted mortgages. Conversely, the modifications offered to borrowers are generally modest. A study by White (2009) provides the following data:

> The average loss for the 21,000 first mortgages liquidated in November was $145,000, representing an average loss of 55 percent of the amount due. Losses on second lien mortgages were close to 100 percent. In comparison, for the modified loans with some amount of principal or interest written off, the average loss recognized was $23,610. This seven-to-one difference between foreclosure losses and modification write-offs is striking, and lies at the heart of the failure of the voluntary mortgage modification program. Particularly for foreclosed loans with losses above the 57 percent average, some of which approach 100 percent, the decisions of servicers to foreclose is mystifying.... At a minimum, there is room for servicers to be more generous in writing down debt for the loans they are modifying, while still recovering far more than from foreclosures in the depressed real estate market of late 2008.[34]

To explain the small number of concessions and the large number of foreclosures, many analysts blame institutional factors related to the collection of mortgages into mortgage-backed securities (MBS). Such loans are owned by trusts on behalf of a large number of individual investors, rather than by a single entity (such as a local bank). White's quote mentions the decisions of loan servicers, who are responsible for funneling mortgage payments to these MBS investors and performing various other tasks related to securitized mortgages.[35] Most importantly, when a borrower falls behind on his mortgage, it is the servicer who decides whether a loan modification or a foreclosure is more appropriate.

Analysts who blame securitization for the low number of modifications argue that the incentives of the servicers have become decoupled from those of investors, who ultimately bear the losses entailed in foreclosure. We label this claim the *renegotiation-failure theory*. Securitization can potentially limit modifications in at least two ways. First, servicers can be hamstrung by restrictive agreements they signed with investors at the origination of the mortgage trust, well before the crisis hit.[36] The actions of a servicer working for a trust are

[34] White (2009), pp. 14–15.

[35] Mortgages held in the portfolio of a single financial institution are normally serviced by that institution.

[36] For example, the authors of the COP report write that "[r]estrictions on mortgage servicers' ability to modify loans are an obstacle that has contributed to foreclosure that destroys value for homeowners and investors alike" (p. 50.)

governed by so-called Pooling and Servicing Agreements (PSAs). Among other things, these agreements specify the latitude that servicers have when deciding between modification and foreclosure. As a general rule, PSAs allow servicers to make modifications, but only in cases where default is likely and where the benefit of a modification over foreclosure can be shown with a net-present-value (NPV) calculation. Second, proponents of the renegotiation-failure theory claim that servicers are afraid that they will be sued by one tranche of investors in the MBS if they make modifications, even if these modifications benefit the investors in the trust as a whole. Because different tranches of investors have different claims to the payment streams from the MBS, a modification may alter these streams in a way that will benefit one tranche at the expense of another. One might think that the PSAs would have foreseen this possibility, but some analysts claim that the PSAs were not written with an eye to the current foreclosure crisis. Thus, it is claimed that there is enough ambiguity in the PSAs to make servicers wary of getting caught up in "tranche warfare," so servicers are thought to follow the path of least resistance and foreclose on delinquent borrowers.[37]

A central implication of this theory is that securitization and the related frictions embedded in the contracts between investors and servicers are preventing modifications that would make even the lender better off. As Eggert (2007) states:

> The complex webs that securitization weaves can be a trap and leave no one, not even those who own the loans, able effectively to save borrowers from foreclosure. With the loan sliced and tranched into so many separate interests, the different claimants with their antagonistic rights may find it difficult to provide borrowers with the necessary loan modifications, whether they want to or not (p. 292).[38]

4.2 Reasons to doubt the renegotiation-failure theory

There are, however, reasons to doubt the renegotiation-failure theory. First, there is little evidence on the extent to which PSAs have limited modifications in practice.[39] A 2007 study by Credit Suisse of approximately 30 PSAs concluded that fewer than 10 percent of them completely ruled out modifications. About 40 percent of the PSAs allowed modifications, but with some restrictions. These restrictions included a limit on the percentage

[37] The authors of the COP report write that "[s]ervicers may also be reluctant to engage in more active loan modification efforts because of litigation risk" (p. 46).

[38] Other policy analysts have adopted a similar view. For example, the COP writes in its recent report that "A series of impediments now block the negotiations that would bring together can-pay homeowners with investors who hold their mortgages .... Because of these impediments, foreclosures that injure both the investor and homeowner continue to mount" (COP report, p. 2).

[39] For a discussion of the role of PSAs in reducing modifications, see Cordell, Dynan, Lehnert, Liang, and Mauskopf (2008), which also discusses the incentives faced by servicers more generally.

of mortgages in the pool that could be modified without permission from the trustee of the mortgage-backed security (often 5 percent), and/or a floor for the mortgage rate that could be applied in the event of a modification that entailed a reduction in the borrower's interest rate. The remainder of PSAs contained no restrictions. It is unlikely that even PSAs with 5-percent caps are preventing modification to any significant degree. The Congressional Oversight Panel for the Troubled Asset Recovery Program examined a number of securitized pools with 5-percent caps and found that none had yet approached this cap.[40] Moreover, one can make a case that the typical PSA actually *compels* the servicer to make modifications if these modifications are in the best interests of the investor. According to Cordell, Dynan, Lehnert, Liang, and Mauskopf (2008), "While investors seem somewhat concerned about servicer capacity, they do not convey widespread concern that servicers are relying overmuch on foreclosures relative to modifications." In fact, investors opposed additional incentives for modifications:

> Investors with whom we spoke were not enthusiastic about an idea to reimburse servicers for expenses of loss mitigation. In their view, such payments could lead to more modifications than warranted by the NPV calculations. They also felt that the PSA adequately specified that modifications that maximized NPV should be undertaken. A typical response from an investor was, Why should I pay servicers for doing something that I already paid them to do?[41]

Regarding the fear of lawsuits, no servicer has yet been sued for making too many loan modifications. There has been a well-publicized lawsuit filed by a group of investors against a servicer doing modifications, but the details of this suit should not make other servicers wary about making modifications.[42] Moreover, Hunt (2009) studied a number of subprime securitization contracts and found not only that outright bans on modifications were rare, but also that most contracts allowing modifications essentially instructed the servicer to behave as if it were the single owner of the loan:

> The most common rules [in making modifications] are that the servicer must follow generally applicable servicing standards, service the loans in the interest of the certificate holders and/or the trust, and service the loans as it would

[40] COP report (p. 44).

[41] Cordell, Dynan, Lehnert, Liang, and Mauskopf (2008), p. 19.

[42] Specifically, an MBS investor has sued two large servicers, Countrywide and Bank of America, for promising to make mass modifications as part of a settlement that Countrywide and Bank of America struck with the government in a predatory lending case. The key argument by the investor in this lawsuit was that the modifications were done not because they were profitable for the investors, but rather to settle a predatory lending lawsuit, which the plaintiffs of that lawsuit claimed was the responsibility of Countrywide, in its capacity as the originator of the troubled loans.

> service loans held for its own portfolio. Notably, these conditions taken together can be read as attempting to cause the loans to be serviced as if they had not been securitized. (p. 8, insertion added)

The Hunt (2009) findings speak directly to whether the modification of securitized mortgages is analogous to the restructuring of troubled corporations, as has been suggested by some economists. As was illustrated in negotiations over the recent Chrysler bankruptcy, a single corporate bond holder can block a deal that is in the interests of all other stakeholders in the firm.[43] But any analogy between corporate bankruptcy and mortgage modification is not appropriate. Not only can the typical mortgage servicer proceed with a modification without the approval of *all* investors, the servicer does not need the approval of *any* investor to modify a loan. Thus, there is no possibility of a hold-up problem. The authors of the typical PSA appear to have anticipated the problems that could arise with dispersed ownership, so the contract instructs the servicer to behave *as if* it alone owned the loan. To preview our empirical results, we find that the data are consistent with the claim that servicers are carefully following this type of contract.

While there can be substantial disagreement about the importance of any particular institutional impediment to loan modification, perhaps the most compelling reason to be skeptical about the renegotiation-failure theory is the sheer size of the losses it implies. We can use White's figures quoted above to come up with a back-of-the-envelope calculation for the total losses that follow from the renegotiation-failure theory. One figure often cited for the total number of foreclosures that can be prevented with modifications is 1.5 million.[44] For a dollar figure, we can multiply this number of preventable foreclosures by the $120,000 that White claims is lost by investors for each foreclosure performed.[45] This results in a total deadweight loss of $180 billion.

Losses of this size may be hard to square with economic theory, as Eric Maskin recently pointed out in a letter to the *New York Times*. Maskin wrote his letter in response to an earlier op-ed that had claimed the government has a role in facilitating loan modifications, specifically mass write-downs of principal balances.[46] According to Maskin: "If, as claimed, such write-downs are truly 'win-win' moves — allowing borrowers to keep their homes and giving mortgage holders a higher return than foreclosure — they may not need the government's assistance." The writers of the original op-ed column had claimed that servicers now

[43] See "A Chrysler Creditor Finds Himself Torn," *The Wall Street Journal*, April 30, 2009.

[44] This figure comes from FDIC Chairman Sheila Bair. For details see "Sheila Bair's Mortgage Miracle," *Wall Street Journal*, December 3, 2008.

[45] White (2008)

[46] The op-ed to which Maskin responded is Geanakoplos and Koniak (2008). Maskin's letter appeared on March 7, 2009.

have an undue incentive to foreclose rather than modify loans. Maskin pointed out that if this were the case, then

> mortgage holders themselves have strong motivation to renegotiate those contracts, so that the servicers' incentives are corrected. That would be a win-win-win move (for mortgage holders, servicers and borrowers), and to complete their argument, the writers must show why it won't happen.

Economists will recognize the reasoning in Maskin's critique. The Coase Theorem implies that economically efficient decisions will be made as long as property rights are well-defined and transactions costs are not of first-order importance. Under these conditions, it does not matter that servicers are not the ones who suffer the $180 billion losses entailed in foreclosure, or even that existing PSAs might unduly limit modifications. The party that suffers the potential losses — the investors — has an incentive to make side payments or to change contractual arrangements so as to prevent these massive losses from occurring. To take this reasoning one step further, if one class of investors has more to gain from modification than another class stands to lose, the first class has an incentive to strike deals with (or buy out) the second class. Consequently, to be consistent with the Coase Theorem, the renegotiation-failure theory must also assert that the transactions costs implied by securitization are large enough to derail these efficiency-enhancing arrangements, at the cost to lenders of $180 billion.

4.3 A theory of loan modifications

There is another way to explain the low number of modifications that does not rely on enormous transactions costs and yet is consistent with the Coase Theorem. It is simply that most potential modifications are negative-NPV transactions from the standpoint of investors. In other words, when all the relevant costs and benefits are considered, servicers may *already* be acting in the best interests of the investors when they foreclose.[47]

To start with, modifications do not always prevent foreclosures, especially when defaults are of the double-trigger variety. Consider a borrower who has lost his job. No permanent modification can make the house affordable if the borrower has no income. Lenders often offer "forbearance" in these cases, whereby the borrower pays sharply reduced payments for a time. The borrower is then obligated to make up these arrears, with interest, later on. Lenders may be reluctant to offer forbearance for any length of time if they are unsure

[47] Note that because of externalities from foreclosures, modifications may be in society's interests even if they are not investors' interests.

when the borrower will find a new job (and at what wage). When the value of the house that collateralizes the loan is falling, and when all parties know that the house has probably become unaffordable to the borrower, then the servicer may simply decide to take a loss now by foreclosing, rather than risk an even larger loss down the road.[48]

The possibility that borrowers will re-default on their loans reduces the *benefits* of loan modifications and thereby makes them less likely to occur. There are also reasons to think that *costs* of modifications are higher than many housing analysts recognize. These analysts typically ignore the costs of modifications that are made to borrowers who would have repaid their loans anyway. Consider a lender facing a troubled borrower who is requesting a modification. If the lender fails to modify the loan and the borrower defaults, the lender will lose because (as White points out above), the cost of modifying the loan falls far short of the cost of foreclosing. We will call this loss "Type I error." However, Type I error is only part of the story, as the lender faces another potential problem. If, unbeknownst to the lender, the borrower requesting the modified loan will not default in the absence of a modification, then the lender will lose the money he would have received according to the original terms of the loan. We call this situation "Type II error." For a modification to make economic sense from the lender's perspective, Type I error must exceed Type II error.

More formally, we can follow Foote, Gerardi, and Willen (2008), who consider a lender with a borrower who owes m on a house currently worth p_H dollars. This borrower will default with probability α_0, in which case the lender recovers p_H less λ dollars in foreclosure costs. A modification lowers the value of the loan to $m^* < m$ and the probability of foreclosure to $\alpha_1 < \alpha_0$. Note that we do not assume that modification guarantees full repayment of the mortgage — there is some probability of re-default when $\alpha_1 > 0$. Some simple arithmetic shows that renegotiation occurs when:

$$\text{Renegotiation} \Leftrightarrow \underbrace{(\alpha_0 - \alpha_1)}_{\substack{\text{Reduction in} \\ \text{foreclosure prob.}}} \times \underbrace{(m^* - (p_H - \lambda))}_{\substack{\text{Reduced} \\ \text{loss}}} > \underbrace{(1 - \alpha_0)}_{\substack{\text{Pct. repay without} \\ \text{mitigation}}} \times \underbrace{(m - m^*)}_{\substack{\text{Reduced value of} \\ \text{the mortgage}}} . \quad (3)$$

The first term corresponds to the Type I error — if a foreclosure is prevented, the lender recovers m^* rather than $p_H - \lambda$. The second term corresponds to the Type II error — borrowers who would have repaid in full, but take advantage of principal reduction to reduce their debt burden.

[48] We have been told that there is a macabre saying in the servicing industry: "The first loss is the best loss."

The following reformulation of equation (3) is instructive:

$$m - m^* < \frac{\alpha_0 - \alpha_1}{1 - \alpha_1}[m - (p_H - \lambda)]. \tag{4}$$

The right-hand side is the maximum possible concession the lender can profitably make. To understand this, consider some simple examples. If we set α_0, the probability of default without a modification, equal to 1, then equation (4) becomes

$$m^* > p_H - \lambda.$$

This is the case that White (2009) has in mind when he writes, "Particularly for foreclosed loans with losses above the 57 percent average, some of which approach 100 percent, the decisions of servicers to foreclose is mystifying."[49] In White's extreme example of 100 percent loss given default, even a modification that reduces the probability of default from 1 to anything even infinitesimally less than one, and in which the lender recovers infinitesimally more than 0, makes economic sense.

However, even a little uncertainty about whether the borrower will default invalidates the above logic. If we assume modification ensures that the loan will repay with certainty ($\alpha_1 = 0$), then equation (4) becomes:

$$m - m^* < \alpha_0[m - (p_H - \lambda)]. \tag{5}$$

It is easy to see in this equation exactly how the math works against modification. Suppose the expected loss is 57 percent and the likelihood of default is 50 percent, then the lender can only reduce the value of the loan by 28.5 percent.

How big are Type I and Type II errors in practice? Results in Gerardi and Willen (2009) show that for most categories of homeowners in Massachusetts, Type II is large relative to Type I error: even with major stresses, most homeowners will not default on their mortgages. The authors find that concessionary modifications make sense only for multi-family properties purchased with subprime mortgages.

Equation (3) clearly illustrates that the observation that a foreclosure, on the surface, seems to lead to greater monetary losses than an apparently reasonable modification is not *prima facie* evidence of inefficiency. Such foreclosures may well be *ex ante* efficient, when the issue of moral hazard is factored into the equation. This type of moral hazard explains why mortgage investors are not unduly concerned about too few modifications being performed,

[49] White (2009), p. 15.

and why, to date, there have been no lawsuits against servicers encouraging them to do more modifications.

4.4 Statistical evidence on loan modifications

The LPS data allow us to perform an econometric test of the renegotiation-failure theory, because these data contain information on the ultimate holder (investor) of the residential mortgages. Specifically, we are able to tell whether a mortgage is held on the balance sheet of a financial institution, securitized by a government sponsored enterprise (GSE) such as Freddie Mac (FHLMC) or Fannie Mae (FNMA), or securitized by a non-agency, private institution. With this information, combined with information that allows us to identify modified loans, we are able to compare the relative modification frequency between loans held in portfolio and loans that are securitized. If institutional constraints inherent in the securitization process are preventing profitable modifications, then we expect to see in the data relatively few modifications among securitized loans, as compared with loans held in portfolio.

The LPS dataset does not include direct information on loan modifications. However, it does contain updated loan terms at a monthly frequency, with which we are able to identify loan modifications indirectly (and imperfectly).[50] With these data we label a loan as modified if there is a change in its terms that was not stipulated by the initial terms of the contract. These changes include interest-rate reductions, principal-balance reductions, and term extensions. We can also identify principal-balance and mortgage-payment *increases* that reflect the addition of arrears to the balance of a loan.[51]

Table 7 reports the number of modifications made by quarter from the first quarter of 2007 through the last quarter of 2008, disaggregated by the type of modification made. Each of the numbers in the table is a multiple of 10 because we used a 10 percent random sample and scaled up the numbers we found. The first column simply reports the total

[50] The Office of Thrift Supervision (OTS) and Office of the Comptroller of Currency (OCC) used very similar data from LPS to analyze the outcomes of recent mortgage modification programs (OCC and OTS Mortgage Metrics Report, Third Quarter 2008) In their report, they used supplementary data directly from large mortgage servicers that included the identification of loans in the LPS data that had been modified. While we do not have access to those data, our findings are fairly consistent with theirs.

[51] There are two potential mistakes we can make in this exercise. First, we may falsely identify modifications ("false positives") because of measurement error in the data (for example, a mistake in the updated balance or interest rate) or some endogenous behavior on the part of the borrower (for example, a borrower making extra principal payments). Second, we may miss modifications ("false negatives") because our algorithm for finding modifications is incomplete. In this section we are more concerned with false positives than with false negatives, so we use a conservative set of criteria. See Adelino, Gerardi, and Willen (2009) for a detailed explanation of the exact algorithm used to identify modified loans in the LPS data.

number of loan modifications performed and shows that they have become more common as the housing market has weakened. By our calculations, there appear to be more than seven times as many modifications performed in the fourth quarter of 2008 as in the first quarter of 2007.

In addition to the rapid growth in loan modifications, the composition of modifications has changed over time. This can be seen in the remaining columns of Table 7, which list the incidence of modifications of different types.[52] A somewhat surprising finding is that most modifications entailed *increases* in the principal balance of a mortgage. Such increases are likely due to the addition of arrears to the outstanding mortgage balance for delinquent borrowers, and they often increase the monthly mortgage payment by a nontrivial amount. Table 7 shows that while the absolute numbers of balance-increasing modifications are still rising, they are falling as a percentage of total modifications. In the last few quarters in our data, interest-rate reductions, which necessarily involve a decrease in the mortgage payment, have become more frequent, rising to more than 25 percent of all modifications performed in 2008:Q4. Adelino, Gerardi, and Willen (2009) provide further information regarding the behavior of monthly mortgage payments for loans that have undergone a modification. The authors find that until the fourth quarter of 2008, modifications involving payment increases were more common than those involving payment decreases. In addition, they find that the average and median magnitudes of payment decreases have recently increased from approximately 10–14 percent in the period between 2007:Q1 and 2008:Q2, to approximately 20 percent in the final two quarters of 2008. Based on the logic from our simple framework above, it is likely that these will have more success than modifications involving increases in the payment and/or balance.

Figure 8 contains some evidence from the LPS data to support this claim. The figure contains Kaplan-Meier non-parametric, survival estimates (also known as the product limit estimator) of the transition from modification to default.[53] The figure considers a loan to be in default when it becomes 90 days delinquent (approximately three missed payments).

[52] In many cases a mortgage will experience multiple types of modifications at the same time. For example, we see cases in the data in which the interest rate is decreased and at the same time the term of the loan is extended. Thus, the percentages in Table 7 are not calculated with respect to the number of loans modified, but rather with respect to the number of modifications performed.

[53] The Kaplan-Meier estimate of the survival function for delinquency is given by:

$$\hat{S}_t = \prod_{t_i<t} \frac{n_i - m_i}{n_i}, \tag{6}$$

where $S(t)$ is the probability that a borrower will not default through time t, d_i corresponds to the number of loans that default at time t_i, while n_i corresponds to the number of loans that are "at-risk" of default at time t_i, or in other words the number of loans that are still active and that have not defaulted before time t_i.

The figure shows that modifications involving a decrease in the monthly payment are far more successful than those involving an increase in the payment. For example, after one year, the probability that a modified loan involving a payment increase becomes 90 days delinquent is approximately 69 percent. In contrast, a modified loan involving a payment decrease has a probability of becoming 90 days delinquent of approximately 52 percent.[54] Of course, it should be noted that the underlying data in Figure 8 come predominantly from loan modifications that took place in 2007 and early-to-mid 2008, while the majority of modifications in the LPS data occurred in the last two quarters of 2008. The Kaplan-Meier estimator does account for right-censoring, but in order to draw more conclusive inferences we will need to observe more data on these recent modifications. Another noteworthy observation from Table 7 is that the incidence of principal reductions is extremely low in our data. This is likely due to two factors. First, the LPS data under-represent the subprime mortgage market.[55] A few servicers that focus almost exclusively on subprime mortgages have recently begun modification programs that involve principal reduction.[56] In addition, from a theoretical perspective, principal reduction plans suffer from the severe incomplete-information problem noted earlier. Balance reductions are appealing to both borrowers in danger of default and those who are not. As a result, lenders have a strong incentive to provide modifications only to those borrowers who are most likely to default. Adelino, Gerardi, and Willen (2009) provide evidence to support this claim, as they show that modified loans in the LPS dataset are characterized by high leverage, high initial debt-to-income ratios, and low initial credit scores. These are the loans that are most likely to default without a modification (that is, loans where α_0 is high).

Table 8 contains modification statistics broken down by the holder of the mortgage. We distinguish between mortgages held in portfolio, mortgages securitized by a GSE such as Fannie Mae or Freddie Mac, and mortgages securitized by a private entity. For each quarter of 2008, we calculate the percentage of loans outstanding at the beginning of each quarter that were modified at some point in that quarter. Each panel in the table corresponds to a different sample of mortgages. Panel A corresponds to all types of mortgages in the data. Panel B corresponds to both subprime and Alt-A mortgages.[57] Finally, each panel in

[54]The pattern is similar if we assume the more stringent definition of default, corresponding to the situation in which foreclosure proceedings are initiated by the holder of the mortgage. In this case, modified loans involving a payment increase have a probability of experiencing a foreclosure of about 34 percent, while modifications involving a payment decrease have an associated probability of about 17 percent.

[55]The majority of subprime mortgages are securitized by non-agency firms, and for the period of interest, the LPS dataset includes approximately 35 percent of mortgages securitized by non-agency corporations.

[56]An October report by Credit Suisse notes that Ocwen Loan Servicing, LLC and Litton Loan Servicing LP were the only subprime servicers that had performed a nontrivial number of principal reduction modifications. Neither of these servicers contribute to the LPS dataset.

[57]The definition of subprime and Alt-A comes directly from the servicers that contribute to the LPS

the table is disaggregated into three parts, corresponding to different denominators used in calculating the percentages. The first part uses all loans outstanding at the beginning of the respective quarter, the second part uses all loans that are 30 days delinquent at the start of the respective quarter, and the third part uses all loans that are 60 days delinquent at the start of the respective quarter. By limiting the sample to delinquent loans, we are partially controlling for differences in credit quality between loans held in portfolio and loans that are securitized. This control turns out to be important. In both of the panels, and in almost all quarters, modifications for privately securitized loans are more frequent than for portfolio loans when the relevant universe is the full sample of loans. However, privately securitized loans are generally riskier than other loans, so this discrepancy may simply reflect the fact that more privately securitized loans are in danger of foreclosure and are thus, candidates for modification. When we narrow the focus to *delinquent* loans, the results become more balanced. Portfolio loans have a slightly higher incidence of modification compared with privately securitized in Panel A, while modifications are more common among portfolio loans in many instances in Panel B (except in the fourth quarter of 2008).

There are at least two patterns of note in Table 8. First, while delinquent loans held in portfolio appear to be modified more frequently than privately securitized mortgages (except for subprime and Alt-A mortgages, as defined in the LPS data), the discrepancy is not as large as it is often made out to be in policy circles and in media reports. For the sample of all 30-day delinquent loans (Panel A) held in portfolio, 6.81 percent were modified in the third quarter of 2008 and 8.55 percent in the fourth quarter of 2008. In comparison, 6.28 percent and 6.23 percent of privately securitized mortgages were modified in the third quarter and fourth quarter of 2008, respectively. We see similar, although slightly larger discrepancies for 60-day delinquent loans, but in many instances the sign changes for subprime and Alt-A loans (Panel B). The second take-away from the table is that the GSEs appear to have been much more reluctant to modify loans, with the exception of Freddie Mac in the third and fourth quarters of 2008. While the summary statistics presented above suggest that the incidence of modification does not seem to be greatly impeded by the process of securitization, there are a variety of factors that could be contributing to the variation in Table 8, including substantial differences in characteristics between portfolio-held loans and securitized loans. In addition, there may be significant lags between the time when a loan becomes delinquent and the point when it is modified that are not captured in Table 8. For example, if it were the case that the percentages of modified loans were the same, but portfolio-held loans were modified more quickly than privately securitized loans, Table 8 would show more portfolio-held loans being modified (since the

dataset. There is no additional distinction between subprime and Alt-A in the LPS dataset.

slower, privately securitized modifications would not be picked up in the table). For this reason, a slightly more formal analysis is necessary, in which other observable differences between securitized and portfolio loans are controlled for, and in which the timing issues as well as right-censoring are also taken into account. Censoring is an especially important problem, as there are currently many delinquent loans outstanding that are, or will soon be, good candidates for modification, as the housing market continues to decline.

Figure 9 displays Kaplan-Meier estimates of the survival function with respect to the transition from delinquency to modification, broken down by the holder of the mortgage. While the Kaplan-Meier estimator does not control for other observable differences in mortgage characteristics, it does account for censoring and the timing issues discussed above.[58] The figure contains two plots. The first plot displays estimates of the survival function corresponding to the transition from 30 days delinquency (one mortgage payment behind) to modification of all mortgages originated after 2004 in the LPS dataset, while the second plot uses only data from subprime/Alt-A mortgages in the LPS data originated after 2004. There are a few notable patterns contained in Figure 9. First, looking at the universe of all mortgages, privately securitized loans and GNMA loans are *more* likely to have been modified than loans held in portfolio and FNMA loans over a fairly long horizon. Conditional on 30-day delinquency, a privately securitized loan has a 15 percent probability of being modified after two years, and a 26 percent probability after three years, compared with 11 percent and 16 percent for loans held in portfolio, respectively.[59] Over a shorter horizon, (less than one year), there is very little difference across different types of loans when conditioning on 30-day delinquency. The patterns are slightly different for the sample of subprime/Alt-A loans, as the incidence of modification is virtually the same over all horizons for portfolio-held and privately securitized loans.[60]

Before concluding our analysis of loan modifications, we take note of some other papers that have examined the issue with the same data. Piskorski, Seru, and Vig (2009) find that seriously delinquent portfolio loans in the LPS data are less likely to experience a completed foreclosure than seriously delinquent securitized loans. The authors attribute

[58] Adelino, Gerardi, and Willen (2009) estimate Cox proportional hazard models of the transition from delinquency to modification, in which differences in observable loan and borrower characteristics are controlled for, and find results that support the patterns in Figure 9.

[59] These probabilities increase substantially for loans that become 60 days delinquent, but the relative patterns are similar. Conditional on 60-day delinquency, a privately securitized loan has a 27 percent probability of being modified after two years, and a 40 percent probability after three years, compared with 23 percent and 32 percent for loans held in portfolio, respectively. See Adelino, Gerardi, and Willen (2009) for these plots.

[60] There are a trivial number of GNMA subprime loans in the data, and thus we drop GNMA from the graph. In addition, there are only a small number of FNMA and FHLMC subprime loans that are seasoned beyond two years, and thus we decided to truncate the graph for these types of loans after two years.

this finding to a greater willingness of portfolio lenders to modify loans, but a careful analysis of the data does not support this inference. First, as we seen, portfolio lenders are not more likely to modify mortgages.[61] Portfolio lenders might be making "better" modifications than servicers of securitized loans, which could in theory explain the smaller number of foreclosures among delinquent portfolio loans. However, Adelino, Gerardi, and Willen (2009) show that the sheer number of modifications among all types of seriously delinquent loans (about 7 percent) is far too low for differences in modification quality to explain Piskorski et al.'s findings. A second issue stems from Piskorski et al.'s use of a completed foreclosure as the relevant loan outcome. If portfolio lenders were truly more willing to modify, as Piskorski et al. claim, then we would expect not only fewer bad outcomes among portfolio loans (that is, fewer foreclosures), but also more good outcomes (for example, more transitions to current status or to prepayment). After all, servicers immediately classify modified loans as current. But Adelino et al. also show that delinquent portfolio loans are no more likely to transition to current or prepaid status than securitized loans.[62] All told, the likely explanation for the Piskorski et al. finding of fewer foreclosures among delinquent portolio loans is not a higher willingness of portfolio lenders to modify loans, but rather various accounting and regulatory issues that make portfolio servicers less willing to complete the foreclosure process.

4.5 Historical evidence on loan modifications

In addition to comparing securitized vs. non-securitized loans today, we can evaluate claims about contract-related frictions by looking at the historical record. It is often claimed that renegotiation was frequent in the past, before securitized mortgages were common. For example, a report from the Congressional Oversight Panel for the Troubled Asset Recovery Program states that

> For decades, lenders in this circumstance could negotiate with can-pay borrowers to maximize the value of the loan for the lender (100 percent of the market value) and for the homeowner (a sustainable mortgage that lets the family stay in the home). Because the lender held the mortgage and bore all the loss if the family couldn't pay, it had every incentive to work something out if a repayment was

[61] The Piskorski et al. paper never tries to identify modifications directly, as we do.

[62] This finding may seem inconsistent with the reduced likelihood of completed foreclosures among portfolio loans. But a complicating fact is that most of the loan data is right-censored. The difference in completed foreclosures is offset by an increased number of loans that are more than 90 days delinquent or in some stage of foreclosure when the data is truncated.

possible.[63]

Other authors, including Zingales (2008) and Geanakoplos and Koniak (2008), have also claimed that renegotiation used to be common, but we know of no historical studies that verify this claim. There are, however, reasons to be skeptical. First, foreclosures were quite common in the past. Between 1929 and 1936, lenders carried out 1.8 million foreclosures in the United States. To put that number in perspective, keep in mind that the number of occupied dwellings more than quadrupled from 22.9 million in 1930 to 105 million in 2000.[64] In addition, increases in credit and increases in owner-occupancy have resulted in the number of owner-occupied, mortgaged homes rising from 4.8 million in 1940 to 39 million in 2000. Thus, an equivalent figure for the current crisis would be between 8.3 and 17 million foreclosures.

Another way to compare foreclosures in the current era with foreclosures during the Depression is to the look at the performance of vintages of loans. The top panel of Figure 10 shows the fraction of loans foreclosed upon by year of origination for the three principal sources of credit in that period: savings and loan institutions (S&L), life insurance companies, and commercial banks. The worst vintages were those of the late 1920s, when approximately 30 percent of loans originated by life insurance companies ended in foreclosure, 20 percent of S&L mortgages ended in foreclosure, and about 15 percent of commercial bank loans were foreclosed upon. The bottom panel shows the fraction of homeownerships (not loans) originated each year in Massachusetts from 1988 through 2008 that eventually ended in foreclosure.[65] Since at least some of these foreclosures did not occur on purchase mortgages, but rather on subsequent refinances, one can view this as an upper bound on a similar measure using current data. What is clear is that we see far *fewer* foreclosures than we did in the 1930s. These statistics are difficult to square with the claim that renegotiation was more common in the past.

In fact, historical documents do suggest that modifications occurred in the past. The Home Owners Loan Corporation (HOLC), set up by the federal government in 1933 in the midst of the Great Depression, would buy loans at a deep discount from lenders and re-underwrite the borrower into a new mortgage consistent with the borrower's financial situation at the time. However, it is important to understand that the economic situation was extremely poor, as 40 percent of American homeowners were more than 15 months in arrears. In terms of our model, this made Type I error large and Type II error small.[66]

[63] COP report, p. 2.

[64] Source: U.S. Census of Housing, 2000, Table DP-4, and 1950, Part 1, Table J.

[65] See Gerardi, Shapiro, and Willen (2007) for details regarding the Massachusetts data.

[66] See Harriss (1951) for details about HOLC.

Unfortunately, we do not have detailed data on the subsequent mortgages to analyze the ultimate experiences of HOLC borrowers.

In addition, commercial banks commonly modified loans in this time period. Behrens (1952) shows that as many as 40 percent of the loans originated in a given year would be modified at least once, and as many as half of those more than once. However, it is important to understand that until the 1930s, commercial banks could not make long-term amortized loans, so renegotiation for term extensions and interest rate changes was common. According to Behrens, "It should also be observed that the low level of interest rates current in the 1930s as compared with that prevailing during the 1920s doubtless stimulated a good many of the loan modifications, primarily for those loans in good standing..."

In general, discussions of foreclosure from contemporary sources in "past decades" never mention concessionary modification as a strategy for dealing with troubled borrowers. A book on what we would now call "best practices" in mortgage banking, written in the mid-1950s, gives a detailed discussion of how to contact delinquent borrowers, but then recommends turning the problem over to an attorney.[67] The author then discusses how to deal with the sale of a foreclosed property but never suggests that the servicer should make concessions to help the borrower continue making payments. Even HOLC, to a large extent, considered mostly non-concessionary modifications and foreclosed on almost 20 percent of the borrowers to whom it lent.[68]

Foreclosure has always been a common outcome in mortgage lending, even for the best-intentioned of lenders. The first borrower ever to obtain a loan from a Building and Loan Society in the U.S. was eventually forced out of his home. A man named Comly Rich took out a mortgage on April 11, 1831, but "was frequently fined for failure to pay his dues and interest." The problems were resolved in what amounts to a foreclosure: both the house and the mortgage were transferred to another borrower.[69]

5 Conclusion

In this paper, we have attempted to make two main points. First, while the concept of mortgage "affordability" is often used in explanations of the current rise in mortgage defaults, this concept is not helpful if it is not defined precisely. Many people believe that the affordability of a mortgage is adequately summarized in the DTI at origination. However, this ratio does not appear to be a strong predictor of default. What really matters

[67] Pease and Cherrington (1953).
[68] Harriss (1951).
[69] See Bodfish (1931), pp. 66–72.

in the default decision is the mortgage payment relative to the borrower's income in the present and future, not the borrower's income in the past. Consequently, the high degree of volatility in individual incomes means that mortgages that start out with low DTIs can end in default if housing prices are falling. A second, related point concerns the apparent unwillingness of loan servicers to turn "bad" (that is, high-DTI) mortgages into "good" (low-DTI) mortgages. It is true that lenders may lose a great deal of money with each individual foreclosure, but the loan modifications might have negative NPV if they are sometimes extended to people who are likely to pay on time anyway. And the benefits of modifications are uncertain if borrowers have lost their jobs.

What do these findings suggest for foreclosure-reduction policy? One suggestion would be to focus a program on the effects of income volatility, helping people who lose their jobs get through difficult periods without having to leave their homes. For example, the government could replace a portion of lost income for a period of one or two years, through a program of loans or grants to individual homeowners.[70] For more permanent and very large setbacks, the government could help homeowners transition to rentership through short sales or other procedures. Whatever policies are adopted, the results of this paper suggest that policies that encourage moderate, long-term reductions in DTIs face important hurdles in addressing the current foreclosure crisis.

[70]For details of such a plan, see `http://bosfed.org/economic/paymentsharingproposal.pdf`.

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Table 1: Probability that a loan will become "unaffordable" at least once in the first three years, where unaffordability is defined as DTI above a certain threshold.

		(1)	(2)	(3)	(4)
std(η_t)		15%	15%	0%	15%
std(ε_t)		21%	21%	0%	42%
Resets		No	Yes	Yes	No
A. ***Ex Post* Unaffordable Defined as DTI>31%**					
Initial DTI =	31%	70.1	81.7	100.0	72.6
B. ***Ex Post* Unaffordable Defined as DTI>38%**					
Initial DTI =	31%	45.6	60.5	0.0	58.6
	38%	70.3	81.8	100.0	74.7
C. ***Ex Post* Unaffordable Defined as DTI>50%**					
Initial DTI =	31%	16.4	30.6	0.0	38.3
	38%	36.5	51.8	0.0	54.8
	50%	69.7	81.4	100.0	72.0

Table 2: Shares of various loans in LPS data, by seniority, subprime status, and investor: December 2008

Investor	First-lien Prime and Near Prime	Second-lien Prime and Near Prime	First-lien Subprime	Second-Lien Subprime	Other	Total
			Panel A: Counts			
GSE Securitized:						
Fannie Mae	9,410,856	7,292	48,093	130	0	9,466,371
Freddie Mac	6,342,870	2,672	7,911	0	15	6,353,468
Ginnie Mae	4,709,406	391	751	1	6	4,710,555
Private Securitized	4,224,463	208,722	486,469	121,987	250	5,041,891
Portfolio	2,224,951	412,691	87,843	11,823	32,267	2,769,575
Unknown	121,635	1,830	7,953	76	0	131,494
Other	271,696	4,173	122	0	0	275,991
Total	27,305,877	637,771	639,142	134,017	32,538	28,749,345
			Panel B: Percentages			
GSE Securitized:						
Fannie Mae	32.73	0.03	0.17	0.00	0.00	32.93
Freddie Mac	22.06	0.01	0.03	0.00	0.00	22.10
Ginnie Mae	16.38	0.00	0.00	0.00	0.00	16.38
Private Securitized	14.69	0.73	1.69	0.42	0.00	17.54
Portfolio	7.74	1.44	0.31	0.04	0.11	9.63
Unknown	0.42	0.01	0.03	0.00	0.00	0.46
Other	0.95	0.01	0.00	0.00	0.00	0.96
Total	94.98	2.22	2.22	0.47	0.11	100.00

Notes: The investor "Other" category includes local housing authorities, the Federal Home Loan Bank (FHLB), and GNMA Buyout Loans.

Table 3: Incidence of Missing DTI Ratios and FICO Scores in LPS data, By Year of Loan Origination

	DTI Ratio			FICO Score		
	All	Prime	Subprime	All	Prime	Subprime
2002	88.3	88.1	100.0	22.2	22.4	10.0
2003	65.1	64.5	90.9	22.2	22.1	26.2
2004	44.1	42.7	60.8	16.1	17.1	4.4
2005	40.4	40.6	38.8	15.5	16.5	5.1
2006	40.3	40.4	39.8	17.4	17.9	12.9
2007	31.7	32.1	22.5	13.3	13.8	1.6
2008	42.5	42.5	26.2	12.3	12.3	0.0
All years	50.1	50.2	48.6	17.4	17.9	8.7

Table 4: Summary Statistics: Loans Originated from 2005–2008

	Prime		Subprime	
	Mean	Std Dev	Mean	Std Dev
DTI Ratio	35.1	13.8	40.0	11.1
FICO Score	714.1	61.6	609.0	54.9
LTV Ratio	73.4	18.2	79.2	12.5
Adjustable Rate Dummy	.21	.40	.56	.50
Number of Loans	501,317		41,132	

Figure 1: Loan-Specific Characteristics in LPS Sample

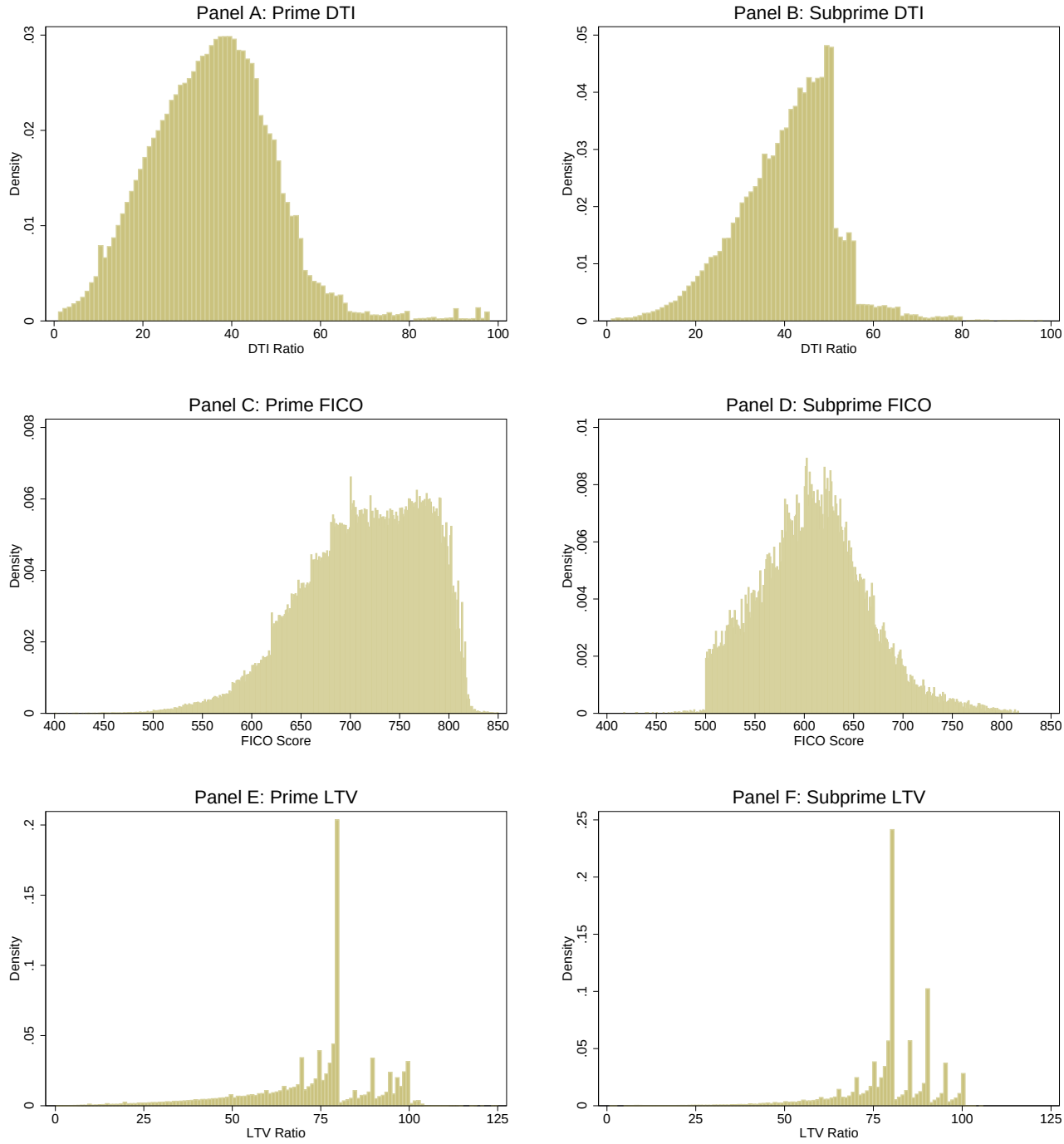


Figure 2: Cumulative Changes in State-Level House Prices for LPS Loans

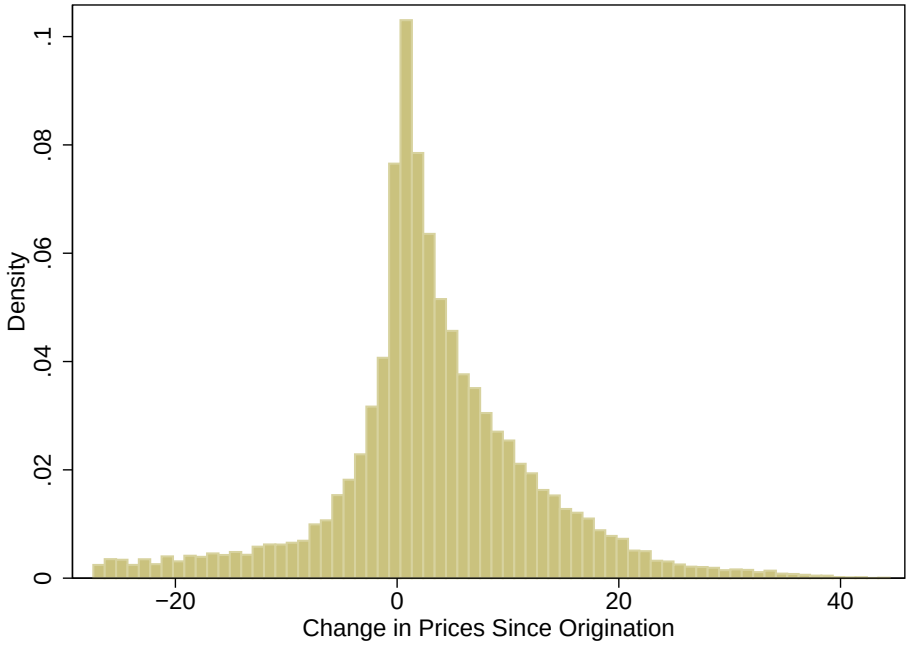


Figure 3: Cumulative Changes in County-Level Unemployment for LPS Loans

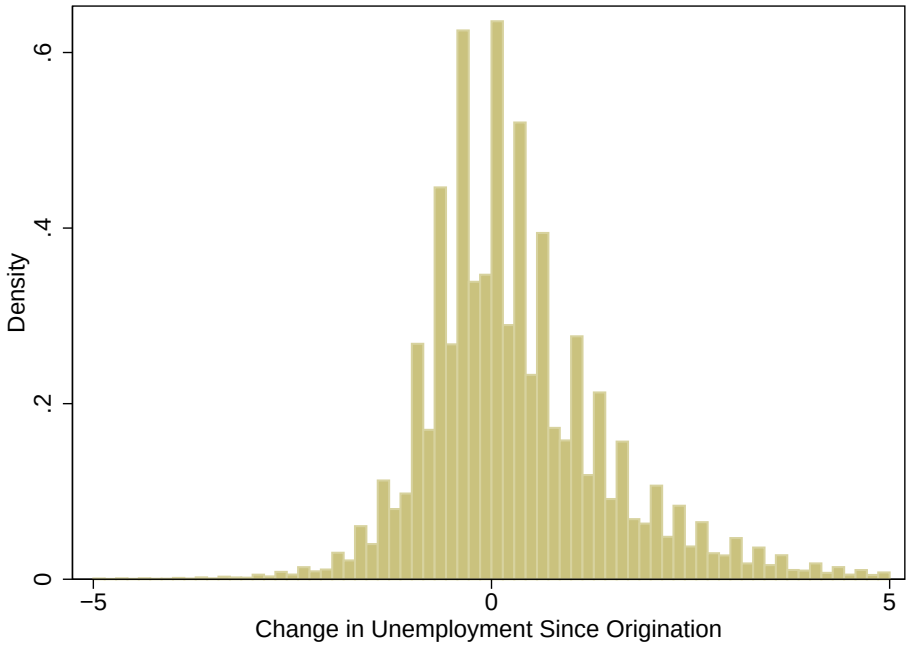


Figure 4: Baseline Default Hazards: Prime and Subprime Loans

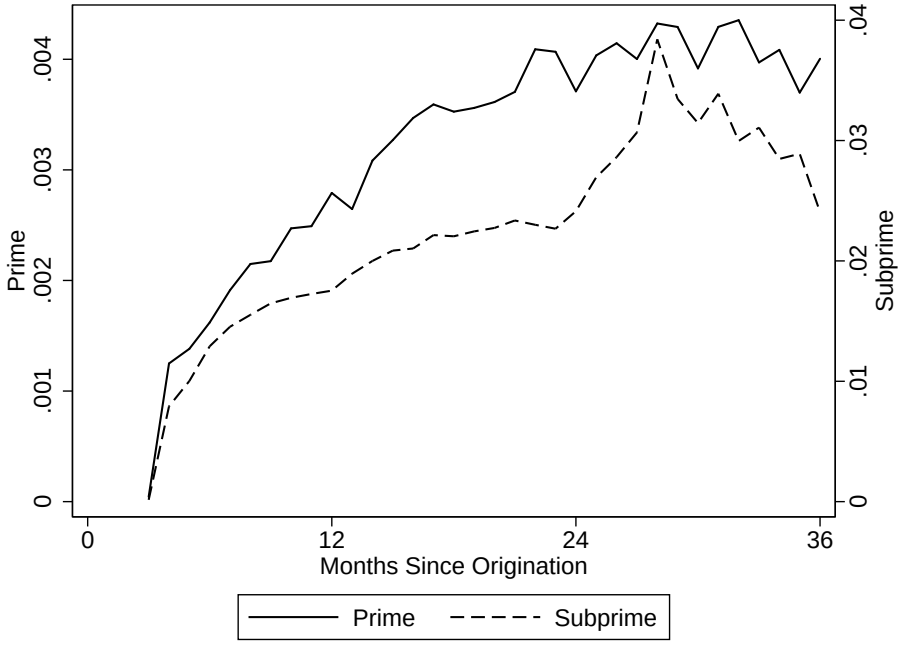


Figure 5: Baseline Prepayment Hazards: Prime and Subprime Loans

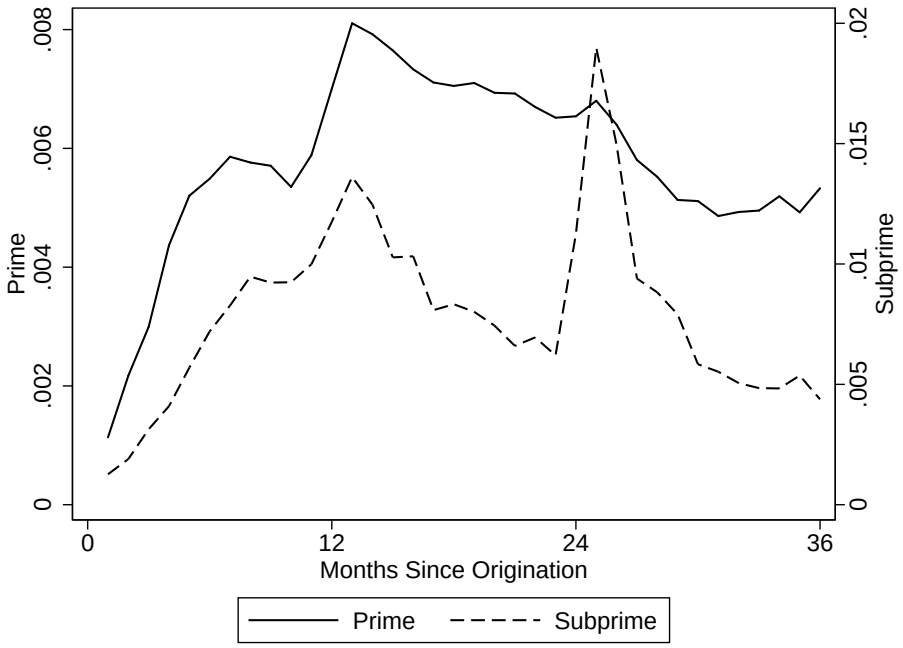


Table 5: Estimates from Cox Proportional Hazard Models

	Prime Defaults	Subprime Defaults	Prime Prepayments	Subprime Prepayments
DTI Ratio	.0105**	.0072**	.0046**	–.0003
	(.0009)	(.0012)	(.0005)	(.0012)
FICO Score	–.0124**	–.0035**	–.0004	–.0016**
	(.0003)	(.0003)	(.0002)	(.0005)
LTV Ratio	.0308**	.0212**	–.0108**	–.0234**
	(.0021)	(.0026)	(.0010)	(.0017)
LTV $\neq$ 80 dummy	–.2973**	–.1836*	.1126**	.2447**
	(.0453)	(.0738)	(.0219)	(.0286)
Adjustable Rate Dummy	.7521**	.5074**	.6465**	.5605**
	(.0539)	(.0354)	(.0568)	(.0537)
Δ UR	.2068**	.1007**	–.0344	–.0476
	(.0207)	(.0156)	(.0210)	(.0345)
Δ HP >= 0	–.0571**	–.0516**	.0236**	.0384**
	(.0061)	(.0071)	(.0032)	(.0043)
Δ HP < 0	–.0592**	–.0451**	.0555**	.0925**
	(.0051)	(.0049)	(.0062)	(.0088)
Δ HP * Δ UR	.0061**	.0069**	.0015	.0019
	(.0009)	(.0008)	(.0012)	(.0016)
Δ HP * LTV	–.0001	–.0003**	.0007**	.0009**
	(.0001)	(.0001)	(.0001)	(.0001)
Δ HP * DTI	–.0000	.0001	.00010*	.0001
	(.0001)	(.0001)	(.00004)	(.0001)
Δ HP * FICO	–.0000	–.0000	–.00012**	.0000
	(.0000)	(.0000)	(.00002)	(.0000)
Δ UR * FICO	.0010**	.0003**	.0002	-.0000
	(.0001)	(.0001)	(.0001)	(.0000)
FICO * DTI	.0000	–.000055**	–.0000	–.00004**
	(.0000)	(.000017)	(.0000)	(.00001)
DTI * Δ UR	–.0008	.0003	–.0005	.0008
	(.0005)	(.0005)	(.0003)	(.0006)
No. of monthly observations	10,796,387	821,020	10,796,387	821,020
No. of loans	501,317	41,132	501,317	41,132

Notes: Standard errors are clustered by state. * denotes significance at 5 percent. ** denotes significance at 1 percent. A negative value of a house-price change ($HP < 0$) is entered directly in the regression (not as an absolute value.)

Figure 6: Model-Generated Monthly Defaults and Prepayments (Per 100 Loans Originated) Under Various Assumptions

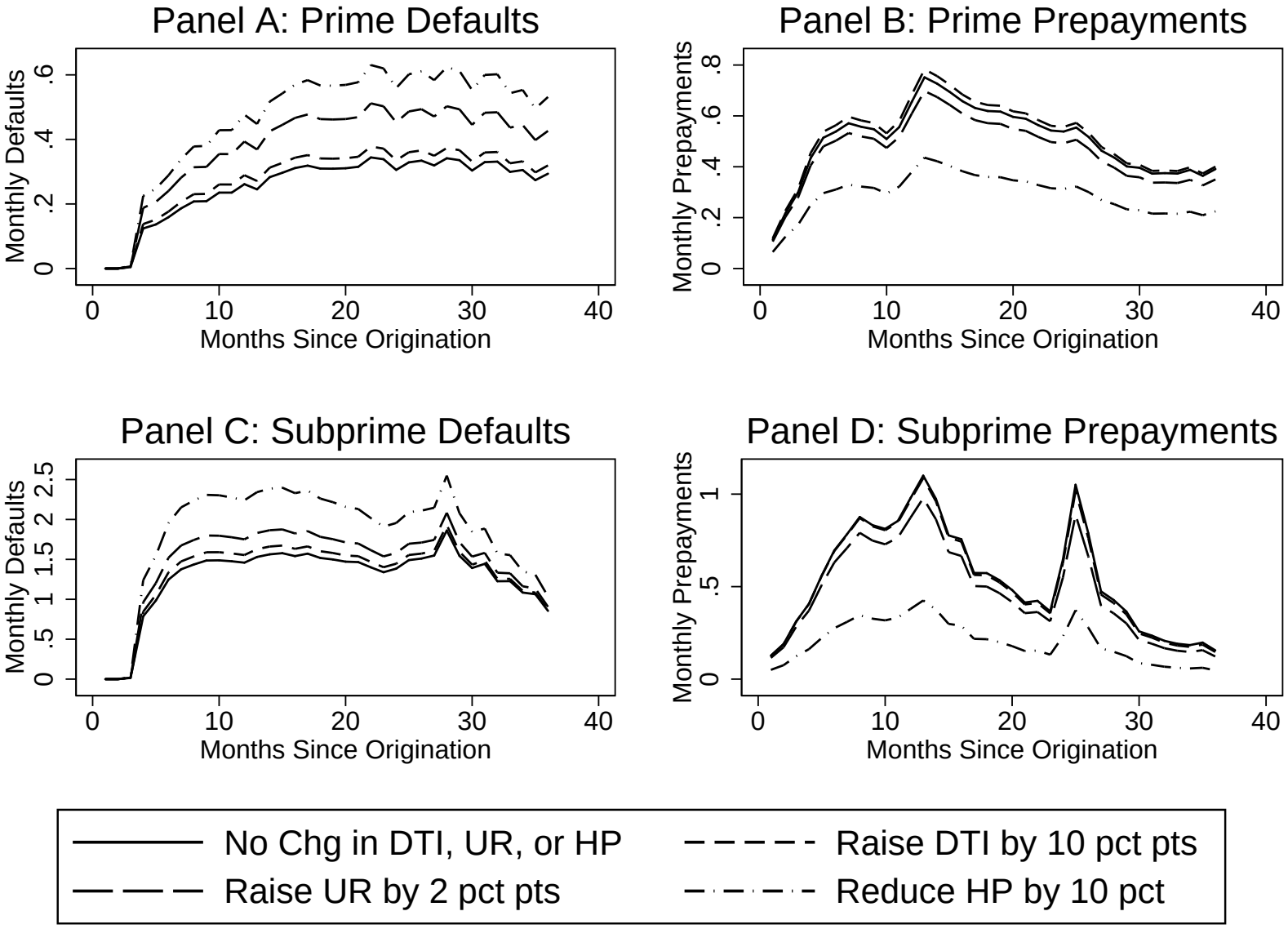


Figure 7: Roll Rates by Initial Delinquency Status

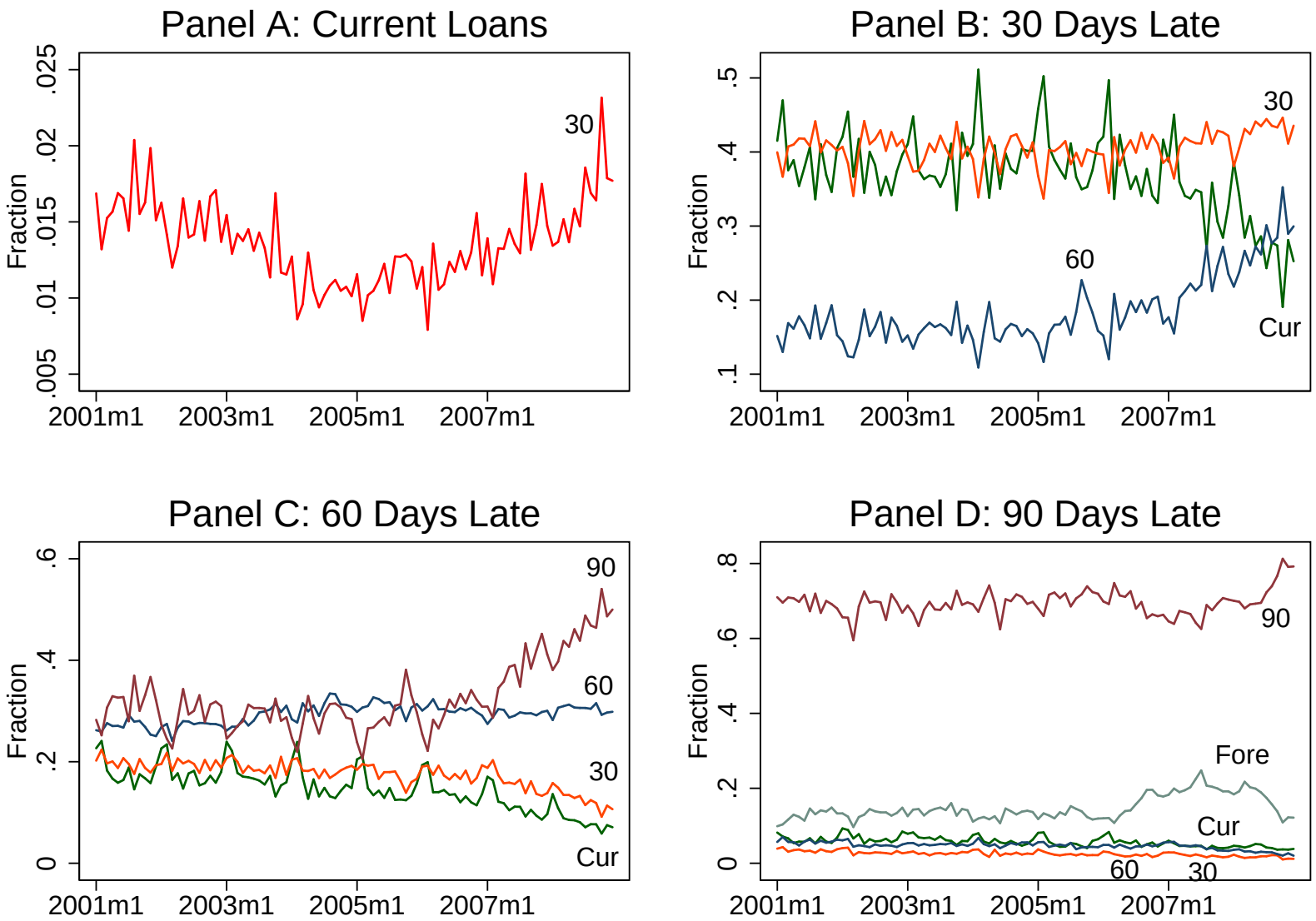


Table 6: Direct Defaults as a Share of All Defaults, by Year of Origination and Year of Default

Year of Origination	Year of Default 2003	2004	2005	2006	2007	2008	Total
Panel A: All States							
2003	11.4	10.8	15.3	14.1	18.0	28.1	16.4
2004		8.2	12.5	14.5	22.7	34.4	20.4
2005			11.2	15.8	31.4	44.6	32.1
2006				11.7	25.7	44.0	34.9
2007					25.5	39.7	37.4
2008						38.1	38.1
All Orig. Years	11.4	10.3	13.1	14.5	26.6	41.6	30.8
Panel B: AZ, CA, FL, & NV							
2003	9.4	5.0	5.4	8.7	20.9	41.0	16.8
2004		7.3	6.6	13.7	33.9	49.3	30.5
2005			5.0	18.1	43.9	57.7	46.2
2006				12.5	34.4	55.8	46.5
2007					31.3	53.9	50.6
2008						47.1	47.1
All Orig. Years	9.4	5.5	6.0	15.4	36.8	55.1	44.8
Panel C: 47 Remaining States							
2003	11.8	11.9	16.3	14.6	17.6	24.9	16.4
2004		8.4	13.4	14.7	19.9	27.3	17.8
2005			12.6	15.0	23.0	31.5	22.9
2006				11.3	19.8	31.6	25.0
2007					22.0	29.6	28.3
2008						34.5	34.5
All Orig. Years	11.8	11.2	14.1	14.3	20.7	30.4	22.7

Table 7: Modification Statistics by Type: 2007:Q1–2008:Q4

	# Loans Modified	Interest Rate Reductions		Principal Balance Reductions		Principal Balance Increases		Term Extensions	
		#	(% total)	#	(% total)	#	(% total)	#	(% total)
2007:Q1	10,940	600	5.3	700	6.2	8,660	76.4	1,380	12.2
2007:Q2	14,600	820	5.4	550	3.7	11,630	77.3	2,050	13.6
2007:Q3	17,720	770	4.1	810	4.3	15,170	81.2	1,940	10.4
2007:Q4	27,150	2,990	9.7	700	2.3	22,520	72.8	4,740	15.3
2008:Q1	36,230	6,010	13.8	900	2.1	32,100	73.8	4,500	10.3
2008:Q2	44,750	9,050	16.4	1,300	2.4	39,750	72.1	5,030	9.1
2008:Q3	62,190	16,280	20.3	940	1.2	56,940	70.9	6,110	7.6
2008:Q4	74,800	28,630	26.7	1,450	1.4	65,960	61.5	11,230	10.5

Notes: These statistics were computed using a 10 percent random sample of the LPS data. Quantities obtained from the data are multiplied by a factor of 10. The percentages are taken with respect to the total number of modifications, and *not* loans modified. Thus, there is double-counting in the sense that some loans received multiple types of modifications in a given quarter.

Table 8: Modification Statistics by Loan Holder

Panel A – All Loan Types

	Modification % of all loans outstanding				Modification % of 30 days delinquent or worse				Modification % of 60 days delinquent or worse			
	2008:Q1	2008:Q2	2008:Q3	2008:Q4	2008:Q1	2008:Q2	2008:Q3	2008:Q4	2008:Q1	2008:Q2	2008:Q3	2008:Q4
GNMA	0.04	0.04	0.03	0.03	0.39	0.36	0.31	0.27	0.80	0.74	0.64	0.51
FNMA	0.10	0.06	0.05	0.04	2.32	1.30	0.88	0.61	4.87	2.51	1.58	1.03
FHLMC	0.05	0.05	0.16	0.23	1.95	1.75	4.72	5.26	4.56	3.74	9.06	9.30
Private Securitized	0.55	0.84	1.25	1.42	3.45	4.63	6.28	6.23	5.03	6.41	8.49	8.31
Portfolio	0.53	0.65	0.69	1.05	6.31	7.53	6.81	8.55	10.23	11.47	10.32	12.57

Panel B – Subprime/Alt-A Loans (LPS Defintion)

	Modification % of all outstanding loans				Modification % of 30 days delinquent or worse				Modification % of 60 days delinquent or worse			
	2008:Q1	2008:Q2	2008:Q3	2008:Q4	2008:Q1	2008:Q2	2008:Q3	2008:Q4	2008:Q1	2008:Q2	2008:Q3	2008:Q4
FNMA	0.80	0.42	0.37	0.19	3.42	1.70	1.32	0.56	6.01	3.05	2.24	0.87
FHLMC	0.23	0.12	2.48	1.70	1.30	0.56	9.59	5.35	2.92	1.18	17.86	8.68
Private Securitized	1.59	2.58	4.39	4.56	4.41	6.65	10.41	9.46	6.28	9.11	14.13	12.55
Portfolio	1.41	2.51	3.97	6.93	3.72	6.23	9.95	15.83	5.21	8.57	13.55	21.75

Figure 8: Kaplan-Meier Survival Estimates: Transition from Modification to Default

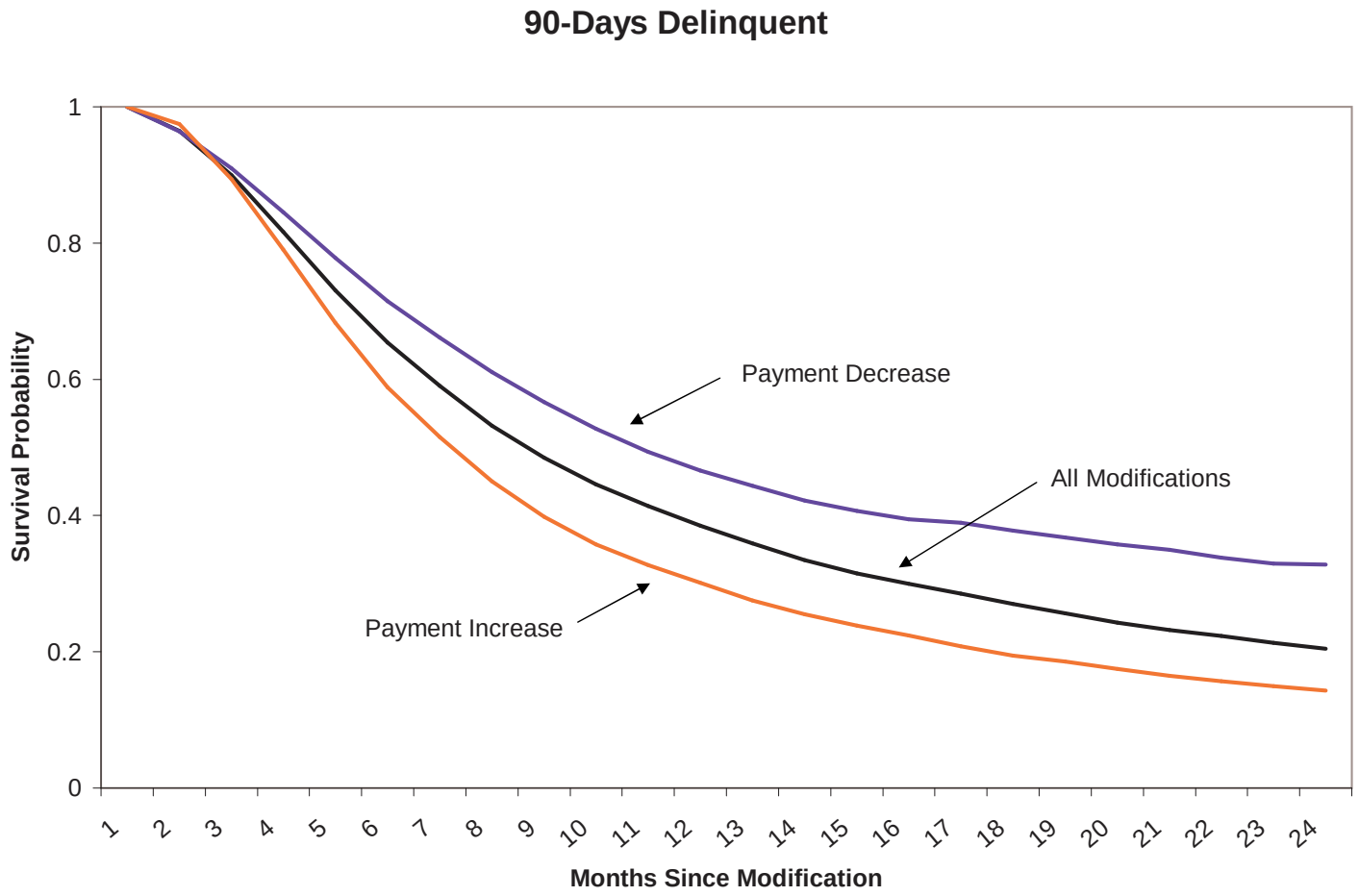


Figure 9: Kaplan-Meier Survival Estimates: Transition from Delinquency to Modification

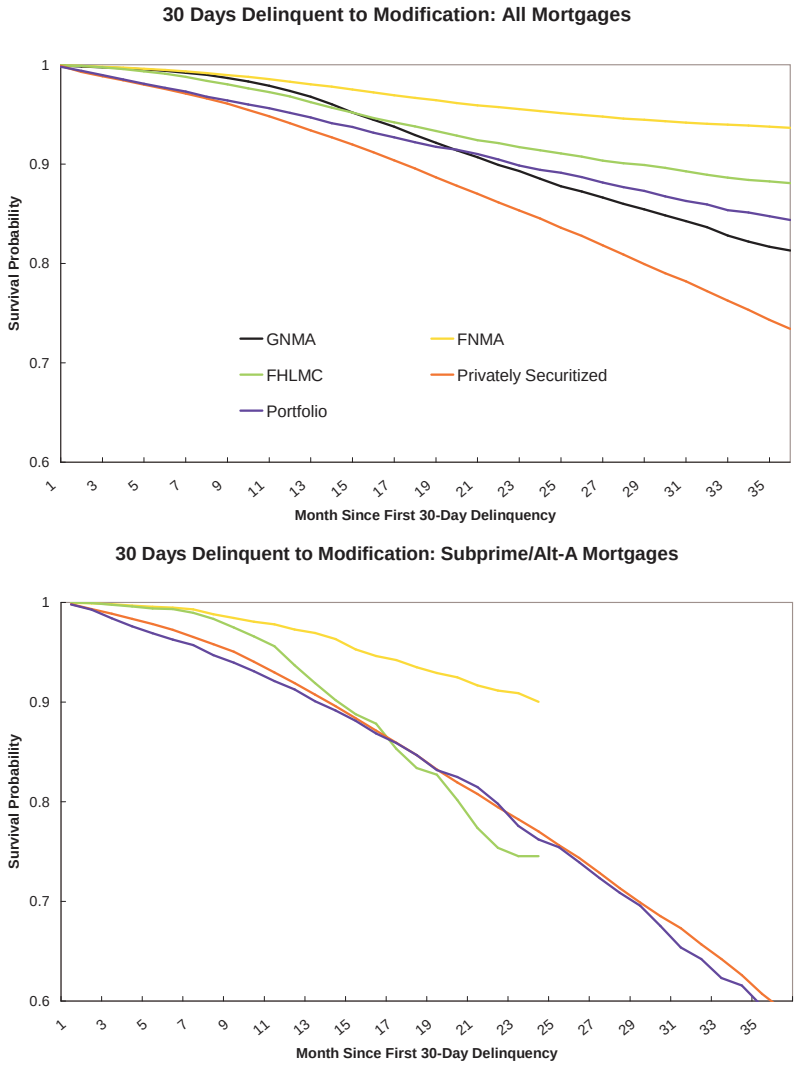
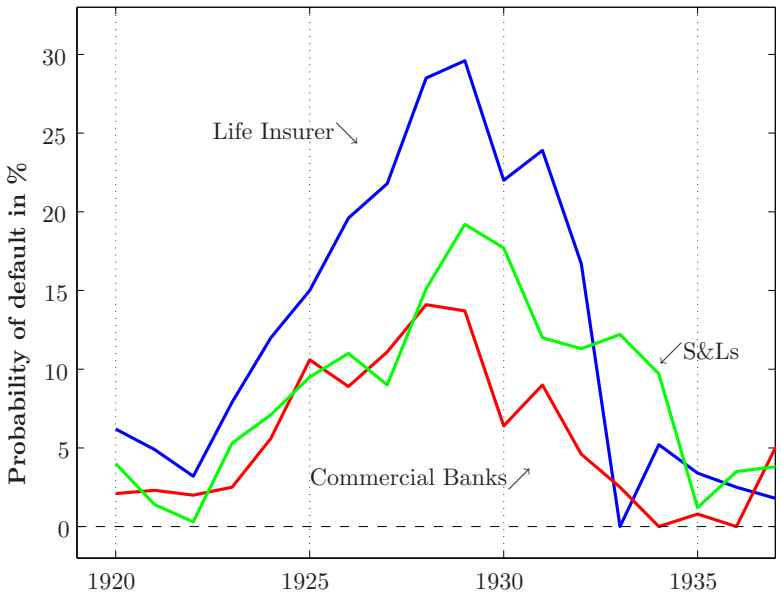


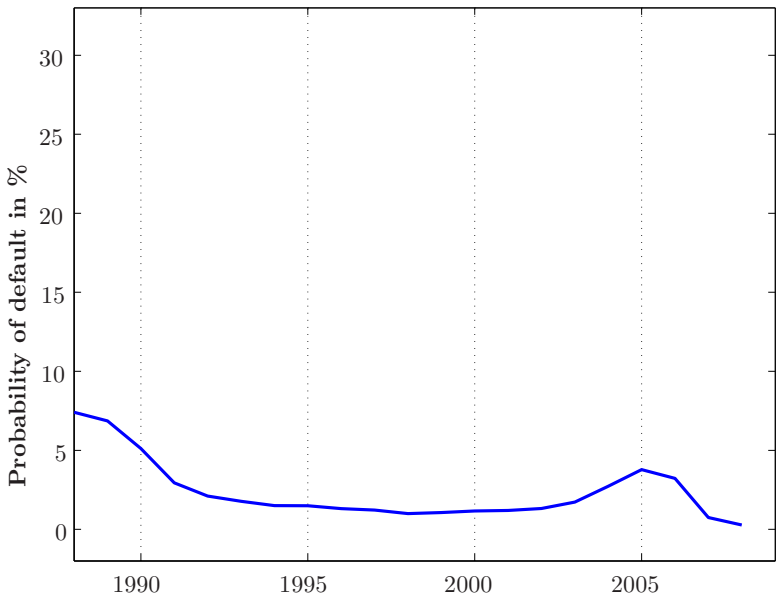
Figure 10: Default Probability by Year.

The top panel reports foreclosures on loans originated in that year. Loans may be purchase or refinance. Data comes from Morton (1956). The bottom panel reports foreclosures on homes purchased with mortgages in that year. For these data, we count a loan as foreclosed if there was a foreclosure on that loan or any subsequent mortgage to that owner. Thus the probabilities in the lower panel are an upper bound on the probabilities in the top panel. See Gerardi, Shapiro, and Willen (2007) for details.

Foreclosure probabilities between 1920 and 1947 by origination year



Foreclosure probabilities between 1989 and 2008 by origination year



Journal of Housing Economics 17 (2008) 291–305

Contents lists available at ScienceDirect

Journal of Housing Economics

journal homepage: www.elsevier.com/locate/jhe

Just the facts: An initial analysis of subprime's role in the housing crisis ☆

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ARTICLE INFO

Article history:
Received 8 August 2008
Available online 10 October 2008

JEL classification:
R21
R31
G21

Keywords:
Mortgage
Subprime
Crisis

ABSTRACT

Using two large proprietary datasets from New England, this paper establishes some basic facts about the subprime crisis. First, while unaffordable interest-rate resets are often blamed for setting off this crisis, most subprime borrowers who defaulted did so well in advance of their reset dates. Defaults on subprime adjustable-rate mortgages are more sensitive to declining housing prices than are defaults on fixed-rate loans, however, and the data support a number of alternative explanations for this finding. Second, many borrowers with good credit scores took out subprime loans as the housing boom gathered steam. It is hard to construct a *prima facie* case that these borrowers were inappropriately steered into the subprime market, however, because the loans that these borrowers took out were too risky for prime treatment. Finally, 70% of Massachusetts homes recently lost to foreclosure were originally purchased with prime mortgages. But subprime refinancing is especially prevalent among owners who were likely to have extracted substantial amounts of equity before they defaulted.

1. Introduction

Subprime mortgages lie at the center of recent turmoil in housing and credit markets. Unfortunately, many housing researchers have been prevented from performing formal analyses of the subprime market due to the difficulty of obtaining appropriate data. Proprietary, loan-level data used by Wall Street investment banks and hedge funds often cost more than $100,000, placing these data out of reach for most housing researchers. Moreover, even these loan-level datasets sometimes paint an incomplete picture, because they do not link various mortgages to the same borrower over time. This paper presents some basic facts about the subprime market using two large, micro-level datasets. These data were purchased by the Federal Reserve Bank of Boston and have been used extensively in policy work. Though the datasets cover only Massachusetts (in one case) and southern New England (in another), we will argue that they are quite useful for understanding the subprime crisis in the nation as a whole.

Three sets of facts emerge from our analysis. The first concerns the relationship between the timing of interest-rate resets and the current surge in subprime defaults. The typical subprime loan was an adjustable-rate "hybrid," meaning that it had a fixed "teaser" interest rate during an initial 2- or 3-year period, after which the loan reset to a floating rate (usually around 6 percentage points above a short-term interbank lending rate). Many commentators have claimed that a wave of unaffordable resets sparked

☆ We thank participants at various forums, summits, breakfasts, brownbags, seminars and other gatherings for helpful comments and suggestions. We also thank Tim Warren and Alan Pasnik of the The Warren Group and Dick Howe Jr., the Register of Deeds of North Middlesex County, Massachusetts, for providing us with data, advice, and insight. Finally, we thank Elizabeth Murry for providing helpful comments and edits. The views in this paper are our own and not necessarily those of the Federal Reserve Bank of Boston or the Federal Reserve System. Any remaining errors are our own.

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doi:10.1016/j.jhe.2008.09.005

the current crisis. Yet the data show that most borrowers who defaulted on subprime adjustable-rate mortgages (ARMs) did so well in advance of their reset dates. Moreover, the data also show that the initial "teaser" rates were not artificially low; in fact, they were quite high. It is possible that some characteristics of subprime ARMs made foreclosures more likely, even though these foreclosures did not occur precisely at the reset dates.[1] In fact, we find that defaults among subprime ARMs are more sensitive to house price declines than defaults on subprime fixed-rate mortgages (FRMs). However, it is hard to know whether the higher sensitivity stems from features of the ARM contracts, or rather from the characteristics of borrowers who were likely to choose ARMs over FRMs.

A second set of facts concerns underwriting standards of subprime loans. Subprime lending began in the mid-1990s as a way for persons with less-than-perfect credit to purchase homes. Several commentators have noted, however, that the average credit score of subprime borrowers grew as the housing boom gathered steam. The commentators have interpreted this pattern as evidence that persons with good credit were "steered" into subprime loans by unscrupulous mortgage brokers. Our data confirm that persons with high credit scores were increasingly likely to take out subprime loans. Yet the data also show that these borrowers could not have obtained these same loans from prime lenders. The subprime loans taken out by "good" borrowers typically had high loan-to-value (LTV) or debt-to-income (DTI) ratios, or they lacked full documentation of borrower incomes and assets. These heightened risk characteristics would have made these loans unattractive to prime lenders, in spite of the borrowers' high credit scores. Of course, these higher risk characteristics also made the subprime loans very sensitive to the recent decline in housing prices, helping to explain high defaults among subprime mortgages.[2]

The third set of facts involves the importance of subprime refinancing to foreclosure. Our data show that slightly less than half (45.2%) of recently defaulted Massachusetts mortgages were subprime loans. This share is close to, though somewhat lower than, figures from national analyses. However, one of our datasets allows us to link mortgages taken out by the same owner on the same house. We are therefore able to analyze the purchase mortgage of each foreclosed home, even if the owner refinanced out of his purchase mortgage before defaulting. While ownerships that begin with subprime mortgages are much more likely to default than ownerships beginning with prime mortgages, less than one-third of homes recently lost to foreclosure in Massachusetts were originally purchased with subprime loans. Somewhat surprisingly, many foreclosed homes were purchased before the early 2000s housing boom and had thus accumulated substantial equity. Though we cannot measure cash-out refinancing directly, we provide suggestive evidence that subprime loans were especially popular among homes that had appreciated in price but that were later lost to foreclosure, due in part to a large extraction of equity.

The paper is organized as follows. Section 2 describes the two main datasets used in our analysis. It also discusses alternative definitions of "subprime" and quantifies the extent of subprime defaults. Section 3 explores the role of interest-rate resets in subprime foreclosures, and compares the performance of subprime ARMs with that of subprime fixed-rate mortgages. Section 4 discusses changes in subprime underwriting standards and the effect that these standards may have had on foreclosure patterns in Massachusetts. Section 5 explores the role of subprime refinances in foreclosures, while Section 6 concludes with a discussion of a crucial outstanding question: whether higher subprime lending in the early 2000s put upward pressure on housing prices.

2. Background and data

2.1. The Warren Group's Registry of Deeds data

The most fundamental dataset in our research was supplied by The Warren Group, a private Boston firm that has been tracking real estate transactions in New England for more than a century. The Warren Group dataset is a standardized, electronic version of publicly available real estate transaction records filed at Massachusetts Registry of Deeds offices during the past 20 years. The dataset includes the universe of purchase mortgages, refinance mortgages, home equity loans, and purchase deeds transacted in Massachusetts from January 1987 through March 2008. Foreclosure deeds are available starting in 1989. So, for every house purchased in the state during the sample period, we know the location and price of the house, the size of all mortgages associated with the sale,[3] and the identity of the mortgage lender, among other variables.

2.1.1. Sales and foreclosures

The Warren Group data allow us to paint a detailed picture of the Massachusetts housing market, both before and after the introduction of subprime lending in the mid-1990s. Fig. 1 presents Massachusetts sales and foreclosures by year, clearly illustrating the state's two foreclosure waves during the past two decades. The first foreclosure wave occurred in the early 1990s, when the combination of a severe recession and a significant downturn in the housing market resulted in a dramatic increase in foreclosures. In 2006 and 2007, we see evidence of the state's current foreclosure wave.

[1] For example, borrowers might have predicted that they could not have afforded the eventual interest rates after they reset, and defaulted in advance of that date.

[2] A natural question is whether the reduced quality of subprime loans is fully responsible for increased defaults among subprime loans originated at the height of the housing boom. Gerardi et al. (forthcoming) investigates this question with a nationwide dataset. They find that subprime loans originated at the end of the boom had worse risk characteristics than those originated earlier, a finding that is corroborated by the results of the current paper as well. But Gerardi et al. (forthcoming) also finds that these changes in risk characteristics are not large enough to explain the astronomical rise in default probabilities among the later vintages of subprime loans.

[3] Specifically, we see second mortgages ("piggybacks") as well any other mortgage secured by the home.

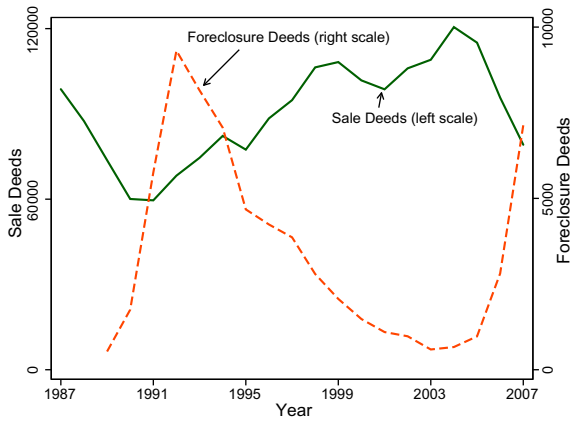

Fig. 1. Sales and foreclosures in Massachusetts, 1990–2007.

While the absolute number of current foreclosures is approaching early 1990s levels, there are some important qualitative differences across the two foreclosure waves. The early 1990s followed a burst of residential construction in Massachusetts, in which new condominiums were often used as investment vehicles (Jordan, 1992). When this building boom ended and house prices fell, many of these investment properties ended up in foreclosure. By contrast, residential construction was much more subdued in Massachusetts during the early 2000s boom. The condominium share of foreclosures has been replaced to some extent by foreclosures of multi-family properties, which were built some time ago and which are predominantly located in low-to-moderate income areas.[4]

Table 1 presents the importance of single-families, condos, and multi-families in the past two foreclosure waves, according to the Warren Group data, along with the share of 1990–2007 purchases attributable to each of the three dwelling types. The share of foreclosures attributable to condominiums has fallen from 33.7% in the earlier wave to only 13.3% recently. By contrast, the share accounted for by multi-families has risen from 20.4% to 28.4%. The bad news for current policymakers is that the negative external effects from multi-family foreclosures are generally more serious than from condo foreclosures. Generally, multi-families are owned by residents of one of the units, with the other residents paying rent. When the owner loses the home, the renters can also be evicted.[5]

Table 1
Shares of residence types in foreclosures and purchases.

	Single-family	Condominium	Multi-family
2006–2007 Foreclosures	58.3%	13.3%	28.4%
1991–1992 Foreclosures	45.9%	33.7%	20.4%
1990–2007 Purchases	68.8%	20.4%	10.8%

2.1.2. Prices

Our data also allow a careful measurement of housing prices, which have a close theoretical relationship to foreclosures. Standard models of housing finance predict that falling prices make foreclosures more likely by fostering negative equity, which occurs when the outstanding balance on a home mortgage exceeds the market price of the house. Even when the aggregate economy is doing well, individual homeowners often experience life events—such as illness, job loss, or divorce—which cause them to fall behind on their mortgages. When borrowers have positive equity, these adverse life events often prompt profitable sales, or, if the problems are temporary, cash-out refinances. But when equity is negative, borrowers facing adverse life events cannot retire their mortgages with sales at market prices, nor can they tide themselves over with cash-out refinances. Thus, after a sustained decline in housing prices that eliminates home equity, adverse life events often lead to foreclosures.[6]

In light of the theoretical link between prices and foreclosure, it is important to obtain an estimate of Massachusetts housing prices. Moreover, this estimate should encompass homes typically purchased with subprime mortgages and should not be contaminated by changes in the mix of houses being sold. Repeat-sales indexes, originally suggested by Case and Shiller (1987), attempt to solve problems engendered by a changing sales mix by aggregating price changes on individual homes between sales.[7] The Office of Federal Housing Enterprise Oversight (OFHEO) uses the repeat-sales method when constructing its price index for Massachusetts, but this index may not accurately reflect price trends among subprime homes. Purchases that contribute to the OFHEO index must conform to securitization limits set by the government-sponsored housing enterprises, Fannie Mae and Freddie Mac. Because agency-conforming mortgages are generally prime mortgages, the use of a broader price index is important when studying subprime lending.

[4] Multi-family dwellings, meaning properties containing between two and four separate units, accounted for 23.0% of the total housing units in Massachusetts as of 2000 (U.S. Census Bureau, 2005). This percentage is the second highest in the nation (followed only by Rhode Island's 25.2%) and far exceeds the national average of 9.1%. The iconic multi-family dwelling in Massachusetts is the "triple-decker," which consists of three units, one of which is typically occupied by the owner while the other two are rented out.

[5] Like the speculative condominiums of the early 1990s, purchases of multi-family dwellings in the early 2000s often had an "investment" quality to them, because multi-family purchasers sometimes qualified for purchase mortgages based on the rents they hoped to receive, even if the new owners planned to live in one of the units themselves. This strategy can turn out poorly if rental income is more volatile than the new owners had hoped.

[6] This line of thinking is akin to the "double trigger" theory of foreclosure, which holds that foreclosures occur when an owner has negative equity and suffers an adverse life event. We argue elsewhere (Foote et al., 2008) that while the double-trigger explanation essentially gets the facts right, it can be made more theoretically robust by recognizing the roles that credit-constraints and heterogeneity in time-discount rates play in explaining foreclosures at the individual level.

[7] A drawback to our repeat sales measure is that it is impossible to know which houses have undergone major renovations in the Warren Group data, and which therefore should be excluded from the repeat sales calculations. We excluded any home that had risen in value by more than 50% for repeat sales within 1 year, and by more than 100% for repeat sales within 3 years, figuring that such a large price increase could only be explained by a renovation. In practice, the precise cutoff that we used to exclude renovations made little difference to our final results. See Appendix A of Gerardi et al. (2007) for details.

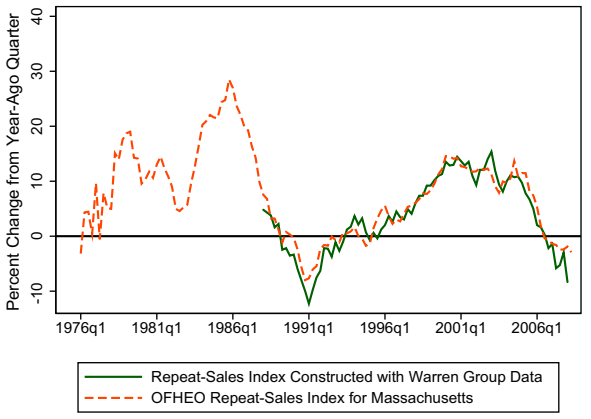

Fig. 2. Statewide repeat-sales index constructed with Warren Group data and OFHEO price index for Massachusetts.

Fortunately, the Warren Group data allow us to match individual homes across sales, so we are able to construct a repeat-sales index that uses all properties in the state. Fig. 2 graphs our repeat-sales price index along with the OFHEO index for Massachusetts. Gratifyingly, the two indexes are in close agreement during periods of overlap. Additionally, as is implied by theory, both indexes imply that periods of high foreclosures (as shown in Fig. 1) are also periods of low or negative price appreciation. Our index, however, shows larger price declines during the two housing downturns of the past two decades. This pattern suggests that homes financed with non-conforming mortgages suffered larger price declines during these downturns.[8] More to the point of this paper, the pattern suggests that subprime properties were not spared the decline in housing prices during the past few years; if anything, these declines were more severe. Thus, the link between negative equity and foreclosure discussed above should also be applicable to the subprime market.

2.1.3. "Ownership experiences" and LTV ratios

In addition to matching individual homes across sales, we are also able to match individual mortgages for a single homeowner during the time he owned a specific house, a period that we term an *ownership experience*. By constructing ownership experiences, we can carry variables generated at the time of purchase through all of the periods that the owner lives in the home, even if he refinances out of the initial purchase mortgage. An example of such a variable is the homeowner's initial LTV ratio, which correlates with eventual foreclosure probabilities. Table 2 presents LTV ratios for the complete sample of Massachusetts ownership experiences, as well as for those ownerships that end in foreclosure. The first lesson from the table is that average purchase LTVs have risen over time, from 79% in 1990 to 84% in 2007. (The increase is even greater if one tracks median LTV rather than mean LTV.) A second takeaway from Table 2 is the well-known regularity that high-LTV ownership experiences are more likely to end in default. Average LTVs among defaulting ownership experiences are generally 8–12 percentage points higher than the LTV for the typical ownership experience.

Table 2
Initial loan-to-value ratios, by year of purchase.

	All ownerships			Ownerships that default		
	#	Mean	Median	#	Mean	Median
1990	44,545	0.79	0.80	2495	0.87	0.90
1991	45,436	0.80	0.80	1218	0.90	0.95
1992	53,807	0.81	0.80	913	0.91	0.95
1993	61,004	0.82	0.85	906	0.92	0.95
1994	66,568	0.83	0.88	931	0.92	0.95
1995	60,762	0.83	0.88	850	0.94	0.97
1996	69,718	0.83	0.88	831	0.94	0.98
1997	74,350	0.83	0.86	822	0.93	0.97
1998	85,947	0.83	0.85	715	0.92	0.95
1999	86,895	0.83	0.85	769	0.92	0.95
2000	78,045	0.82	0.85	776	0.92	0.95
2001	77,645	0.82	0.87	696	0.92	0.95
2002	81,337	0.82	0.85	822	0.92	0.95
2003	86,966	0.82	0.85	1072	0.92	0.95
2004	95,890	0.82	0.87	1875	0.94	0.98
2005	94,539	0.83	0.90	2291	0.95	1.00
2006	79,142	0.84	0.90	1291	0.96	1.00
2007	67,127	0.84	0.90	59	0.94	1.00

The ability to construct complete ownership experiences makes the Warren Group dataset uniquely valuable for housing research. However, the dataset does have some important shortcomings. The most significant is a lack of information on interest rates. Massachusetts law does not require interest rates on fixed-rate loans to be recorded at deed registries. For ARMs, interest rates are included in special riders to the main transaction records, but the Warren Group has not yet transcribed this information electronically (with some exceptions discussed below). Another disadvantage of the Warren Group dataset is that it does not tell us when any particular mortgage is paid off, or *discharged*. The lack of discharge information prevents us from calculating the amount of cash-out refinancing at various points.[9] Finally, the Warren Group dataset does not include any demographic information about borrowers, such as income, race, or previous credit history.

2.2. LoanPerformance (LP) data

Most of our information on interest rates and other detailed mortgage characteristics comes from the First-

[8] We also compared our index to the S&P/Case–Shiller price index for Boston. This index includes homes purchased with both conforming and non-conforming mortgages, but only for the Boston area. The S&P/Case–Shiller price index also showed larger price declines during the housing downturns of the early 1990s and the mid-to-late 2000s.

[9] Obviously, if a new mortgage is used to pay off an old one, then the amount of cash left over for the homeowner will be much smaller than if the old mortgage remains on the books. Therefore, calculating the amount of equity taken out of the house with any degree of accuracy requires us to know when and if a particular mortgage is discharged. Discharges are officially registered at Massachusetts deeds offices and we are currently looking into ways of adding them to the Warren Group data. An obvious case where discharges can be inferred with the data we do have is when a house is sold, in which case all outstanding mortgages are discharged.

American LoanPerformance company (LP). This firm collects information on individual loans that have been packaged into non-agency, mortgage-backed securities (MBS) and sold to investors in the secondary mortgage market. We refer to two separate LP datasets in our research. The first is a loan-level dataset that the Boston Fed purchased from LP in mid-2007. This dataset covers Massachusetts, Connecticut, and Rhode Island from 1992 through August 2007.[10] Elsewhere in this paper, we will refer to summary statistics generated by a nationwide LP dataset that was purchased by the Board of Governors of the Federal Reserve System in Washington, D.C., and used by research economists there.

The major strength of the LP dataset is its extensive loan-level information on interest rates and other lending terms. It also contains information regarding the type of MBS each loan was packaged into—subprime, Alt-A, or prime.[11] In addition, the LP dataset also includes information on borrowers. For approximately 97% of the loans in our sample we know the borrower's FICO score.[12] For 60% of the loans we know the DTI ratio, figured as the borrower's monthly debt payment divided by his monthly income,[13] while for virtually every loan in our sample we know the combined LTV ratio implied by the size of the loan and the value of the house.[14] A major shortcoming of the LP dataset is the inability to create complete ownership experiences by matching loans made to the same borrower on the same house. Also, the LP dataset has only limited information on borrowers. Like the Warren Group dataset, the LP dataset does not include demographic information such as race, education, or gender.

2.3. Defining the subprime market

A paper discussing facts about the subprime market obviously needs a definition of "subprime" lending, but there is no single way to define the subprime market. One description could be based on the characteristics of *borrowers*. A subprime borrower could be someone who has missed a mortgage payment during the past year or two, who has filed for bankruptcy in the past few years, or who has a low FICO score for other reasons. However, as we will see, many borrowers with good credit scores also made use of the subprime market, especially at the height of the housing boom. Alternatively, a subprime definition could be based on *lenders*. Many lenders typically, but not exclusively, originated loans to subprime borrowers, generally with high fees and interest rates. Yet these same lenders also made loans to prime borrowers.[15] Finally, we can construct a subprime designation using information on characteristics of the *loans*. For example, we could define a subprime loan to be a mortgage that was packaged into a subprime MBS.

The availability of different information in our two main datasets leads to different definitions of the subprime market. The Warren Group dataset does not contain mortgage interest rates or credit scores, so we use the identity of the lender to characterize individual mortgages as subprime or prime. Our list of subprime lenders comes from the Department of Housing and Urban Development (HUD), which has maintained a list of predominantly subprime lenders since 1993. HUD bases this list on characteristics of lenders' business models that are generally associated with subprime lending.[16] By standardizing this list across years and matching it to the lender variable in the Warren Group dataset, we can designate loans in this dataset as subprime or prime. A drawback of this approach is that subprime lenders sometimes make prime loans. To get a sense of the misclassification that the use of the HUD list is likely to generate, we checked our subprime classification against interest rates in a small subsample of ARMs that the Warren Group had recorded electronically. The results were encouraging. Of the mortgages in the Warren Group data that were identified as subprime from the HUD list, and for which interest rate information is available, approximately 93% had an initial rate of at least 200 basis points above an equivalent prime mortgage rate, *or* had an associated margin of at least 350 basis points above the typical benchmark interest rate used for determining subprime rates.[17]

Table 3 presents the total share of subprime mortgages in the Warren Group data using the HUD-list definition. The table suggests that the subprime share in Massachusetts is comparable to, though somewhat lower than, the subprime

[10] To be specific, 1992 was the first year in which a pool of securitized mortgages was included in the LoanPerformance dataset. However, the mortgage pools sometimes include mortgages that were originated well before the securitization process was initiated. Thus, there are mortgages in the dataset that were originated before 1992, but because of sample selection issues, we do not use any information from those mortgages.

[11] The Alt-A classification is for loans whose riskiness falls between that of the subprime and prime classifications. Because the LP data cover only non-agency securities, the prime loans included in the LP data are typically *jumbo* loans. Jumbo loans exceed the federally mandated limit for securitization by Freddie Mac or Fannie Mae.

[12] FICO is the acronym for Fair Isaac & Co., which developed a widely used score designed to evaluate creditworthiness. The dividing line that typically places a borrower in the subprime class is a FICO score of 620 or lower.

[13] This calculation includes the amount of the monthly mortgage payment, as well as other types of debt, such as credit card debt, car loans, education loans, and medical loans. In the housing-finance literature, this debt-to-income ratio is typically referred to as the "back-end" debt-to-income ratio. The "front-end" ratio involves only the home mortgage debt itself.

[14] The LTV ratio in the LP data includes second mortgages, but (unlike the Warren Group dataset) LP does not include home equity loans or home equity lines of credit. For purchases, the value of the house is assumed to be the purchase price, while for refinances, the appraised value of the house is used.

[15] An example of such a firm is Countrywide.

[16] Specifically, a lender makes the HUD list if most of its business is in refinance rather than purchase loans, and if the lender does not sell a significant portion of its portfolio to the two government-sponsored housing agencies (Fannie Mae and Freddie Mac). Recently HUD has checked its subprime list against the designation of "high-cost" loans in a dataset generated by the Home Mortgage Disclosure Act, which began tracking high-cost loans in 2004. This exercise has found that the HUD lender list is in general agreement with the HMDA high-cost variable. The HUD list and supporting documentation is available at http://www.huduser.org/datasets/manu.html.

[17] More extensive robustness checks for the subprime classification in the Warren Group dataset are found in Appendix B of Gerardi et al. (2007). A "margin" on a subprime adjustable-rate mortgage is the constant difference between a benchmark interest rate (typically 6-month LIBOR) and the "fully indexed" interest rate, which obtains when the subprime ARM is reset. We discuss the institutional details involved in the pricing of subprime adjustable-rate mortgages more extensively below.

Table 3
Subprime shares (in percent) for Massachusetts mortgages by origination year.

	1999	2000	2001	2002	2003	2004	2005	2006	2007
All mortgages	4.4	5.7	4.4	4.4	5.3	9.2	11.7	10.3	3.6
Purchase mortgages	2.5	2.5	3.0	4.0	7.0	10.1	14.8	13.1	3.1
By house type									
Single-family purchase	2.3	2.3	2.6	3.5	5.9	8.6	13.2	11.4	2.6
Condominium purchase	2.2	2.1	2.2	2.5	4.3	6.0	10.7	10.7	3.4
Multi-family purchase	4.2	4.6	6.4	9.4	18.0	26.4	32.6	28.6	5.8

share for the nation as a whole. Mayer and Pence (2008) construct a series of subprime shares using the HUD list and nationwide data collected as part of the Home Mortgage Disclosure Act (HMDA) for 1998–2005. They find that the subprime share of all originations fluctuates between about 8% and 12% from 1998 through 2003.[18] In 2004 and 2005, the national subprime share rises sharply, reaching about 18% in those 2 years. Table 3 shows that this general pattern is also found in the Massachusetts data, though our series is about 5–7 percentage points lower than the national data. For national purchase mortgages, Mayer and Pence find a similar time-series pattern, with this share rising in 2004 and 2005 to about 15% and 18%, respectively. Our data also show a purchase-share peak in these years, though again the Massachusetts data are a few percentage points lower. The lower rows of Table 3 disaggregate the subprime share of purchase mortgages in the Warren Group data for each of the three types of residences. The table shows that subprime purchases were especially popular among multi-family homes at the height of the housing boom, with the subprime fraction of multi-family purchases reaching 32.6% in 2005. This high share is not surprising, because multi-family homes are typically located in low-to-moderate income areas and are often more costly (taking all housing units together) than the purchase of just one housing unit in a single-family home.[19] The bottom line of this analysis is that subprime lending is likely to be somewhat less important in Massachusetts than for the nation as a whole, while the particular pattern of subprime lending is affected to some extent by the prevalence of multi-family homes in the state. But the time-series pattern of subprime lending in Massachusetts is qualitatively similar to that for the entire country.

In the LP data, creating the subprime loan designation is conceptually easier. Subprime mortgages are those that were securitized into a subprime MBS (as opposed to prime or Alt-A). No restriction is made on the FICO score of the borrower. Also note that, unlike the Warren Group dataset, the subprime definition is not based on the originator of the mortgage, but rather the type of security into which the mortgage was grouped in the secondary market.

Fig. 3 illustrates the evolution of borrower and loan characteristics among subprime loans in the LP dataset. Because much of the discussion below will focus on differences between subprime ARMs and FRMs, we present data for these two types of loans separately. Panel A shows that average FICO scores generally improved over the sample period; we will have more to say on this topic below. Panel B shows that LTV ratios were generally rising during the housing boom, especially for ARMs. By 2006, the average LTV ratio for subprime ARMs was in excess of 90%, with the average LTV for FRMs very close to that level. Panel C shows that DTI ratios were in excess of 40% for both types of loans by the end of the sample period. Finally, the last panel shows that the fraction of fully documented loans declined for both types of loans after 2000, though this decline was more consistent among ARMs than FRMs. All in all, most of the risk characteristics of subprime loans deteriorated over the sample period, with the notable exception of FICO scores.

2.4. Quantifying subprime defaults

We next turn to the quantitative importance of subprime defaults, using the universe of Massachusetts mortgages in the Warren Group data. The first column of Table 4 shows the percentage of defaulted mortgages from 2006–2007 that were originated by subprime lenders. This fraction ranges from more than half for multi-family homes to slightly more than 40% for single-families and condos. Across all types of homes, the fraction is 45.2%, a number that is close to, but somewhat lower than, subprime fractions found in nationwide studies. For example, Nothaft (2008) found that around 52–56 percentage of defaulted mortgages during this period were subprime. The discrepancy of approximately 10 percentage points may reflect differences in the Massachusetts housing market relative to the rest of the country, or differences in the way that the two studies define subprime mortgages. Because the Warren Group data allows us to link mortgages within the same ownership experiences, we can also ask how many foreclosed homes were originally purchased with subprime mortgages. These fractions, reported in the second column of the table, range from a low of about one quarter for single-family homes to a high of 43% for multi-families. The overall share, across all three types of homes, is 30%.

One implication of Table 4 is that many prime purchasers refinanced into subprime loans before defaulting. This is seen by noting that the subprime share of defaulted mortgages in the first column is larger than the subprime shares among purchase mortgages of foreclosed homes in the second column. The last section of the paper investigates this type of refinancing activity in detail. A second takeaway from Table 4 is that subprime purchases default

[18] The Mayer and Pence data quoted in this paragraph come from their Fig. 1b found on page 22.

[19] For a borrower with a small downpayment, the purchase of an expensive multi-family property would require a mortgage with a high-LTV ratio. As we will discuss, such a mortgage may have been unattractive to prime lenders.

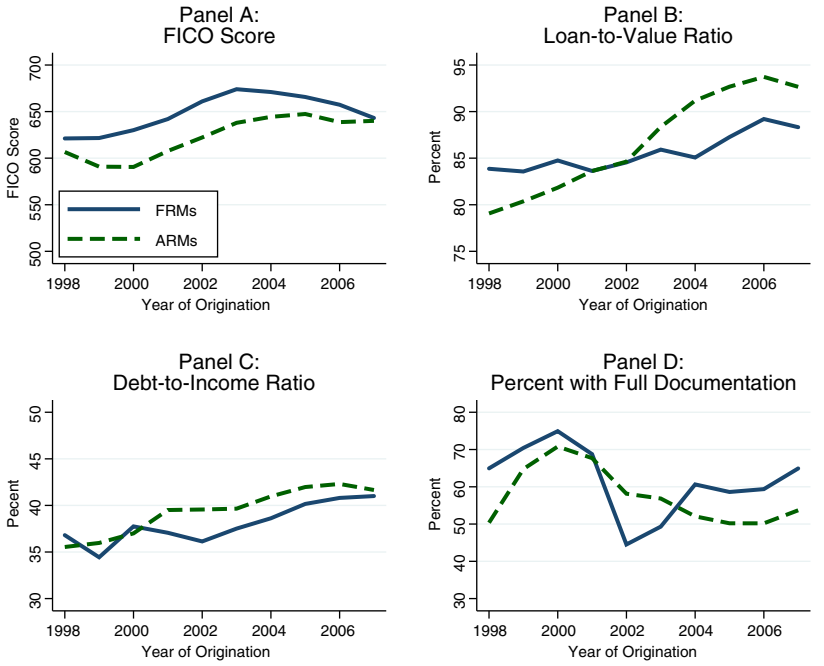

Fig. 3. Characteristics of subprime ARMs and FRMs.

more often than prime purchases. Although the share of subprime purchase mortgages peaked at slightly less than 15% (Table 3), about 30% of recently foreclosed homes were purchased with subprime mortgages (Table 4).

Fig. 4 explores foreclosure propensities of various homes in detail, by presenting cumulative default hazards disaggregated by subprime-purchase status, type of house and purchase year.[20] A comparison of the two rows in the figure reveals that subprime purchases are more likely to default, no matter what the type of house or purchase-year cohort. (Note the different vertical scales across the two rows.) For prime single-families and condos purchased in 2005–2006, the cumulative default hazard reached about 1.3% at the end of 2007. For the same types of homes purchased with subprime mortgages, the corresponding hazard was 11.9%. A large discrepancy in foreclosure rates also exists for multi-family homes. The cumulative hazard for multi-families purchased with subprime mortgages in 2005–2006 reached nearly 25% by the end of 2007. The corresponding hazard for prime multi-families was about 8%.

The next two sections of the paper evaluate some potential explanations for high subprime default probabilities related to interest rates and underwriting standards. But at this point, it is useful to point out that Fig. 4 is consistent with the theoretical link between falling prices and foreclosures discussed earlier.[21] The figure shows that homes purchased late in the housing boom are more likely to default than homes purchased earlier, and that this pattern is true for both prime and subprime purchases. One explanation for this pattern is that homes purchased early in the boom are more likely to have amassed positive equity before house prices fell, whether or not they were purchased with prime or subprime loans. Of course, the fact that falling prices played a role in defaults does not mean that other potential factors were unimportant for subprime loans. In the next section, we investigate the role of one such factor: interest-rate resets on subprime hybrid ARMs.

3. The role of subprime ARMs and interest-rate resets

Many of the policy proposals that were initially advanced to address the housing crisis involved interest-rate resets among subprime hybrid ARMs.[22] This section

[20] A cumulative default hazard is a measure of how many foreclosures are likely to have occurred among a group of homes purchased in some year, as a function of how much time has elapsed since the purchases took place. The cumulative default hazard takes into account the fact that some homeownerships are "right-censored" with respect to foreclosure. That is, in every period, some homeownerships end in a sale rather than foreclosure, and therefore drop out of the pool of potential foreclosures for the next period. As a result, a cumulative default hazard is not strictly the probability that a given house purchased in some period will be foreclosed some time later.

[21] Gerardi et al. (2007) estimate a formal duration model of default using the Warren Group data. The explanatory variables in their model include LTV ratio at purchase, type of residence, cumulative price appreciation since purchase, and subprime-purchase status. The paper finds a strong (negative) role for cumulative appreciation in defaults for both prime and subprime purchases. Consistent with Fig. 4, the paper also shows that subprime purchases are about six times more likely to default than prime purchases, all else equal.

[22] In December 2007, the White House announced the voluntary Hope Now initiative, in which lenders agreed to suspend interest-rate resets for 5 years for borrowers who could afford their mortgages only at their initial interest rates. Resets are also a component of the government's new *FHASecure* program, announced in August 2007. This program initially allowed borrowers who were delinquent on their mortgages to qualify for new FHA loans, but only if these delinquencies resulted from previous interest-rate resets. In April 2008, the program was extended to borrowers who had missed a limited number of payments either before or after their resets.

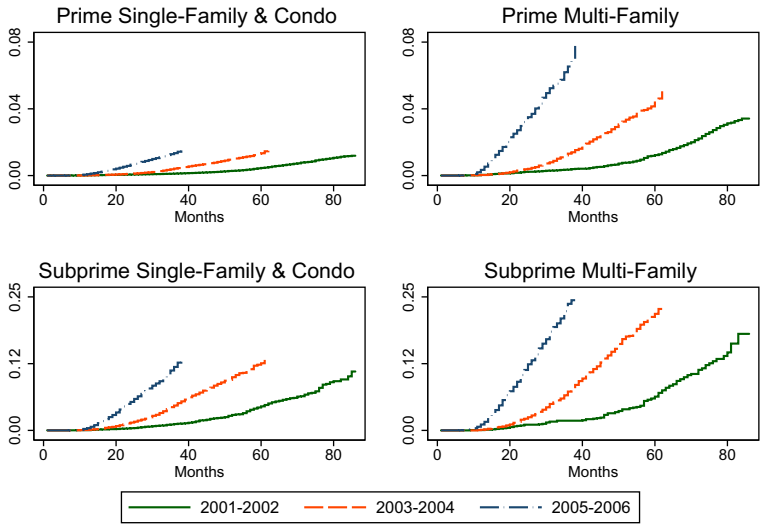

Fig. 4. Cumulative default hazards for Massachusetts homes purchased from 2001 to 2006, by type of residence and subprime-purchase status.

Table 4
Subprime shares among defaulted ownership experiences and mortgages, 2006–2007.

	Subprime fraction of defaulted mortgages	Fraction of defaulted ownerships purchased with subprime mortgages
Single-family	42.2%	24.3%
Condominium	40.1%	27.3%
Multi-family	53.3%	43.0%
All	45.2%	30.0%

Table 5
Interest rates for subprime 2/28 mortgages, by year of origination.

Year of origination	Initial (pre-reset) interest rate	1-year prime ARM rate	Margin of fully indexed (post-reset) rate over benchmark rate	Fully indexed interest rate
2004	7.3	3.9	6.1	11.5
2005	7.5	4.5	5.9	10.5
2006	8.5	5.5	6.1	9.1
2007	8.6	5.7	6.1	9.1

Note: The 2006 and 2007 cohorts of mortgages reset in 2008 and 2009. For these mortgages, the 6-month LIBOR 2 years after origination is assumed to be 3.0% (the April 2008 value) to allow comparison with other cohorts.

describes the general lending model that gave rise to the hybrid ARM. We then assess the link between the timing of interest-rate resets on these mortgages and defaults. We conclude with a comparison of the sensitivity of ARMs and FRMs to declines in housing prices and a puzzle related to how these mortgages were priced.

3.1. The subprime business model

Proponents of the centrality of resets in the current crisis based their view on the following logic. Subprime hybrid ARMs offered borrowers extremely low "teaser" rates for some initial period (usually 2 or 3 years) but then these mortgages "exploded" to high rates thereafter. Lenders found such loans attractive because of the high post-reset interest rates. Borrowers found them attractive because of the teaser, but later regretted their decisions when they found themselves paying high post-reset interest rates. Is this an accurate description of the subprime lending model? No.

First, there was never something like a low "teaser" rate on the typical subprime ARM. Table 5 presents summary statistics from the Board of Governors's LP dataset on "2/28" mortgages originated from 2004 to 2007. This type of 30-year mortgage is by far the most common type of subprime ARM. The "2" in the 2/28 designation indicates that the interest rate is fixed for the loan's first 2 years. For the remaining 28 years, the interest rate adjusts every 6 months until the mortgage is paid off. Almost all 2/28s were fully amortized, meaning that the borrower repays some of the principal with every monthly payment. Table 5 shows that the initial interest rate for subprime 2/28s ranged from 7.3% in 2004 to 8.6% in 2007. These initial rates are not low; on the contrary, they are quite high. As the table shows, 2/28 borrowers paid rates that were about three full percentage points higher than rates on the closest prime equivalent, a 1-year prime ARM. In short, subprime lenders did not need to wait until the resets occurred in order to profit from these loans.

Second, the interest-rate adjustments at reset, while not trivial, were not explosive. The "fully indexed" rate on a subprime 2/28 mortgage—the rate paid after the initial interest rate expired—typically equaled a benchmark rate plus a fixed margin. Most often, the benchmark interest rate was the 6-month London Interbank Offered Rate (LIBOR), and the margin was about 6 percentage points. Table 5 illustrates the calculation, showing both the average margin and the average fully indexed rates. When the 2004 cohort of mortgages reset in 2006, the 6-month LIBOR was slightly higher than 5%, so a margin of a little more than 6% points generated fully indexed rates that

averaged about 11.5%. Similar numbers hold for the 2005 loans, which reset in 2007.

A comparison of the first and last columns of Table 5 shows that the fully indexed interest rates were about 3–4 percentage points higher than initial rates for mortgages originated in 2004 and 2005. This would lead to a monthly payment increase, or "payment shock," of about 25%. While sizable, this payment shock is small compared to, say, payment shocks in the credit card market, where interest rates can easily increase by a factor of five when teaser rates expire. In addition, a simple comparison of pre- and post-reset interest rates on 2/28 mortgages typically overstates the payment shocks experienced by people who bought homes with subprime mortgages. During the height of the housing boom, many subprime purchasers also used second mortgages ("piggybacks") when they bought their homes, because they did not make downpayments of at least 20%. These second mortgages had high interest rates and short amortization schedules, so they accounted for a disproportionate share of a borrower's monthly house payment. Moreover, these mortgages were almost always fixed-rate loans, so they were not affected when the interest rate adjusted on the main subprime loan. The presence of second mortgages therefore limited the percentage increase in a borrower's house payment that was caused by the interest-rate reset of the main 2/28 mortgage. Specifically, a reset on a 2/28 mortgage only affected about 60% of the typical borrower's monthly payment.[23]

Finally, subprime lenders anticipated that most borrowers would refinance their mortgages before or shortly after their interest-rate resets. Table 6 presents data on the disposition of subprime 2/28s in the Boston Fed's LP dataset.[24] For the years 2001–2005, the disposition is measured as of 27 months after origination, which is 3 months past the reset date. The first row shows that only 22.3% of subprime 2/28s originated in 2001 were still active 3 months after the reset. About two-thirds of the original 2001 pool (66%) had already been refinanced, with the remainder either in foreclosure or seriously delinquent. The refinanced shares for the 2002 and 2003 mortgages are even higher, 74.1% and 74.6%, respectively. Clearly, most subprime borrowers did not spend much time paying on mortgages that had reached their reset dates. Lenders would have understood this and would not have relied on high post-reset payments to construct a profitable business model.

[23] Consider a borrower with a $100,000 30-year first mortgage with an initial rate of 8.5% and a $25,000 10-year second mortgage with a contract rate of 12%. The initial payment on the first mortgage is $776 and on the second is $358, making the pre-reset payment $1134 a month. At reset, assume that the rate on the first mortgage jumps to 11%, so the payment on the first mortgage jumps by 22%, to $952. Because the payment on the second lien stays the same (at $358), the overall payment only rises to $1,310, or 15%.

[24] Recall that this is a loan-level dataset covering Massachusetts, Rhode Island, and Connecticut.

Table 6
Disposition of subprime 2/28 mortgages in the Boston Fed's LP dataset.

Year of origination	Percent active	Percent refinanced	Percent foreclosed	Percent 60–90 days delinquent	Total
	As of 27 months after origination				
2001	22.3	66.0	8.4	3.3	100
2002	15.8	74.1	6.5	3.6	100
2003	15.5	74.6	6.2	3.7	100
2004	17.9	68.0	10.5	3.7	100
2005	23.4	53.5	20.2	3.0	100
	As of March 2008				
2006	42.4	27.1	28.3	2.2	100
2007	65.5	12.3	21.5	0.7	100

3.2. Subprime foreclosures and the timing of interest-rate resets

As we move down the rows in Table 6 the increase in foreclosures among later vintages of mortgages becomes apparent. Data for the 2006 and 2007 2/28s reflects their status as of March 2008, not after 27 months, because mortgages made in these years have generally not been in existence for a full 27 months. Even with this shorter horizon, however, foreclosure rates for the 2006 and 2007 mortgages are much higher than those of other years. Fully 28.3% of 2/28s originated in 2006 are in foreclosure. The 2007 vintage is not far behind at 21.5%.

A closer look at the data shows little or no relationship subprime defaults and reset dates. Fig. 5 displays monthly default probabilities for three yearly vintages of subprime 2/28s, again from the Boston Fed's LP dataset. Default probabilities typically rise rapidly until the loans are about 12 months old, then decline gradually thereafter. If mortgage resets were a direct cause of foreclosure—or at least an important precipitating factor—then we would expect to see spikes in default rates at or shortly after 24 months. Yet for the two vintages originated more than two years ago (2002 and 2005), no such spikes appear. Indeed, if a vertical line were not placed on the figure at 24 months, it would be difficult to notice anything special about this

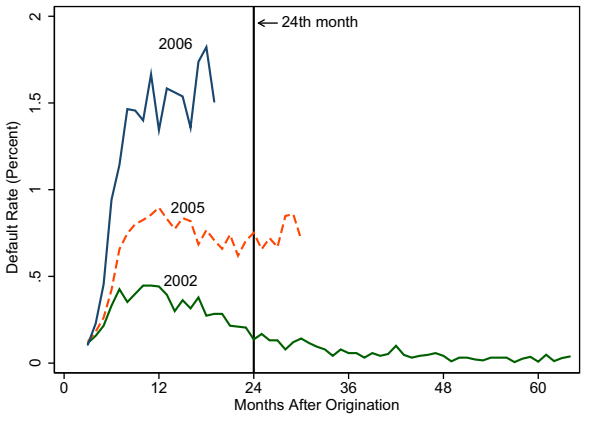

Fig. 5. Default probabilities for subprime 2/28 ARMs, by year of origination.

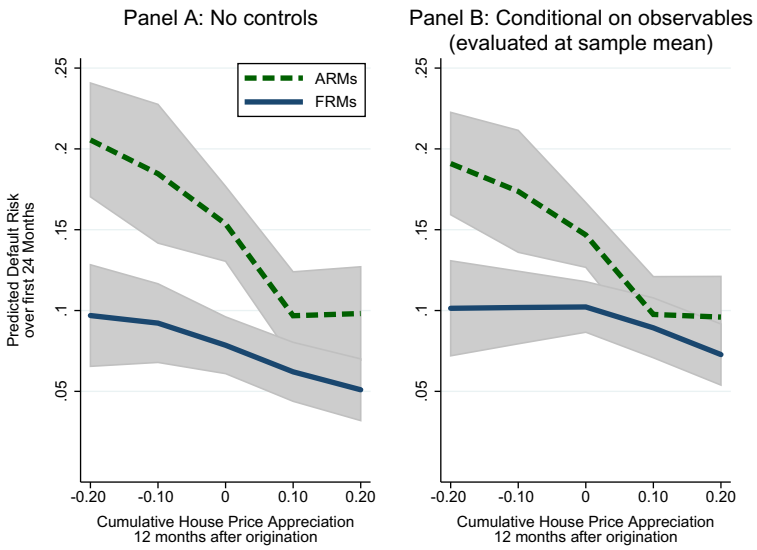

Fig. 6. Subprime foreclosures and cumulative house price changes: ARMs vs. FRMs.

month. The most salient feature of Fig. 5 is the large increase in default probabilities for the later vintages that took place *before* the reset occurred. For the 2006 vintage, default probabilities are about four times higher than the 2002 cohort, even though the 2006 loans had not yet reset at the time that the figure was created. The increase in defaults for the 2005 cohort is also substantial in its pre-reset period.

3.3. The effect of falling prices on subprime ARMs and FRMs

The previous results suggest that the timing of resets has little or no relationship to the timing of defaults. But this finding does not rule out the possibility that characteristics of subprime ARMs made them more likely to default. In particular, the data show that defaults among subprime ARMs were more sensitive to declines in housing prices than were defaults on subprime FRMs.

Using the Boston Fed's LP dataset, Fig. 6 graphs the estimated 24-month foreclosure probability of adjustable-rate and fixed-rate subprime mortgages, as a function of cumulative price appreciation during the first 12 months of the loan. In Panel A, no controls are included for risk characteristics of individual borrowers. By contrast, Panel B controls for FICO scores, LTVs, the presence of second mortgages, and documentation status. In both panels, the gray bars are standard-error bands. The figure shows that when house prices grow rapidly (at more than 10% per year), there is no significant difference in foreclosure rates between FRMs and ARMs, with or without controls for borrower and loan characteristics.[25] However, as house price growth decelerates and falls below 10%, differences do emerge. Moving from right to left in both panels, average default rates on ARMs rise much more rapidly as prices fall than do the default rates on FRMs. Once house price growth becomes strongly negative, the standard error bands no longer overlap, suggesting a statistically significant difference in foreclosure propensities between the two types of loans. Note that controls for borrower and loan characteristics make some difference to the *average* gap between the two lines in each panel, suggesting that these characteristics do help predict the average level of foreclosures. However, the *differential sensitivity* of ARMs to falling prices is present with or without the controls.

There are number of reasons why subprime ARMs are more sensitive to falling prices. One is that ARM borrowers might have expected to refinance within the initial 2- or 3-year period of their mortgages. When house prices fell, these borrowers may have correctly surmised that their chances to refinance their loans had fallen. If these borrowers believed that they could not have afforded their fully indexed interest rates, then they may have simply defaulted well in advance of their reset dates. (Fixed-rate mortgages, by contrast, offer more flexibility in refinancing due to the lack of a specific reset date.) If this theory is correct, it implies that a specific feature of ARM contracts made these mortgages more sensitive to falling prices. But the differential sensitivities in Fig. 6 could also result from differences in borrowers likely to choose ARMs over FRMs. ARM borrowers may have had higher expectations for future price appreciation than FRM borrowers. Alternatively, ARM borrowers may have also been less "financially literate," with the implication that these borrowers were more likely to run into liquidity problems during periods of declining house prices than FRM borrowers.

3.4. A related puzzle on the pricing subprime of ARMs and FRMs

A related issue concerns how subprime ARMs and FRMs were priced in the market. We would expect the initial interest rate for a hybrid ARM to be much lower than the interest rate on an FRM, because the ARM borrower is taking on

[25] The standard error bars overlap, indicating that any difference may stem from statistical uncertainty surrounding the estimates.

Table 7
Initial interest rate differentials between fixed-rate and adjustable-rate subprime mortgages: 1998–2007.

	Interest rate differential: FRM rate less initial ARM rate
(1) Raw difference	−0.086 (0.042)
(2) Controlling for borrower's FICO score	0.141 (0.033)
(3) Controlling for borrower's FICO score, presence of second mortgage, documentation status, and LTVs on first and second mortgages	0.199 (0.038)
(4) Controls as in previous row, using 2005–2007 data only	0.163 (0.015)

Notes: Estimates are generated by ordinary least squares (OLS) regressions of initial subprime interest rates on a dummy that equals 1 if the loan is a fixed-rate loan (and other controls as noted). All regressions include quarterly dummies. FICO score controls in rows 2–4 are piece-wise linear controls. Standard errors are in parentheses. Rows 1–3 cluster the standard errors by quarter. Row 4 does not, because of the small number of quarters available.

interest-rate risk. In the data, however, initial rates on ARMs and FRMs are strikingly close. Table 7 presents interest-rate differentials on FRMs versus ARMs from regressions run on 1998–2007 data from the Boston Fed's LP dataset.[26] Row 1 shows that the typical interest rate on a fixed-rate loan appears *lower* than the typical initial ARM rate when we perform a simple comparison of raw averages. This difference may not be the true cost of using a fixed-rate product, however, given the systematic differences between borrowers that choose ARMs and those that choose FRMs. As we have seen, fixed-rate borrowers tend to have better FICO scores and lower LTVs than ARM borrowers, and they are also more likely to fully document their mortgage applications.

These good characteristics partially explain why FRM borrowers enjoyed relatively low interest rates. Row (2) controls for differences in borrower credit histories by adding a flexible control for borrower FICO scores in the regression. The interest-rate differential turns positive and equals about 14 basis points. While this estimate is statistically significant, it is small in magnitude.[27] In row (3), we add some additional controls, but the difference remains quantitatively small. Finally, row (4) uses data from 2005–2007 only, but the regression again implies a small difference in interest rates of slightly more than 16 basis points.

This small differential is difficult to explain. One possible interpretation is that ARM borrowers do not bother to demand a risk premium because they expect to refinance before their resets hit. Alternatively, ARM borrowers could be more likely to fold their closing costs into their mortgages, paying these costs with higher interest rates. If so, then the resulting increase in the ARM interest rate could mask a true rate differential between FRMs and ARMs that actual borrowers face in the market. Finally, financial literacy may also play a role. If ARM borrowers are unable to quantify the degree of interest-rate risk they take on with an adjustable-rate product, then these borrowers may not demand to be compensated for this risk with lower initial interest rates. Unfortunately, our data do not allow us to test these hypotheses directly, nor do they allow tests of theories to explain the differential default sensitivities shown earlier in Fig. 6. We therefore leave these questions for future research.

[26] The data for the table come from subprime first-lien mortgages used for home purchases only.

[27] A difference of 14 basis points is only 14 one-hundredths of a percentage point, so this implies an adjustable-rate mortgage with an 8% interest rate could be replaced with a fixed-rate mortgage with an 8.14% interest rate.

4. The role of subprime underwriting standards

Differences in underwriting standards and in corresponding risk characteristics will obviously affect the performance of different types of mortgages. In popular accounts, the most-often mentioned risk characteristic of a subprime loan is the credit history of the borrower. While subprime lending originated as a way to serve borrowers with tarnished credit histories, the mature subprime mortgage market cannot be characterized along the single dimension of borrower credit quality. Subprime loans were riskier than prime loans for other reasons as well. In this section, we discuss how underwriting standards for subprime loans changed as the housing boom matured. We then explain how changing risk characteristics made subprime loans highly sensitive to declines in housing prices.

4.1. Explaining rising FICO scores among subprime borrowers

Fig. 7 investigates risk characteristics for all types of subprime borrowers (grouping ARMs and FRMs together), illustrating how the characteristics of different types of subprime borrowers changed over time. To set the stage, we can simply note that the average FICO score of subprime borrowers was rising. This fact is reflected in Panel A of Fig. 7; the higher line in this panel is the fraction of subprime borrowers that had a FICO score of 620 or higher. This fraction rises from slightly less than 40% in 1999 to around 70% by 2004. Increases in the fraction of high-FICO borrowers in subprime pools have also been found in other nationwide datasets (Gerardi et al., forthcoming; Brooks and Simon, 2007). These increases suggest that the quality of the subprime pool was actually getting better over time.

We saw in Fig. 3, however, that other risk characteristics of subprime loans deteriorated over the sample period, so that a plot of average credit scores presents an incomplete picture of the riskiness of subprime loans. The lower line in Panel A of Fig. 7 plots the fraction of subprime loans for which the borrower had a credit score of 620 or higher, the DTI ratio on the loan was 40% or less, the LTV ratio was 90% or less, and full documentation of the application was provided. This fraction begins at about 13% in 1999 and falls to around 5% by 2006. In contrast to the graph of bor-

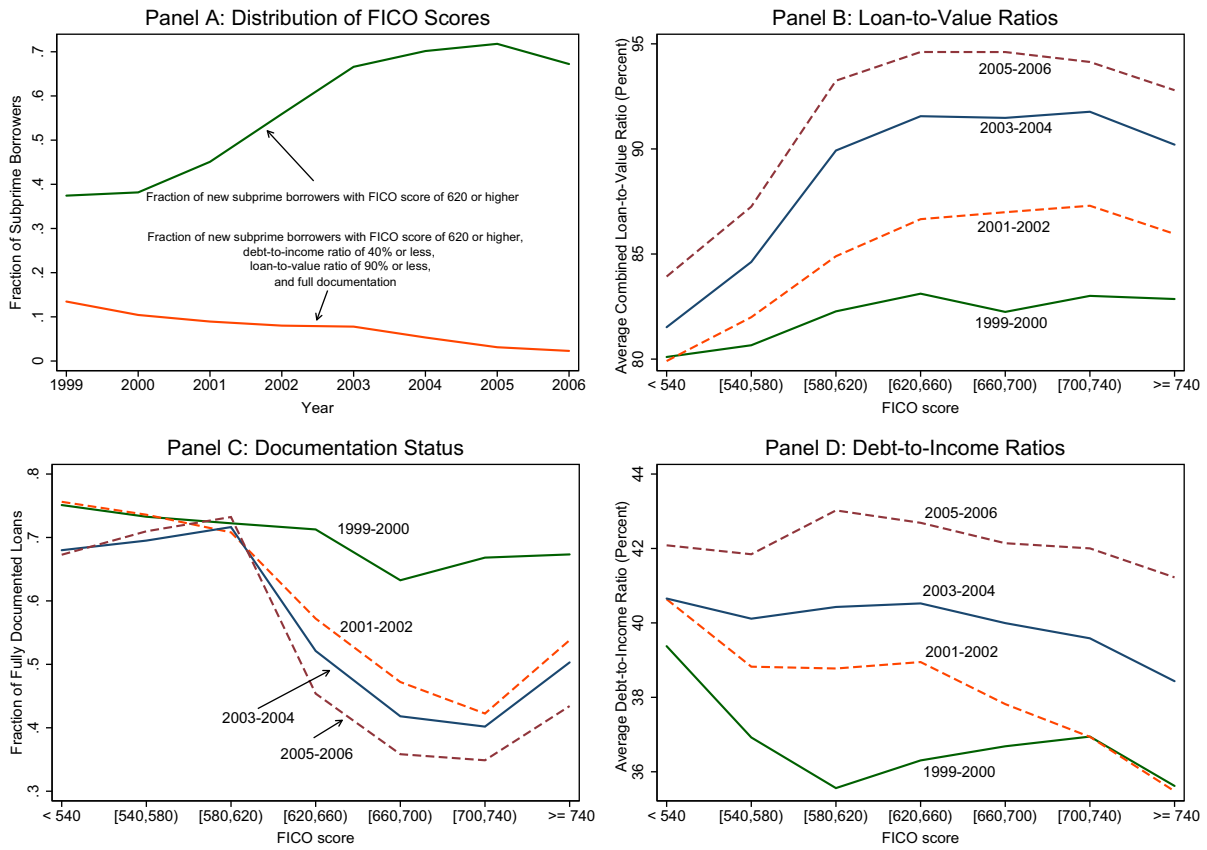

Fig. 7. Alternative measures of risk in the subprime pool. Figures are generated from all newly originated subprime mortgages in the Boston Fed's LP dataset, including both purchase and refinance loans.

rower credit scores, this more complete measure of subprime loan quality is getting worse over time.

The opposite movements of the two lines can be reconciled by asking why the share of high-FICO borrowers is rising over time. One reason typically offered for the presence of high-FICO borrowers in the subprime market is that they were inappropriately steered there by unscrupulous mortgage brokers in search of higher commissions. While this is a possibility, high-FICO borrowers will also show up in the subprime pool if they desire mortgages that are riskier than those offered by prime lenders.

Panel B of Fig. 7 illustrates this point by showing the evolution of average LTVs for different cohorts of subprime borrowers. The horizontal axis groups borrowers into seven categories based on their credit scores. Each line in the figure represents a 2-year cohort of subprime loans. For the earliest cohort (1999–2000), the average LTV is around 80% for borrowers in the lowest category, suggesting an average downpayment of 20%. The LTV is only slightly higher for borrowers in this cohort with the highest credit scores. As the years pass, however, the difference in LTVs across different FICO classes begins to grow. By 2005–2006, average LTVs for the lowest-score borrowers had risen to around 85%, but average LTVs for the highest-score borrowers had surged to near 95%.

A similar analysis for documentation status is shown in Panel C. In the earliest years of the sample, the fraction of fully documented loans made to the lowest-FICO borrowers was between 70 and 80%. The corresponding fraction for high-FICO borrowers was about the same. But in 2001, the fraction for high-FICO borrowers began to fall. By 2005–2006, the fraction of fully documented loans for high-FICO borrowers had declined all the way to 40%, even though the corresponding fraction for the low-FICO borrowers had changed only a little since the start of the sample period. Qualitatively, this pattern resembles that of the previous graph of LTVs; the riskiness of the entire subprime pool grew because of the behavior of the high-FICO borrowers.

Finally, Panel D displays the third indicator of loan risk, the DTI ratio. Early in the sample, DTIs for the lowest-FICO borrowers in the subprime pool were somewhat higher than those for the highest-FICO borrowers. The subsequent behavior of this characteristic is different than that of the previous two characteristics, in that DTIs deteriorated for borrowers of all FICO classes, not just the high-FICO borrowers. By the end of the housing boom, average DTIs for all borrowers exceeded 42%.

Taken together, the three risk characteristics—LTVs, documentation status, and DTIs—tell a consistent story. All of these indicators moved in the direction of greater

risk as the housing boom progressed and house prices moved higher. For LTVs and documentation status, most of this movement was caused by borrowers with high credit scores who were entering the subprime pool in larger numbers. In all likelihood, it would have been impossible for these borrowers to find prime lenders willing to make loans as risky as the subprime loans they eventually obtained. Prime lenders would have required larger downpayments, they would have insisted on lower DTI ratios, and they would have demanded better documentation of income and assets.

4.2. Implications

There are at least three important implications of these findings. First, from a policy perspective, they speak to the issue of whether some of the high-FICO borrowers were inappropriately steered into the subprime market. It is possible that little such coercion occurred. Mortgage brokers may have simply found subprime lenders that were willing to make the risky loans that high-FICO borrowers themselves had determined were appropriate, given the market prices of the homes that they wanted to buy. As prime borrowers would have frowned on these loans, the subprime market was the only option available. The evidence is not supportive of the view that borrowers were steered into the subprime market for loans they could have received more cheaply elsewhere. But it does not speak to the possibility that borrowers were steered into buying homes or borrowing amounts of money that required them to take subprime loans. In any case, the problem of "potentially prime" borrowers stuck in subprime loans is mitigated by the risk-based pricing models used by most subprime lenders. Using our LP data, we calculated the percentage of subprime loans for owner-occupied homes that had an LTV of 90% or below, that were fully documented, that had borrower FICO scores of 620 or higher, and had a DTI of 45% or less. About 9.6% of the subprime mortgages in the LP data met all of these criteria, so about 10% of the borrowers with outstanding subprime loans could have qualified for prime loans. We then asked whether these borrowers were paying the onerous terms typically associated with subprime loans. Of these borrowers, approximately 65% had fixed interest rates. Furthermore, the average initial interest rate for these loans was 6.7%, the median was 6.6%, and the 90th percentile rate was 7.9%. By contrast, only 29% of all subprime loans in the dataset were fixed-rate instruments, and the average interest rate calculated over all subprime loans was 7.7% (90th percentile was 9.4%). This calculation shows that the borrowers that can be identified as "potentially prime" already had much more favorable mortgage terms than the typical subprime borrower.

A second implication of our findings concerns claims by some commentators that the subprime crisis is proof that "some people should not own houses." Implicit in this view is the notion that the subprime market is wholly characterized by irresponsible low-FICO borrowers who lack the financial or emotional wherewithal to remain current on mortgages. It is true that the subprime market originally specialized in serving borrowers with tarnished credit histories. Yet we have seen that risky subprime loans were also made to borrowers with high FICO scores. Thus, blaming borrowers with low credit scores for the subprime mess is a vast oversimplification of the problem. Understanding why prime borrowers stretched themselves into risky loans available only in the subprime market would seem to be a more productive line of research.

A final implication concerns the debate over the whether the subprime crisis resulted from poor underwriting standards, which placed people in unaffordable mortgages, or from falling house prices, which brought about widespread negative equity and thus prevented profitable sales or refinances when borrowers suffered adverse life events. To us, this is an artificial debate. We learn from Figs. 3 and 7 that subprime LTV ratios rose during the housing boom. Because loans with high LTV ratios have small equity cushions, they are more likely to suffer from negative equity when house prices fall. Other panels of Figs. 3 and 7 showed that the prevalence of high DTI ratios and low-doc or no-doc loans rose in the subprime market over time. These are precisely the types of loans that are likely to cause borrower distress when adverse life events occur.[28] Thus, these loans will default more often when house prices fall. All in all, the right way to think about the subprime housing crisis is that both falling prices and relaxed underwriting standards were important. Looser underwriting standards created a class of loans that were highly sensitive to falling prices. When housing prices did fall, subprime loans therefore defaulted in greater numbers than prime loans. But, if prices had not fallen, we would not have seen nearly the number of subprime foreclosures that we did.[29]

5. The role of subprime refinancing

In this section, we take a closer look at subprime refinancings. Table 1 showed that the subprime fraction of defaulted loans was larger than the subprime fraction of purchase mortgages of foreclosed homes. This discrepancy indicates that many prime purchasers refinanced into subprime loans before defaulting. A main motivation for refinancing is to liquify home equity in a cash-out refinancing. Though our data do not allow us to measure cash-outs directly, we can use the purchase date of homes to get a rough indication of how much equity was available to be cashed out. According to our state-wide repeat-sales index, average Massachusetts house prices increased by more than 60% from 1999 to early 2008. If we find that homes purchased in 1999 or before were eventually lost to foreclosure, it is likely that the owners refinanced at one or more points along the way in order to extract equity. Our data allow us to count the number of mortgages in each ownership experience to test this hypothesis.

[28] Higher DTI ratios increase the probability that a borrower suffering a decline in income or an increase in expenses will find his mortgage payment onerous. A lack of complete documentation acts as a "multiplier" on the effect of DTI, since the true DTI is likely to be higher than the DTI listed on the loan.

[29] See Gerardi et al. (2007) for some calculations along these lines.

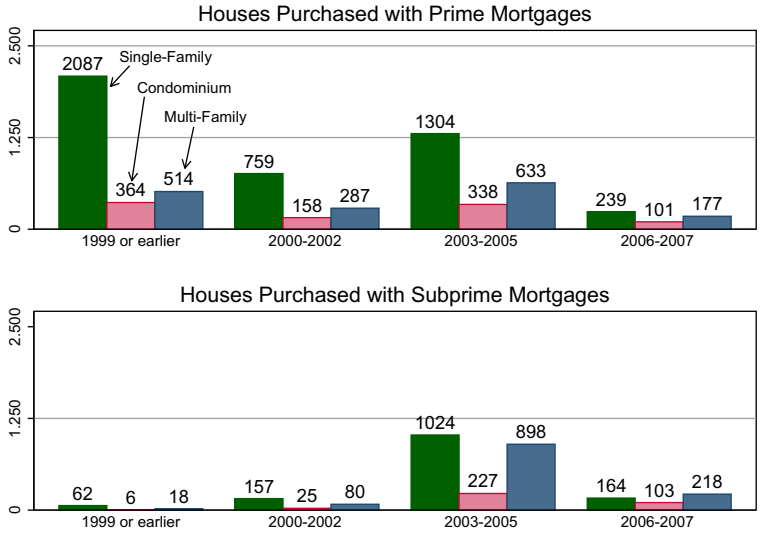

Fig. 8. 2006–2007 Massachusetts foreclosures by type of residence, purchase year, and subprime-purchase status.

In fact, the data do show that many of the prime purchases that were eventually lost to foreclosure were purchased in 1999 or earlier, so they were likely to have amassed substantial equity. Fig. 8 presents the absolute numbers of 2006–2007 Massachusetts foreclosures grouped by type of house, subprime-purchase status, and year of purchase. The top panel plots the data for prime purchases. Of the 4389 single-family foreclosures designated as prime purchases, almost half (2087) were purchased in 1999 or before. Across all types of homes, there were 6961 prime purchases foreclosed upon in 2006 and 2007. Of these, 2965 (42.6%) were purchased before 1999.

Fig. 8 also confirms our other findings. We saw in Fig. 4 that foreclosures are high among homes purchased at the height of the housing boom, presumably because these homes never had a chance to amass positive equity before prices started falling. As we would expect, Fig. 8 confirms that homes purchased in 2003–2005 are strongly represented in 2006–2007 foreclosures. Additionally, Fig. 8 illustrates the high rates of foreclosure among multi-family homes, particularly for multi-families purchased with subprime mortgages near the height of the recent boom (2003–2005). The absolute number of subprime multi-family foreclosures from the 2003–2005 cohort (898) is close to the number of subprime single-family foreclosures in that cohort (1024), even though the multi-family purchases were far less common than purchases of single-family homes in this period.

We next look for evidence of refinancing activity among homes that had appreciated in price. Table 8 shows that foreclosed homes experienced higher refinancing activity than homes that were purchased at the same time, but that have not yet been foreclosed upon or sold. The first row of the table measures the total number of mortgages for homes purchased in 1999. Homes that were purchased in that year and foreclosed upon in 2007 averaged 5.1 mortgages during their entire ownership experiences. For homes purchased in 1999 that have not yet been foreclosed upon or sold, the average number of lifetime mortgages is only 3.8. A similar discrepancy is present for homes purchased in 2000 through 2003.

What role did subprime refinances play in these foreclosure patterns? Table 9 repeats this exercise but focuses only on the total number of subprime mortgages for various ownership experiences. The top row shows

Table 8
Average number of lifetime mortgages for Massachusetts ownership experiences, for homes purchased 1999–2007.

		Foreclosed ownership experiences, by year of foreclosure									Non-foreclosed ownership experiences
		1999	2000	2001	2002	2003	2004	2005	2006	2007	
Year of purchase	1999	1.6	1.6	1.6	1.8	2.2	2.6	3.5	4.3	5.1	3.8
	2000		1.5	1.4	1.6	1.8	2.1	3.0	4.1	4.9	4.1
	2001			1.3	1.3	1.5	1.8	2.5	3.9	4.1	3.6
	2002				1.6	1.4	1.5	2.2	3.0	3.7	3.1
	2003					1.3	1.2	1.8	2.3	3.0	2.4
	2004						1.1	1.6	2.0	2.4	2.2
	2005							1.0	1.8	2.0	1.9
	2006								1.8	1.8	1.7
	2007									1.6	1.4

Note: Non-foreclosed ownership experiences in the last column correspond to ownerships that had not ended with a sale by the end of 2007.

Table 9
Average number of lifetime subprime mortgages for Massachusetts ownership experiences.

	Foreclosed Ownership Experiences, by Year of Foreclosure									Non-Foreclosed Ownership Experiences
	1999	2000	2001	2002	2003	2004	2005	2006	2007	
1999	0.2	0.1	0.1	0.3	0.4	0.5	1.2	1.2	1.6	0.2
2000		0.0	0.1	0.4	0.6	0.5	0.7	1.5	1.4	0.2
2001			0.2	0.2	0.4	0.5	0.7	1.3	1.2	0.2
2002				0.3	0.2	0.5	0.7	1.1	1.2	0.2
2003					0.3	0.3	0.8	1.0	1.1	0.2
2004						0.4	0.7	1.0	1.1	0.2
2005							0.0	1.0	1.1	0.3
2006								0.8	0.9	0.2
2007									0.1	0.0

Note: Non-foreclosed ownership experiences in the last column correspond to ownerships that had not ended with a sale by the end of 2007.

that homes that were purchased in 1999 and foreclosed upon in 2007 had an average of 1.6 subprime mortgages during their ownership experiences. The comparable number for homes purchased in 1999 that have not yet been foreclosed upon or sold is only 0.2. The inability to measure cash-out refinancing makes this analysis only suggestive. Yet the data are consistent with the view that subprime mortgages were extensively used to exact equity from homes that had appreciated in price, and that this extraction had an important impact on foreclosure patterns.

6. Conclusion and directions for future research

This paper has presented a number of facts about the subprime crisis which are at odds with oft-made claims. A simple model that claims a wave of subprime resets set off the crisis is hard to square with the facts, and it is hard to make a *prima facie* case that large numbers of subprime borrowers were inappropriately steered into their mortgages. Additionally, though subprime mortgages have proven especially fragile during the current housing downturn, prime mortgages have also been affected. Indeed, most of the homes lost to foreclosure in Massachusetts were purchased with prime mortgages, though many of their owners refinanced into subprime mortgages before defaulting.

These facts are consistent with the view that the widespread decline in housing prices is the proximate cause of the current housing crisis. They are also consistent with a claim that higher housing prices caused many high-FICO borrowers to turn to the subprime market in order to purchase increasingly expensive homes. Yet while high prices may have encouraged subprime lending, a crucial outstanding question is the degree of causality in the other direction, specifically, whether subprime lending put upward pressure on housing prices. This question lies beyond the scope of this paper. But there is some suggestive evidence that, at least in Massachusetts, higher housing prices were not caused by higher subprime lending. Fig. 9 shows that house prices started increasing in the Bay State well before subprime lending took off. Specifically, house prices were rising by more than 10% per year by the year 2000, when the subprime fraction of new purchases in the state was still quite small. In any case, figuring out the ultimate effect of subprime lending on house prices, and vice versa, is a difficult problem that will require innovative empirical approaches to answer.

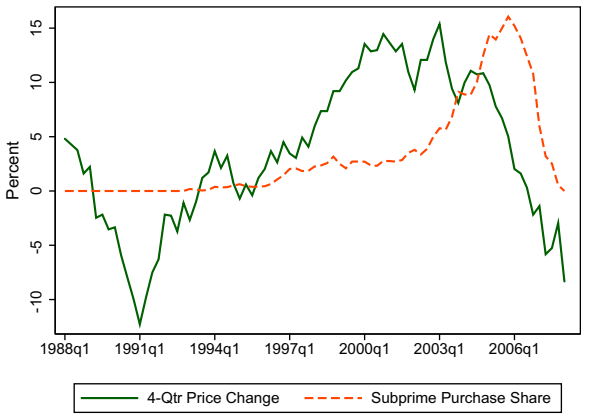

Fig. 9. House price appreciation and subprime-purchase lending in Massachusetts, 1988–2007.

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Public Policy
Discussion Papers

FEDERAL RESERVE BANK OF BOSTON

No. 09-4

Why Don't Lenders Renegotiate More Home Mortgages? Redefaults, Self-Cures, and Securitization

Manuel Adelino, Kristopher Gerardi, and Paul S. Willen

Abstract:
We document the fact that servicers have been reluctant to renegotiate mortgages since the foreclosure crisis started in 2007, having performed payment-reducing modifications on only about 3 percent of seriously delinquent loans. We show that this reluctance does not result from securitization: servicers renegotiate similarly small fractions of loans that they hold in their portfolios. Our results are robust to different definitions of renegotiation, including the one most likely to be affected by securitization, and to different definitions of delinquency. Our results are strongest in subsamples in which unobserved heterogeneity between portfolio and securitized loans is likely to be small, and for subprime loans. We use a theoretical model to show that *redefault risk*, the possibility that a borrower will still default despite costly renegotiation, and *self-cure risk*, the possibility that a seriously delinquent borrower will become current without renegotiation, make renegotiation unattractive to investors.

JEL Classifications: D11, D12, G21

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We thank John Campbell, Chris Foote, Anil Kashyap, Chris Mayer, Julio Rotemberg, and seminar audiences at Freddie Mac, Harvard Business School, University of Connecticut, LSE, and the MIT Finance Lunch for thoughtful comments. We thank Studienzentrum Gerzensee, where the authors completed this paper, for their gracious hospitality.

This paper, which may be revised, is available on the web site of the Federal Reserve Bank of Boston at http://www.bos.frb.org/economic/ppdp/2008/ppdp0904.htm.

version of: July 6, 2009

1 Introduction

Many commentators have attributed the severity of the foreclosure crisis in the United States in the 2007–2009 period to the unwillingness of lenders to renegotiate mortgages, and, as a consequence, have placed renegotiation at the heart of the policy debate. Every major policy action to date has involved encouraging lenders, in one way or another, to renegotiate loan terms in order to reduce borrower debt loads. According to the Treasury-sponsored HopeNow initiative, in December of 2007 lenders were expected to prevent adjustable-rate mortgages from increasing to higher rates at the first reset of the mortgage.[1] "Hope For Homeowners," enacted by Congress in July of 2008, envisioned that lenders would write off a substantial portion of the principal balance of mortgages for financially distressed households.[2] The Obama Adminstration's Making Home Affordable Plan, announced in February of 2009, provided financial incentives to servicers to renegotiate loans on the condition that the lenders reduce the interest rate for a significant period of time.[3]

The appeal of renegotiation to policy makers is simple to understand. If a lender makes a concession to a borrower by, for example, reducing the principal balance on the loan, it can prevent a foreclosure. This is clearly a good outcome for the borrower, and possibly good for society as well. But the key to the appeal of renegotiation is the belief that it can also benefit the lender, as the lender loses money only if the reduction in the value of the loan exceeds the loss the lender would sustain in a foreclosure. In short, according to proponents, renegotiation of home mortgages is a type of public policy holy grail, in that it helps both borrowers and lenders at little or no cost to the government.[4]

In this paper, we explore the renegotiation of home mortgages using a dataset from Lender Processing Services (LPS), a large, detailed sample of residential mortgages. Our primary empirical analysis involves following borrowers over the year subsequent to their first serious delinquency and counting the frequency of renegotiation.[5] Measuring renegotiation in the LPS data is a challenge because there is no field in the data that identifies whether or not a servicer has changed the terms of, or "modified," the loan. We overcome this difficulty by developing an algorithm to identify modifications that we validate on an unrelated dataset that includes a modification flag.

We explore several different definitions of renegotiation in the data. Our first definition of "renegotiation" is concessionary modifications that serve to reduce a borrower's monthly

[1] Edmund L. Andrews, In Mortgage Plan, Lenders Set Terms, *New York Times*, Dec. 7, 2007.

[2] "Bush Signs Wide-Ranging Housing Bill Into Law," *Wall Street Journal*, July 31, 2008.

[3] See "$275 Billion Plan Seeks To Address Crisis In Housing," *New York Times*, Feb. 18, 2009.

[4] See this discussion in Congressional Oversight Panel (2009), Zingales (2008), and Geanakoplos and Koniak (2008), as examples.

[5] Until 2008, the dataset was known as McDash.

payment. These may be reductions in the principal balance or interest rate, extensions of the term, or combinations of all three. This definition of renegotiation is a key focus of our analysis because there is a consensus among many market observers that concessionary modifications are the most, or possibly the only, effective way of preventing foreclosures. As the Congressional Oversight Panel (COP) for the Troubled Asset Recovery Program (TARP) has written, "Any foreclosure mitigation plan must be based on a method of modifying or refinancing distressed mortgages into affordable ones. Clear and sustainable affordability targets achieved through interest rate reductions, principal write-downs, and/or term extensions should be a central component of foreclosure mitigation."[6]

Because the pooling and servicing agreements (PSAs), which govern the conduct of servicers when loans are securitized, often place limits on the number of modifications a servicer can perform, we broaden our definition of renegotiation to include any modification, regardless of whether it lowers the borrower's payment. Modifications are often thought to always involve concessions to the borrower, but many, and in some subsets most, modifications involve the capitalization of arrears into the balance of the loan, and thus lead to increased payments.

Finally, we attempt to include in our definition of renegotiation the transactions whereby lenders allow borrowers to extinguish their liabilities by repaying less than the outstanding balance of the loan. These transactions are known as short payoffs, short sales, or deeds-in-lieu of foreclosure, depending on the structure. We measure this component of renegotiation by counting the number of seriously delinquent loans that the servicer reports as "paid off."

No matter which definition of renegotiation we use, one message is quite clear: lenders rarely renegotiate. Fewer than 3 percent of the seriously delinquent borrowers in our sample received a concessionary modification in the year following the first serious delinquency. More borrowers received modifications under our broader definition, but the total still accounted for fewer than 8 percent of the seriously delinquent borrowers. And finally, fewer than 5 percent of all of our troubled borrowers repaid their mortgages, putting an upper bound on the number who could have repaid less than the principal balance of the loan. These numbers are small both in absolute terms, and relative to the approximately half of the sample for whom foreclosure proceedings were initiated, and the nearly 30 percent for whom they were also completed.

We next turn to the question of why renegotiation is so rare. If the logic described in the second paragraph is correct, lenders should find renegotiation attractive, even in the

[6]See the Congressional Oversight Panel (2009). This view is widely held and is the main focus of the Administration's Making Home Affordable foreclosure prevention plan was to encourage servicers to modify loans to reduce monthly payments to 31 percent of income.

absence of government prodding. Yet, we observe very little renegotiation in the data. We address this apparent paradox.

The leading explanation attributes the reluctance of lenders to renegotiate to the process of securitization.

> The complex webs that securitization weaves can be a trap and leave no one, not even those who own the loans, able effectively to save borrowers from foreclosure. With the loan sliced and tranched into so many separate interests, the different claimants with their antagonistic rights may find it difficult to provide borrowers with the necessary loan modifications, whether they want to or not. In the tranche warfare of securitization, unnecessary foreclosures are the collateral damage. (Eggert 2007)

More precise institutional evidence appears to confirm the role of securitization in impeding renegotiation. As mentioned in more detail below, PSAs do sometimes place global limits on the number of modifications a servicer can perform for a particular pool of mortgages. In addition, the rules by which servicers are reimbursed for expenses may provide a perverse incentive to foreclose rather than modify. Furthermore, because servicers do not internalize the losses on a securitized loan, they may not behave optimally. Another issue is the possibility that those investors whose claims are adversely affected by modification will take legal action. Finally, historically, SEC rules have stated that contacting a borrower who is fewer than 60-days delinquent constitutes an ongoing relationship with the borrower and jeopardizes the off-balance sheet status of the loan.

But some market observers express doubts about the renegotiation-limiting role of securitization. Hunt (2009) conducted an exhaustive review of a sample of PSAs and concluded, "it appears that large-scale modification programs may be undertaken without violating the plain terms of PSAs in most cases." Although some servicers have expressed concern about lawsuits, of the more than 800 lawsuits filed by investors in subprime mortgages through the end of 2008, not one involved the right of a servicer to modify a loan.[7] Even the Congressional Oversight Panel (2009), which did view securitization as a problem in general, conceded, "The specific dynamics of servicer incentives are not well understood." Finally, the SEC ruled in 2008 that if default was "reasonably forseeable," then contact with a borrower prior to 60-day delinquency would not affect the accounting status of the loan.

Our empirical analysis provides strong evidence against the role of securitization in preventing renegotiation. The LPS dataset includes loans that are serviced for private securitization trusts that are not sponsored by any of the government sponsored enterprises

[7]Navigant report, Congressional Oversight Panel (2009).

(GSEs), so-called "private-label" loans, which are subject to all of the contract frictions described above. It also includes loans owned by servicers, so-called "portfolio" loans, which are immune to such problems. We compare renegotiation rates, controlling for observable characteristics of the loans. For our narrowest definition of renegotiation, payment-reducing modification, we find that the differences in the likelihood of renegotiation in the 12 months subsequent to the first 60-day delinquency between the two types of loans is neither economically nor statistically significant. When we consider the broader definition that includes any modification at all, which, as we mentioned above, we would expect to be most affected by securitization, the data even more strongly reject the role of securitization in preventing renegotiation. We also find that servicers are *more* likely to peform modifications, broadly defined, and to allow the borrower to prepay on a private-label loan than on a portfolio loan.

Our results are highly robust. One potential problem with the data is that there is unobserved heterogeneity in the characteristics of portfolio and private-label loans. To address this, we exploit subsets of the LPS data, in which servicers provide an exceptional amount of information about borrowers. When we exclude observations where the servicer failed to report whether the borrower fully documented income at origination, or what the debt-to-income ratio was at origination, our results become even stronger. When we focus only on loans for which the borrower fully documented income, we obtain results that are broadly consistent or, in some cases, stronger than the results for the full sample. Finally, we limit our sample to only subprime loans (as defined in LPS). These loans comprise only 7 percent of the LPS data, but they account for more than 40 percent of all serious delinquencies and almost 50 percent of the modifications that we identify in the data. The results that we obtain for the subprime sample are also consistent with our results for the full sample.

Another potential issue with our focus on 60-day delinquent loans is that portfolio lenders can contact borrowers at any time, whereas some securitization agreements forbid lenders from contacting borrowers until they are at least 60 days delinquent (two missed payments). When we shift our focus to 30-day delinquent borrowers (one missed payment), our results continue to show no meaningful difference between renegotiation of private-label and portfolio loans.

One other possibility is that our algorithm for identifying modifications is somehow missing a class of loss-mitigation actions taken by servicers. Forbearance agreements and repayment plans, for example, would not necessarily show up in our data. However, neither of these actions constitutes renegotiation in any classic sense, because the lender still expects the borrower to repay in full, including interest on any delayed payment. In addition, unlike

modifications, PSAs never place any limits on the use of forbearance agreements or repayment plans, so, *a priori*, we would have less reason to expect a difference in their use across private-label and portfolio loans. Finally, most successful forbearance agreements conclude with a modification to allow the borrower to repay the arrears incurred in forbearance. With all of that said, we test the proposition that servicers engage in other loss mitigation actions by looking at the "cure rate." This is the percentage of loans that transition to current status after becoming 60-days delinquent. We find that in the full sample, private-label loans are less likely to cure, but that the gap, although statistically significant, is small — correcting for observable characteristics, we estimate a cure rate of around 30 percent for the typical portfolio loan and a cure rate of about 2 percentage points less for an otherwise equivalent private-label loan. However, for the subprime subsample, the subsample with information about documentation and debt-to-income (DTI) status, and the sample of fully documented loans, we find that private-label loans are significantly *more* likely to cure.

The policy debate has focused exclusively on the ways securitization impedes renegotiation and implicitly assumes that portfolio lenders face no institutional impediments, but this is not realistic. Portfolio lenders complain about accounting rules, including the need to identify modifications, even when the borrowers are current prior to the modification, as "troubled debt restructurings," which leads to reduction of the amount of Tier II capital and increased scrutiny from investors and cumbersome accounting requirements. The shortage of qualified staff, an oft-heard complaint from borrowers seeking renegotiation, affects servicers of portfolio loans and private label loans equally. Finally, the interests of the managers of a loan portfolio are not necessarily any more likely to be aligned with their investors than are the interests of the trustees of a mortgage pool; many have attributed the catastrophic failures of financial institutions like AIG in 2008 to misaligned incentives of managers and shareholders.

Our results are consistent with the hypothesis that securitization does impede renegotiation but that a different set of impediments leads to similar problems with portfolio loans and generates our finding that there is no difference. However, the small differences would represent a remarkable coincidence.[8] More importantly, the low overall levels of renegotiation mean that even if contract frictions cut the overall number of concessionary modifications in half, 94 percent of seriously delinquent borrowers would still fail to receive a concessionary modification. So the puzzle remains why so few loans are renegotiated.

If contract frictions are not a significant problem, then what is the explanation for

[8]Yet another possible explanation is that equal treatment provisions in PSAs force servicers to modify similar numbers of portfolio and private-label loans and that servicers are reluctant to modify portfolio loans in spite of the fact that they internalize the benefits because they must then modify private label loans for which they don't.

why lenders do not renegotiate with delinquent borrowers more often? We argue for a very mundane explanation: lenders expect to recover more from foreclosure than from a modified loan. This may seem surprising, given the large losses lenders typically incur in foreclosure, which include both the difference between the value of the loan and the collateral, and the substantial legal expenses associated with the conveyance. The problem is that renegotiation exposes lenders to two types of risks that can dramatically increase its cost. The first is what we will call "self-cure" risk. As we mentioned above, more than 30 percent of seriously delinquent borrowers "cure" without receiving a modification; if taken at face value, this means that, in expectation, 30 percent of the money spent on a given modification is wasted. The second cost comes from borrowers who redefault; our results show that a large fraction of borrowers who receive modifications end up back in serious delinquency within six months. For them, the lender has simply postponed foreclosure; in a world with rapidly falling house prices, the lender will now recover even less in foreclosure. In addition, a borrower who faces a high likelihood of eventually losing the home will do little or nothing to maintain the house or may even contribute to its deterioration, again reducing the expected recovery by the lender.

In Section 4 of the paper, we formalize the basic intuition of the investor renegotiation decision, with a simple model. We show that higher cure rates, higher redefault rates, higher expectations of house price depreciation, and a higher discount rate all make renegotiation less attractive to the investor. Thus, one cannot evaluate a modification by simply comparing the reduction in the interest rate on the loan or in the principal balance with the expected loss in foreclosure. One must take into account both the redefault *and* the self-cure risks, something that most proponents of modification fail to do.[9]

To our knowledge, this paper is the first to estimate directly the likelihood of renegotiation of private-label and portfolio-held loans. Piskorski, Seru, and Vig (2009) address the question of the effects of securitization on renegotiation, but rather than directly identifying renegotiation, they run "black-box" foreclosure regressions using LPS data and argue that observed differences in foreclosure rates *imply* differences in renegotiation activity. Our results contradict this interpretation. For renegotiation to explain the differences in foreclosure rates, there would have to be large errors in our algorithm for identifying renegotiation, and those errors would have to be significantly biased toward portfolio loans, a possibility that is particularly problematic given that the renegotiations we focus on are precisely the type that PSAs supposedly prevent. In addition, most of the loan histories in the LPS

[9]Many proponents of aggressive modification take into account redefault risk, and the MHA plan did address it by providing some insurance against further house price declines to investors who modified loans. However, none of the main proponents ever mentions self-cure risk, even though it is well-known in the industry, see: http://www.calculatedriskblog.com/2008/09/loan-modifications-anecdotes-and-data.html.

sample are right-censored, meaning that the borrowers have neither lost their homes nor paid off their mortgages when the data end, making it impossible to equate the absence of a foreclosure with successful renegotiation. By contrast, a "cure" is a necessary condition for renegotiation, and thus the differences we report in cure rates across portfolio and private-label loans that are neither large nor of consistent sign contradict the claim that securitization is a major obstacle to renegotiation.

The implications of our research for policy are three-fold. First, "safe harbor" provisions, which shelter servicers from investor lawsuits, are unlikely to affect the number of modifications and should have little effect. Second, and more broadly, the number of "preventable foreclosures" may be far fewer than many believe.

Finally, we point out that while our model shows why investors may not want to perform modifications, that does not necessarily imply that modifications may not be socially optimal. One key input to our theoretical model is the discount rate, and it is possible that investors, especially in a time when liquidity is highly valued, may be less patient than society as a whole, and therefore foreclose when society would prefer renegotiation. Large financial incentives to investors or even to borrowers to continue payment could mitigate this problem.

1.1 Related Literature and Existing Evidence

Our research draws on existing literature in several different fields. First, there has been substantial interest in the question of renegotiation of home mortgages among real estate economists, both prior to, and as a result of the current crisis. Riddiough and Wyatt (1994a), Riddiough and Wyatt (1994b), and Ambrose and Capone (1996) addressed informational issues that inhibit efficient renegotiation. We draw extensively on this research in Section 4. Springer and Waller (1993), in an early example, explores patterns in the use of forbearance as a loss mitigation tool. Capone (1996) and Cutts and Green (2005) both discuss the institutional issues, with the former study providing historical evidence and focusing on issues in the mid-1990s, and the latter study discussing innovations since then.

The start of the subprime crisis in 2007 led to a resurgence of interest in the topic among real estate economists and aroused new interest from other fields, in particular, the field of law. In real estate, Quercia, Ding, and Ratcliffe (2009), Cutts and Merrill (2008), Stegman, Quercia, Ratcliffe, Ding, Davis, Li, Ernst, Aurand, and Van Zandt (2007), and Mason (2007), all discuss issues with contemporary loss mitigation approaches. Legal researchers, White (2008) and White (2009), for example, have addressed empirical questions about the frequency and characteristics of loan modifications, closely related to the analysis in this

paper. In addition, they have also looked at issues related to the restrictions imposed by contracts (Hunt 2009 and Gelpern and Levitin 2009) and the interactions among foreclosure, renegotiation, and personal bankruptcy (Levitin 2009a and Levitin 2009b).

More broadly, real estate economists have explored the factors that lead delinquent mortgages to transition to foreclosure or to cure, one of which is renegotiation. Pre-crisis papers include Ambrose and Capone (1998), Ambrose, Buttimer Jr, and Capone (1997), Ambrose and Capone (2000), Lauria, Baxter, and Bordelon (2004), Danis and Pennington-Cross (2005), Pennington-Cross (2009), and Pennington-Cross and Ho (2006). Mulherin and Muller (1987) discusses conflicts between mortgage insurers and owners that may lead servicers to induce or postpone foreclosure inefficiently. In light of the crisis, Piskorski, Seru, and Vig (2009) and Cordell, Dynan, Lehnert, Liang, and Mauskopf (2008a) have revisited the question.

The issue of dispersed ownership and debt renegotiation has received a fair amount of attention in the corporate finance literature. Gan and Mayer (2006), for example, focus on commercial mortgages, and find that servicers delay liquidation of delinquent mortgages when they are also the holders of the equity tranche of the deal. This suggests that participating in the losses due to liquidation may alleviate some of the agency problems posed by the separation of ownership and servicing pointed out before. However, it may also lead to conflicts of interest between holders of different tranches. In their setting, Gan and Mayer (2006) find that the servicers' behavior is consistent with asset substitution, as servicers seek to benefit from the option-like payoff of their position. Also, the contractual restrictions imposed by PSAs (discussed above) and standard economic arguments on the effects of dispersed ownership of debt (as in Bolton and Scharfstein 1996 and Asquith, Gertner, and Scharfstein 1994) further reduce the incentives of servicers to modify mortgages.

2 Data

We use a dataset constructed by LPS. This is a loan-level dataset that covers approximately 60 percent of the U.S. mortgage market and contains detailed information on the characteristics of both purchase-money mortgages and mortgages used to refinance existing debt.[10] This dataset is especially useful in the context of this paper, as it includes both securitized mortgages and loans held in portfolio.[11] The LPS data specifically denote whether a mort-

[10] We use a 10 percent random sample of the LPS data when estimating all of our empirical models. The dataset is simply too big to use in its entirety from a computational standpoint. However, we have checked the robustness of our results to using different sample sizes, and we do not find substantial differences.

[11] For a more detailed discussion of the LPS data, we direct the reader to Foote, Gerardi, Goette, and Willen (2009).

gage is held in portfolio, or securitized by a non-agency, private institution.[12] If institutional constraints are restricting the modification process for private-label, securitized loans, we would expect to see relatively few modifications among them, as compared to portfolio loans. Unfortunately, our LPS sample does not include direct information regarding loan modifications.[13] However, LPS does provide monthly updates to loan terms, so it is possible to identify loan modifications indirectly (and imperfectly). Table 1 shows two examples of modifications in the data. In the first example, the servicer cuts the interest rate, capitalizes arrears into the balance of the loan, and extends the term of the loan to 40 years. In the second example, the servicer just capitalizes arrears into the balance of the loan. In both cases the loan is reported as "current" after the modification, whereas before it was 90+ days delinquent.

We denote a loan as being modified if there is a change in its terms that was not stipulated by the initial terms of the contract. Such modifications include interest-rate reductions, principal-balance reductions, and term extensions. We can also identify principal-balance and mortgage-payment *increases* that reflect the addition of arrears into the balance of a loan.[14] We spell out our algorithm for identifying modifications in more detail in Appendix A.

There are two potential mistakes we can make in this exercise. First, we may falsely identify modifications ("false positives") because of measurement error in the data (for example, a mistake in the updated balance or interest rate) or some endogenous behavior on the part of the borrower (for example, a borrower making extra principal payments). Second, we could miss modifications ("false negatives") because our algorithm for finding modifications is incomplete. In order to test our algorithm, we use data from the Columbia files put together by Wells Fargo's CTSLink service. This dataset includes a similar set of variables to those in the LPS dataset (on performace of the loans and characteristics of the borrower at origination) but is limited to private-label loans. These files do include,

[12]The LPS data also denote when a loan is securitized by a GSE (Government Sponsored Enterprise) such as Freddie Mac or Fannie Mae. We eliminate this class of loans, since the GSEs hold all credit risk, and thus are not subject to any modification restrictions.

[13]In a recent report, the Office of Thrift Supervision (OTS), in collaboration with the Office of the Comptroller of Currency (OCC), used data from LPS to analyze the outcomes of recent mortgage modification programs (OCC and OTS Mortgage Metrics Report, Third Quarter 2008). In this report, they had access to supplementary data from servicers that include the identification of loans in the LPS data that had been modified. We have not been able to obtain access to this data.

[14]One of the major types of loan modifications that we are largely unable to identify are interest rate freezes for subprime ARMs, which reset after two or three years. However, the reason that we cannot identify those freezes is because many are not binding; the fully-indexed rate is lower than the initial rate. These modifications will have no major effect on the current terms of the mortgage, so we do not view this as a major drawback.

however, explicit flags for modifications. This allows us to use the same algorithm described in Appendix A and compare the modifications we identify to the "true" modifications. Results are reported in Table 2. Overall our algorithm performs well, with 17 percent false negatives (that is, we do not identify around 17 percent of the "true" modifications) and around the same percentage of false positives (that is, approximately 17 percent of the modifications we identify are not flagged as modifications on the CTSLink data). By type of modification, our algorithm performs best for principal reductions, term increases, and fixed-rate mortgage reductions, and comparatively worse for ARM rate reductions and for principal increases.

2.1 Summary Statistics from the Data

Table 3 reports the number of modifications performed each quarter from the first quarter of 2007 through the final quarter of 2008, disaggregated by the type of modification. Each of the numbers is a multiple of 10 because we used a 10 percent random sample and scaled up the numbers we found. The first column of Table 3 simply reports the total number of loan modifications made. Not surprisingly, modifications have become more common as the housing market has weakened. There appear to be more than 7–8 times as many modifications performed in the fourth quarter of 2008 as in the first quarter of 2007. In addition to the rapid growth in loan modifications, the composition of modifications has changed over time. This can be seen in the remaining columns of Table 3, which list the incidence of modifications of different types.[15]

An interesting finding is that most modifications entailed *increases* in the principal balance of a mortgage. Such increases are likely due to the addition of arrears to the outstanding mortgage balance for delinquent borrowers, and these often increase the monthly mortgage payment by a nontrivial amount. While the absolute numbers of balance-increasing modifications are still rising, they are falling as a percentage of total modifications. In the last few quarters, interest-rate reductions, which necessarily involve a decrease in the monthly mortgage payment, have become more frequent, rising to more than 26 percent of all modifications performed in 2008:Q4. Table 3 provides further information regarding the behavior of monthly mortgage payments for loans that have undergone a modification. There are several notable patterns in this table. First, as of 2008:Q4, modifications that involved payment decreases were more common than those that involved payment increases. Furthermore, the

[15]In many cases a mortgage will experience multiple types of modifications at the same time. For example, we see cases in the data in which the interest rate is decreased and at the same time the term of the loan is extended. Thus, the percentages in Table 3 are not calculated with respect to the number of loans modified, but rather with respect to the number of modifications performed.

average and median magnitude of payment decreases has recently increased in our sample. From 2007:Q1 to 2008:Q2, the median payment decrease ranged from approximately 10 percent to 14 percent, but then increased to approximately 20 percent and 22 percent in 2008:Q3 and 2008:Q4, respectively. Based on the logic from our simple framework above, it is likely that these will have more success than modifications involving increases in the payment and/or balance.

Another interesting observation from Table 3 is that the incidence of principal reductions is quite low in our data. This is likely due to two factors. First, the LPS dataset underrepresents the subprime mortgage market.[16] A few servicers that focus almost exclusively on subprime mortgages have recently begun modification programs that involve principal reduction.[17] In addition, from a theoretical perspective, principal reduction plans suffer from the severe incomplete-information problem noted earlier. Balance reductions are appealing to both borrowers in danger of default and those who are not. In a recent paper, we argued that to avoid such moral hazard concerns, lenders have a strong incentive to only provide modifications to those borrowers who are most likely to default.[18] Table 3 contains summary statistics regarding the characteristics at origination of both the sample of modified mortgages and the sample of all loans in the LPS dataset. The patterns that emerge from the table are consistent with such an argument. We discuss this point in more detail below. The sample of modified mortgages is characterized by substantially lower credit scores, higher loan-to-value (ltv) ratios, and slightly higher debt-to-income ratios. The discrepancy in ltv ratios may be underestimated, as the percentage of mortgages with an ltv ratio of exactly 80 percent is significantly higher in the modification sample than in the full sample. As we argued above, this likely implies a larger fraction of highly leveraged loans, for which the second liens are not observable in the data. In addition, the modification sample includes a higher fraction of mortgages with non-traditional amortization schedules, such as interest-only loans, option ARMS, hybrid ARMs, and subprime loans.

In Table 4 we compare the size of payment decrease and payment increase modifications for loans held in private-label trusts and loans held in portfolio. The results are somewhat mixed, as the size (as a percentage of the original payment) of the median payment decrease due to modification is larger for private-label loans in the first three quarters of 2008, but smaller in the final quarter. We see a similar pattern for the median payment increase due

[16] The majority of subprime mortgages are securitized by non-agency firms, and the LPS dataset includes approximately 35 percent of mortgages securitized by non-agency corporations.

[17] According to an October report by Credit Suisse, Ocwen Loan Servicing, LLC and Litton Loan Servicing LP were the only subprime servicers that had performed a nontrivial number of principal reduction modifications. Neither of these servicers contributes to the LPS dataset.

[18] See Foote, Gerardi, and Willen (2008) for a more detailed discussion.

to modification, while the differences are small for the mean and median payment increase.

3 Differences in Modification Behavior

In this section, we directly address the question of whether the incidence of modification is impeded by the process of securitization. We show evidence that private-label loans and portfolio loans perform similarly, both unconditionally and when observable differences between securitized and portfolio-held loans are controlled for, using both a logit model with a 12-month horizon and a Cox proportional hazard model that takes into account the problem of right censoring in the data.

To make sure that our results are robust to the type of modification performed, we use several different definitions of modification in this section. Our first measure is the number of concessionary modifications, which we define as reductions in the interest rate, reductions in the principal balance, extensions of the term, or combinations of all three. Any or a combination of these serves to reduce a borrower's monthly mortgage payment. We use this as our primary definition of modification in our analysis, as there is a consensus among most market observers that concessionary modifications are the most, or perhaps the only, effective way of preventing foreclosures. Because pooling and servicing agreements, which govern the conduct of servicers when loans are securitized, often limit modifications that change *any* of the contract terms (not just those that result in payment decreases), we broaden our definition of renegotiation to include any modification, regardless of whether it lowers the borrower's payment. As we discussed above, many, and in some subsets, most modifications, involve the capitalization of arrears into the balance of the loan and thus lead to increased payments. Finally, we attempt to include in our measure of renegotiation the number of times that lenders allow borrowers to extinguish their liabilities by repaying less than the outstanding balance of the loan. These transactions are known as short payoffs, short sales, or deeds-in-lieu of foreclosure, depending on the structure. We do this by counting the number of seriously delinquent loans that the servicer reports as paid off, and including these observations in our definition of modification.

Before turning to the regressions, however, it is instructive to look at the unconditional frequencies of modifications in the data. Panel A of Table 5 shows the unconditional frequencies for each type of investor. The first takeaway from the table is the extremely low percentages of modifications for *both* types of mortgages. Only 3 percent of 60-day delinquent loans received concessionary modifications in the 12 months following the first serious delinquency, and only 8.5 percent of the delinquent loans received *any* type of modification in the same period. These are extremely low levels of modifications, and they suggest that

even if there are contract frictions that are preventing modifications in securitized trusts, the economic effects are small. The second takeaway from the table is that the unconditional differences between portfolio loans and private-label loans are very small in absolute terms. There is a difference of approximately 0.6 percentage points and 0.3 percentage points for concessionary modifications and all modifications, respectively. These are very small differences, and they suggest that contract frictions do not play an important role in inhibiting the renegotiation process for loans in securitized trusts. However, these are unconditional statistics, and it is possible that once observable differences in the characteristics of each type of loan and borrower are accounted for, the results may change.[19] Thus, we now estimate differences in modification behavior while controlling for observable loan and borrower characteristics. These characteristics include the contract interest rate at origination; the credit score of the borrower at origination; the loan-to-value ratio of the mortgage (not including second or third liens) at origination[20]; the logarithm of the nominal dollar amount of loan; an indicator of whether the purpose of the loan was a refinance of a previous mortgage or a home purchase; an indicator of whether the loan was considered to be subprime[21]; a measure of the amount of equity in the property at the time of delinquency, specified as a percentage of the original loan balance and updated by state-level house price indexes calculated by the Federal Housing Finance Agency (FHFA)[22] (and an indicator for a borrower who is in a position of negative equity at the time of delinquency, where the value of the mortgage exceeds the value of the home); and the unemployment rate of the county in which the borrower resides, calculated by the Burea of Labor Services (BLS).[23] We also include, but do not show because of space considerations, a set of cohort dummies that control for the quarter when the mortgage was originated, information regarding the amortization schedule of the mortgage (interest-only or negative amortization, including mortgages commonly referred to as option ARMs), an indicator for whether the size of the mortgage is greater than the GSE conforming loan limits, an indicator for whether the

[19] For example, if private-label loans are significantly riskier, and thus better candidates for modification on average, then the unconditional difference will significantly understate things.

[20] Because of the lack of information on second liens in the LPS data and the prevalence of second mortgages as a way to avoid paying mortgage insurance, we include an indicator variable if the ltv ratio is exactly equal to 80 percent. These are the borrowers who likely took out second mortgages, as the requirement for mortgage insurance occurs at ltv ratios above 80 percent. Our experience with other, more complete datasets also confirms that many of these borrowers are likely to have second mortgages that bring the cumulative ltv ratio up to 100 percent.

[21] This definition of subprime comes from the mortgage servicers that contribute to the LPS dataset.

[22] House prices are measured at the state level using the FHFA index. We also tried using Case-Shiller metropolitan area house price indexes and found no substantive differences. We chose to use the OFHEO prices for our primary specifications because of their greater sample coverage.

[23] Equity and periods of unemployment are very important determinants of a borrower's decision to default, and thus should also be important factors in the modification decision.

house is a primary residence, an indicator for adjustable rate mortgages that contain a reset provision (so-called "hybrid ARMs"), and, finally, an indicator for a borrower who does not use the corresponding property as a principal residence (this includes both properties used strictly for investment purposes, and vacation homes).

3.1 Canonical Specification Results

Panel B of Table 5 displays the estimated marginal effects from a set of logit models for the three different types of modification definitions. The dependent variable is 1 if a 60-day deliquent loan is modified at any point in the 12 months following the first delinquency. The first column considers payment-reducing (concessionary) modifications, the second column includes both payment-reducing and payment-increasing modifications, and the third column contains all modifications considered before, as well as prepayments. In all regressions, the group of portfolio-held loans is omitted from the estimation and is thus assumed to be the reference group. We cluster the standard errors at the zip code level to account for the fact that loans in the same geographical area are likely to suffer correlated (unobserved) shocks.

According to the estimates in the first column, private-label loans were approximately 0.3 percentage points less likely to receive concessionary modifications than loans held in portfolio. This estimate is economically small but statistically significant at the 10 percent level. When we consider all modifications the point estimate flips sign and becomes 0.2 percentage points (statistically insignificant), while for the third specification, private-label loans were actually 0.9 percentage points more likely to receive concessionary modifications (statistically significant). As discussed above, all of these specifications include a number of additional loan characteristics that are important in the underwriting process and, thus, likely to play an important role in the modification decision. The first observation to make regarding the results reported in Panel B is that the difference between the incidence of modification for portfolio-held loans and private-label loans becomes even smaller when these variables are controlled for in the estimation. The results also imply that loans with higher credit scores were modified less, loans with higher ltv ratios were modified less, larger loans were modified more, and loans with more equity at the time of delinquency were modified less. We find a sizeable difference in terms of the frequency of modification for both refinances and subprime loans. Conditional on being 60-days delinquent, subprime loans were modified about 2 percentage points more than prime loans. We estimate a model separately for subprime loans in Table 6.

Censoring is an important issue for any sample of mortgages, as there are currently

many delinquent loans that are, or will soon be, good candidates for modification, as the housing market continues to decline. For this reason, we estimate a Cox proportional hazard model of the transition from serious delinquency to modification. The Cox model is very common in the survival analysis literature, and it has the advantage of being both flexible in terms of functional form considerations, as the baseline hazard function can be treated as an incidental parameter, and easy to estimate in terms of computational considerations. The results, expressed as hazard ratios, are reported in Panel C. A hazard ratio less than 1 indicates that private-label loans were less likely to receive a modification compared to portfolio loans, while a ratio greater than 1 signifies the opposite. The estimates are consistent with what we report for the logits in the previous panel. Private-label loans were less likely to receive concessionary modifications, but this coefficient estimate is statistically insignificant. For the our other two modification definitions the sign flips, but again the result is not statistically significant. All three specifications include the same covariates that were included in the logit models.

3.2 Subsample Results

Table 6 contains further logit estimation results for various subsamples of interest to see if there are different probabilities than in the full sample. Since the subprime indicator seems to be such a powerful predictor of modification conditional on serious delinquency in Table 5, we report the estimated marginal effects for only the sample of subprime loans in the second column of Table 6. The subprime sample also has the advantage that the agencies (Fannie Mae and Freddie Mac) were unlikely to be the marginal investor for this type of loans, so it is less likely that the portfolio and private-label samples differ significantly on unobservable characteristics. In the third column, we report results from the sample of LPS mortgages for which the borrower had a FICO score of less than 620, since automated underwriting systems generally instruct lenders to engage in increased scrutiny for such loans because of increased default risk. In the fourth and fifth columns, we focus on samples of loans that we believe contain the most information regarding the borrowers, in order to try to minimize the amount of unobservable heterogeneity that could potentially be biasing the results. In the fourth column, we focus on the sample of loans for which both the DTI ratio and the documentation status contain non-missing values, while the fifth column contains results for only the loans that were fully documented (in terms of income and assets) at origination. Panel A contains both unconditional means and estimated marginal effects for concessionary modifications, while Panel B contains results for the broader definition that also includes non-concessionary modifications.

The results are largely consistent with those contained in Table 5. We redisplay the results from the full sample in the first column of Table 6 for ease of comparison. The difference in modification frequency between private-label and portfolio-held, subprime mortgages for 60-day delinquent loans is small, and not statistically different from zero for both definitions of modification. Using a FICO cutoff of 620 as an alternative definition of subprime does not seem to make much difference. The unconditional means are smaller (for both types of loans) compared to the LPS subprime sample, as the LPS definition includes most of the loans with a FICO less than 620, but also some loans with higher associated FICOs. However, the marginal effects of private-label loans estimated from the logit models are quite similar to those from the LPS subprime sample, as they are economically small, and not statistically significant. Finally, we also find small and largely insignificant results for the last two subsamples, displayed in the fourth and fifth columns of Table 6. Although, it is worth pointing out that we do find a statistically significant, positive estimate of private-label loans for the broad definition of modification (Panel B).

3.3 Alternative Delinquency Definition

As an additional robustness check, we broaden our definition of delinquency and focus on modifications performed on loans subsequent to their first 30-day delinquency, which corresponds to one missed mortgage payment. While waiting until a borrower becomes seriously delinquent (defined as 60-days) to renegotiate is common practice in the servicing industry, there are no direct contractual stipulations (to our knowledge) that restrict a servicer from modifying the loan of a borrower who is 30-days delinquent. Thus, in Table 7 we repeat our analysis of Tables 5 and 6, but condition on 30-days delinquency rather than 60-days. The table contains three panels of estimation results, one for each of our modification definitions, and all of the subsamples described considered in Table 6. The unconditional means, logit marginal effects, and Cox hazard ratios are all reported for each combination of subsample and modification definition.

The results are very similar to those from the analysis of 60-day delinquent loans. According to the full sample and subprime sample logit models, portfolio loans received slightly more concessionary modifications, and the differences (0.3 and 0.5 percentage points respectively) are statistically significant at conventional levels. However, according to the subprime sample and full documentation sample Cox models, private-label loans actually received more concessionary modifications, although those differences are also small.[24] The results

[24]The logit marginal effects correspond to percentage point differences, while the Cox hazard ratios correspond to percent differences. If one expresses the logit marginal effects as a percent change of the unconditional means, those percent changes are very similar in magnitude to the Cox results.

for our second modification definition are similar, although we find more evidence of statistically significant, positive differences between the incidence of portfolio and private-level modifications. The samples of portfolio loans with non-missing information for DTI and documentation status were modified more often than the corresponding sample of private-label loans, but the magnitudes are still relatively small (10 to 20 percent difference from the unconditional mean). Finally, in Panel C, we see strong evidence for both the logit and Cox specifications, that delinquent private-label loans prepayed more often than portfolio loans. The differences are statistically significant for every one of the subsamples.

3.4 Redefault Probabilities and Cure Rates

In the previous subsections, we showed that there is little difference in the frequency of mortgage loan modifications between servicers of loans held in a private trust versus loans held in portfolio. There are two potential reasons that may explain the failure of those exercises to pick up important differences in servicer behavior that may truly exist. First, it may be that contract frictions in securitization trusts do not result in substantial differences in the frequency of modifications (the extensive margin) but do result in significant differences in the intensive margin, with respect to the types of modifications performed, the extent to which contract terms are modified, and, more broadly, the care or effort expended in each modification by private-label servicers compared to that expended by portfolio servicers. Second, there may be a type of renegotiation that our algorithm does not identify, but that is used to a large extent in loss mitigation efforts and used differently by servicers of private-label loans than by servicers of portfolio loans. For example, forms of forbearance, which are often called repayment plans in the industry, would not be picked up by our algorithm.[25] In this subsection, we use the LPS data to attempt to address these possibilities.

We perform two separate empirical exercises to address each of these concerns in turn. First, we compare redefault rates of private-label modified loans with those of portfolio modified loans. We define redefault as a loan that is 60 days delinquent or more, in foreclosure process or already foreclosed and now owned by the lender (REO for "real-estate-owned") six months after the time of the modification. If there are important differences in the manner by which servicers of private-label loans modify mortgages relative to the foreclosure procedures of servicers of portfolio loans, then we would expect to see significant differences in the subsequent performance of modified loans.

Second, to address the possibility that our algorithm misses an important aspect of

[25]However, as we argued above, PSAs do not contain restrictions on repayment plans, because they do not involve changing the terms of the mortgage. Thus, we would argue that differences in forbearance behavior that might exist could not be the result of contract frictions in securitization trusts.

renegotiation, we compare the cure rates of seriously delinquent, private-label loans to those of seriously delinquent portfolio loans. The idea behind this exercise is that any appreciable difference in servicer renegotiation behavior will manifest itself in differences in cure rates. It is important to stress however, that differences in servicer renegotiation behavior are only one potential explanation for differences that may exist in cure rates. To put this idea in the terms of logical reasoning, differences in cure rates are a necessary condition for significant differences in renegotiation behavior, but they are not a sufficient condition.

Table 8 contains the results of the redefault analysis. The first observation to note from the table is that the unconditional probability that a modified mortgage redefaults in this six-month period is very large, at about 20–40 percent for payment-reducing modifications (Panel A), and 40–50 percent for all modifications (Panel B). We argue below that the high level of redefault rates could explain why we observe so few modifications — very often they do not lead to successful outcomes even as little as six months after the modification. The second observation to note is that there is no statistically significant difference between the redefault rates of private-label loans and those of portfolio loans, once the observable characteristics of the mortgages are taken into account (this is valid for all of the subsamples). These results, combined with the statistics displayed in Table 4 suggest that there are no substantial differences in either the type of modification employed or in the care/effort expended by the two types of servicers.

Table 9 shows the results of logit models for the probability that a seriously delinquent loan subsequently cures. Our definition of a cure is that the loan is either current, 30-days delinquent, or prepaid after 12 months following the first 60-day delinquency. The first important point to make is that the unconditional cure probabilities are large (around 30 percent). Given that the unconditional modification probability is about 8 percent, this means that many loans cure without any intervention on the part of servicers. The second important observation to note in this table is that the cure probabilities for portfolio loans and private-label loans are quite similar. The unconditional cure probability is smaller by about 4.4 percentage points for private-label loans in the whole sample, but that is reduced to only 2.2 percentage points (statistically significant) when we control for observable characteristics of the loans and borrowers. We also include results for the subsamples of interest in columns 2–5. For each of the subsamples the sign of the difference actually reverses, as private-label loans were *more* likely to cure (the marginal effects are statistically significant, with the exception of the $FICO < 620$ sample). This is an important robustness check, as we argued above that unobserved heterogeneity is likely to be less of a problem in the subsamples (especially for the non-missing documentation status and DTI ratios sample and the full documentation sample). Thus, the change in the sign of the differences in

cure rates between private-label servicers and portfolio servicers suggests that unobserved heterogeneity between the two loan types plays an important role.

4 Understanding the Empirical Results

If securitization does not block renegotiation, then why is it so rare? In this section, we build a simple model of the renegotiation decision, which, in a stylized way, mirrors the net present value (NPV) calculation that servicers are supposed to perform when deciding whether to offer a borrower a modification. We show that servicer uncertainty about whether the borrower will redefault even after successful renegotiation or uncertainty about whether the borrower will cure without renegotiation can dramatically affect the NPV calculation, ruining what a naive observer might think of as a "win-win" deal for the borrower and lender. While many proponents of modification are aware of the former problem, "redefault risk," none seem to be aware of the latter problem, which we call "self-cure risk."

In addition to the model, we also provide institutional evidence in this section that supports our arguments and findings above. This includes evidence of low modification frequencies in previous housing busts, well before the advent of securitization trusts; the equal treatment provision statements contained in the PSAs, which direct the servicer to behave as if it was in fact the investor of the mortgage-backed security and thus the owner of the mortgages; and finally, the absence of lawsuits to date directed at servicers by investors in mortgage-backed securities, which one would expect to find if modifications were unambiguously better than foreclosures from an NPV calculation.

4.1 A Simple Model of Loss Mitigation

We consider a simple model of a lender's decision to modify a delinquent loan.[26] There are three periods: $t = 0, 1, 2$. The borrower owes a mortgage payment of size m at time 1 and is due to repay the loan balance M in period 2. The mortgage is collateralized by a house, which is worth P_1 and P_2 in periods 1 and 2, respectively. In period 0, the lender has to make a decision to either modify the loan, or do nothing. If the lender fails to modify the loan, then, with probability α_0, the borrower will default in period 1, and the lender will foreclose and recover $P_1 - \lambda$, where λ is the cost of foreclosing on the property. If the borrower does not default next period, then the lender receives the periodic payment m in period 1, and the borrower repays the loan in full in period 2. The value to the lender of

[26] Our model shares some basic similarities with the approach in Ambrose and Capone (1996), who also identify a role for self-cure risk in assessing the profitability of a loss mitigation action.

the loan without modification equals the present discounted value of the cash flow:

$$\alpha_0 * \min[(P_1 - \lambda), M] + (1 - \alpha_0)[m + (1/R)M], \tag{1}$$

where we ignore discounting for the first period because there is no income in period 0. If the lender modifies the loan, then we assume that the borrower makes a reduced periodic payment m^* in period 1 with certainty, but then either defaults with probability α_1 or repays a modified amount M^* in period 2. The value to the lender of the modified loan is:

$$m^* + (1/R)\alpha_1 * \min[(P_2 - \lambda), M^*] + (1 - \alpha_1)(1/R)M^*. \tag{2}$$

Taking the difference between expressions (2) and (1) yields the following proposition:

Proposition 1 *Modification makes sense if:*

$$\begin{aligned}(\alpha_0 - \alpha_1)[m^* + \tfrac{1}{R}M^* - \min[(P_1 - \lambda), M]] \\ - (1 - \alpha_0)[m + \tfrac{1}{R}M - (m^* + \tfrac{1}{R}M^*)] \\ + \alpha_1[m^* + \tfrac{1}{R}\min[(P_2 - \lambda), M^*] - \min[(P_1 - \lambda), M]] > 0.\end{aligned} \tag{3}$$

To interpret equation (3), divide the population of borrowers into three groups. The first group, with mass of $\alpha_0 - \alpha_1$ are borrowers who will repay in full with a modification but who will default otherwise. For this group, the investor gains the difference between the present value of the modified repayment $m^* + \frac{1}{R}M^*$ and the recovery given foreclosure, $\min[(P_1 - \lambda), M]$. The second group, with mass $1 - \alpha_0$, includes borrowers who will repay whether or not they receive a modification. For this group, the investor loses the difference between full repayment and the modified repayment. Gerardi and Willen (2009) refer to the first two terms as Type I error and Type II error, respectively, in analogy with the statistical concepts. In this context, Type I error corresponds to the cost of not renegotiating loans that need modifying, while Type II error corresponds to the cost of modifying loans that would be repaid in the absence of assistance. The third term, with mass α_1, includes borrowers who will default regardless of whether they receive a modification. For these borrowers, modification yields a periodic payment, but postpones foreclosure. Whether this is good or bad for the lender depends on the evolution of house prices and the rate at which the lender discounts the cash flow.

To illustrate the implications of the model, we compute some simple comparative statics. All else being equal, an increase in α_0 makes modification more attractive to the investor, while an increase in α_1 makes modification less attractive. Intuitively, a higher α_0 means

higher Type I error and lower Type II error, and a higher α_1 implies higher Type II error. Since, in general, one would think that α_0 and α_1 would move in the same direction across borrowers, it is useful to note that an increase the gap, $\alpha_0 - \alpha_1$, makes modification more attractive.

We make three points about the model. First, when looking at the data, it is not sufficient to show that one would recover more from a modified loan than from foreclosure *ex post*, to prove that modification is *ex ante* optimal. To prove that a modification makes sense from the perspective of the lender, one must show that the Type I error, the value of the modified loans that would have defaulted, exceeds the Type II error, the value of the modified loans that would have paid off in the absence of modification. White (2009), among many others, focuses entirely on Type I error:

> The average loss for the 21,000 first mortgages liquidated in November was $145,000, representing an average loss of 55 percent of the amount due. Losses on second lien mortgages were close to 100 percent. In comparison, for the modified loans with some amount of principal or interest written off, the average loss recognized was $23,610. This seven-to-one difference between foreclosure losses and modification write-offs is striking, and lies at the heart of the failure of the voluntary mortgage modification program. At a minimum, there is room for servicers to be more generous in writing down debt for the loans they are modifying, while still recovering far more than from foreclosures in the depressed real estate market of late 2008. I will consider some of the reasons for this apparently irrational behavior in a later section.[27]

To see why this is wrong, take an extreme example with $\alpha_1 = 0$. In that case, the gain to modifications equals

$$\alpha_0[m^* + \tfrac{1}{R}M^* - \min[(P_1 - \lambda), M]] - (1 - \alpha_0)[m + \tfrac{1}{R}M - (m^* + \tfrac{1}{R}M^*)]. \tag{4}$$

With α_0 sufficiently low, modification will not make sense. To be clear, our criticism of White (2009) and others has nothing to do with the possibility that the modified loan will default, as we have assumed here that the modified loan will pay off in full.

The second point here is that both the rate at which lenders discount future payoffs and the evolution of prices affect the gains to modification. For mass $(1 - \alpha_1)$ of the borrowers, modification will simply delay foreclosure. In that case, the lender will get some extra income from any mortgage payments the borrower makes before redefaulting, but the lender has to wait longer to obtain the final payout and will get less if prices continue to fall.

[27] White (2009), p. 14–15

The third point is that the lender's information set plays a crucial role here, and one could argue that it should only contain information outside the control of the borrower. This would limit the set to the origination characteristics of the loan, prices, and interest rates. Employment status, income, and marital status all present problems, although they can be partially overcome—as in the case of unemployment insurance. Delinquency status, which seems a natural candidate, is a difficult issue. On one hand, a borrower has virtually complete control over it. On the other hand, it is a costly signal, as a 60-day delinquency does adversely affect one's credit history and future access to credit markets. Thus, when considering ways to design a profitable modification program, which implies attempting to maximize α_0 and minimize α_1, a lender must restrict its information set to a relatively small set of variables that are contemporaneously exogenous to the borrower.

4.2 Institutional Evidence

While the results from Section 3 may be surprising to market commentators who believe that contract frictions inherent in securitization trusts are preventing large-scale modification efforts in mortgage markets, we argue in this section that both historical evidence and evidence from securitization contracts actually support our findings.

First, we look at history. If securitization, or more precisely private-label securitization, inhibits renegotiation, then we would expect that renegotiation would have been common in the 1990s, when there was little private-label securitization, or in the 1970s, when securitization itself was rare. But, the historical evidence we have does not bear that out. In 1975, Touche Ross surveyed loss mitigation activities at savings and loans and found, "Lenders... were unwilling to either modify loans through extended terms or refinancing to a lower rate."[28] In the 1990s, a report commissioned by Congress to study foreclosure alternatives, said, "Along with loan modifications, long-term forbearance/repayment plans are the most under utilized foreclosure avoidance tools currently available to the industry."[29]

Second, many observers have focused on institutional factors that inhibit loan modification when the loan is securitized, but other factors may play a similar role for portfolio lenders as well. In particular, accounting rules force lenders to take writedowns at the time of the modification (reducing Tier II capital), to identify modified loans as troubled debt restructurings (under FAS 15), and also to impose burdensome reporting requirements on modified loans including loan-specific allowances for potential losses (under FAS 114). Additionally, payments made by borrowers for loans that are subject to "troubled debt re-

[28] Capone (1996), p. 20–21.
[29] Capone (1996), p. x.

structurings" are recognized only as principal repayments and generate to interest income until the bank can demonstrate that a borrower is "performing." All of the above accounting requirements potentially make modifications costly for a bank. Downey Financial, for example, attempted to refinance current borrowers out of risky option ARMs into safer, fixed-rate instruments and argued that the change should not affect their balance sheet because the borrowers had never missed payments. However, their accountants viewed the refinancings as "troubled debt restructurings," and forced the firm to restate the share of nonperforming assets for November 2007 to 5.77 percent from 3.65 percent.[30]

If modifications were truly in the best financial interest of investors in mortgage-backed-securities (MBS) as many commentators have alleged, we would expect to see concern on their part regarding the low levels of modifications performed to date. But, according to Cordell, Dynan, Lehnert, Liang, and Mauskopf (2008b), who interviewed a number of MBS investors, they (the investors) are not concerned that servicers are foreclosing on many more mortgages than they are modifying. Thus, there does not seem to be much concern by market participants that either incentives or contract frictions are inhibiting servicers from performing loan modifications. The evidence in the literature seems to suggest a small role for contract frictions in the context of renegotiation. In a 2007 study of a small sample of PSAs, Credit Suisse found that fewer than 10 percent of the contracts ruled out modifications completely, while approximately 40 percent allowed modifications, but with quantity restrictions,[31] and the rest, about half, contained no restrictions on renegotiation behavior. Hunt (2009) also analyzed a sample of subprime PSAs and concluded that outright modification bans were extremely rare. A 2008 report by the COP analyzed a number of securitized mortgage pools with quantity restrictions and concluded that none of the restrictions were binding. In terms of incentive issues, Hunt (2009) found that most of the contracts in his sample explicitly instructed the mortgage servicer to behave as if it were the owner of the pool of the loans:

> The most common rules [in making modifications] are that the servicer must follow generally applicable servicing standards, service the loans in the interest of the certificate holders and/or the trust, and service the loans as it would service loans held for its own portfolio. Notably, these conditions taken together can be read as attempting to cause the loans to be serviced as if they had not been securitized. (p. 8, insertion added)

[30] http://www.housingwire.com/2008/01/14/downey-financial-accounting-rules-suck/

[31] The quantity restrictions often took the form of a limit (usually 5 percent) on the percentage of mortgages in the pool that could be modified without requesting permission from the trustee.

5 Conclusion

There is widespread concern that an inefficiently low number of mortgages have been modified during the current crisis, and that this has led to excessive foreclosure levels, leaving both families and investors worse off. We use a large dataset that accounts for approximately 60 percent of mortgages in the United States originated between 2005 and 2007, to shed more light on the determinants of mortgage modification, with a special focus on the claim that delinquent loans have different probabilities of renegotiation depending on whether they are securitized by private institutions or held in a servicer's portfolio. By comparing the relative frequency of renegotiation between private-label and portfolio mortgages, we are able to shed light on the question of whether institutional frictions in the secondary mortgage market are inhibiting the modification process from taking place.

Our first finding is that renegotiation in mortgage markets during this period was indeed rare. In our full sample of data, approximately 3 percent of the seriously delinquent borrowers received a concessionary modification in the year following their first serious delinquency, while fewer than 8 percent received any type of modification. These numbers are extremely low, considering that foreclosure proceedings were initiated on approximately half of the loans in the sample and completed for almost 30 percent of the sample. Our second finding is that a comparison of renegotiation rates for private-label loans and portfolio loans, while controlling for observable characteristics of loans and borrowers, yields economically small, and for the most part, statistically insignificant differences. This finding holds for a battery of robustness tests we consider, including various definitions of modification, numerous subsamples of the data, including subsamples for which we believe unobserved heterogeneity to be less of an issue, and consideration of potential differences along the intensive margin of renegotiation.

Since we conclude that contract frictions in securitization trusts are not a significant problem, we attempt to reconcile the conventional wisdom held by market commentators, that modifications are a win-win proposition from the standpoint of both borrowers and lenders, with the extraordinarily low levels of renegotiation that we find in the data. We argue that the data are not inconsistent with a situation in which, on average, lenders expect to recover more from foreclosure than from a modified loan. At face value, this assertion may seem implausible, since there are many estimates that suggest the average loss given foreclosure is much greater than the loss in value of a modified loan. However, we point out that renegotiation exposes lenders to two types of risks that are often overlooked by market observers and that can dramatically increase its cost. The first is "self-cure risk," which refers to the situation in which a lender renegotiates with a delinquent borrower who

does not need assistance. This group of borrowers is non-trivial according to our data, as we find that approximately 30 percent of seriously delinquent borrowers "cure" in our data without receiving a modification. The second cost comes from borrowers who default again after receiving a loan modification. We refer to this group as "redefaulters," and our results show that a large fraction (between 30 and 45 percent) of borrowers who receive modifications, end up back in serious delinquency within six months. For this group, the lender has simply postponed foreclosure, and, if the housing market continues to decline, the lender will recover even less in foreclosure in the future.

We believe that our analysis has some important implications for policy. First, "safe harbor provisions," which are designed to shelter servicers from investor lawsuits, are unlikely to have a material impact on the number of modifications and thus will not significantly decrease foreclosures. Second, and more generally, if the presence of self-cure risk and redefault risk do make renegotiation less appealing to investors, the number of easily "preventable" foreclosures may be far smaller than many commentators believe.

A Appendix: Identifying Modifications in the LPS Dataset

In this section we discuss in detail the assumptions that we used to identify modified loans in the LPS dataset. The LPS dataset is updated on a monthly basis, and the updated data include both new mortgages originated and a snapshot of the current terms and delinquency status of outstanding mortgages. Essentially, for a given mortgage, we compare the updated terms to the terms at origination, as well as the change in terms from the proceeding month, and if there is a material change over and above the changes stipulated in the mortgage contract, then we assume that the contract terms of the mortgage have been modified.

A.1 Interest Rate Reductions

We use a different set of rules to identify reduced interest rates for fixed-rate mortgages (FRM) and adjustable-rate mortgages (ARM). In principle, identifying a rate change for an FRM should be easy, since by definition the rate is fixed for the term of the mortgage. However, after a detailed inspection of the LPS data, it became apparent that some of the smaller rate fluctuations were likely due to measurement error rather than to an explicit modification. Thus, we adopt a slightly more complex criterion: The difference between the rate at origination and the current rate must be greater than 50 basis points; *and* the difference between the rate in the previous month and the current rate must be greater than 50 basis points; *and* either the mortgage must be 30-days delinquent with the loan currently in loss mitigation proceedings (as reported by the servicer) or the difference between the rate in the previous month and the current rate must be greater than 300 basis points (which allows for the possibility that a loan that is current could feasibly qualify for a modification).

Identifying interest rate reductions for ARMs is slightly more complicated, since by definition the interest rate is variable and can move both up and down. The LPS data contain the information necessary to figure out how much the interest rate should move from month to month. This rate is often referred to as the fully indexed rate, as it is normally specified as a fixed spread above a common nominal interest rate. The LPS dataset contains information regarding the initial rate, the appropriate index rate, and the spread between the index and the mortgage rate. In addition, the majority of ARMs are characterized by a period at the beginning of the contract in which the interest rate is held constant (these mortgages are often referred to as hybrid ARMs). At the end of this period, the interest rate adjusts (or resets) to a certain spread above an index rate and then subsequently adjusts at a specific frequency. The LPS dataset also contains information regarding the length of

the initial fixed period, enabling us to identify this period in the data and determine the point at which the interest rate should begin to adjust (we refer to this period as the reset date). Our criterion for identifying an interest rate reduction for an ARM is as follows: The difference between the rate at origination and the current rate must be greater than 50 basis points; *and* the difference between the rate in the previous month and the current rate must be greater than 50 basis points; *and* if the reset date has passed, then the difference between the fully-indexed rate and the current rate must be at least 100 basis points ; *and* either the mortgage must be 30-days delinquent with the loan currently in loss mitigation proceedings (as reported by the servicer) or the difference between the rate in the previous month and the current rate must be greater than 300 basis points (which allows for the possibility that a loan that is current could feasibly qualify for a modification). In addition, we allow for more modest month-to-month decreases in the interest rate (200 to 300 basis points) as long as there is also a positive change in the delinquency status of the loan (that is, the loan is reported to be less delinquent). Our inspection of the data suggests that the majority of modifications involve a resetting of the delinquency status back to current, or a minor delinquency, so conditioning on this change likely eliminates many false positives.

A.2 Term Extensions

In theory, it should be straightforward to identify term extensions in the LPS data, but it can be tricky to do so because of possible measurement error in the variable that measures the remaining maturity of each loan. We defined a term extension in the LPS dataset to be a case in which the loan was at least 30-days delinquent at some point and the number of years remaining increases by at least 20 months *or* the change in number of years remaining is greater than the difference between the original term of the loan and the remaining term (for example, if the original maturity is 360 months, and the loan has 350 months remaining, then the increase in length must be at least 10 months) and, finally, either the monthly payment decreases *or* the principal balance increases *or* the loan is in loss mitigation.

A.3 Principal Balance Reductions

A reduction in the remaining balance of a mortgage is perhaps the most difficult type of modification to identify because of the prevalence of "curtailment" or partial prepayment among mortgage borrowers. For example, it is common for borrowers to submit extra mortgage payments in order to pay down the loan at a faster rate. For this reason, we were forced to adopt strict criteria to limit the number of false positives. Our criterion for identifying a principal balance reduction is as follows: The month-to-month decrease in

the remaining principal balance must be at least -10 percent and cannot be more than -30 percent (the upper bound does not matter as much as the lower bound—we experimented with -40 percent and -50 percent, but did not find a substantial difference); the principal balance recorded in the previous month must be greater than $25,000 (since we throw second liens out, and look only at mortgages originated after 2004, this cutoff does not bind often); the month-to-month payment change must be negative (there are only a few cases in which the principal balance is reduced without a corresponding decrease in the payment, but in these cases the term is extended, and thus is picked up in our code for identifying term extensions); and, finally, the mortgage must be either 30-days delinquent or currently in loss mitigation proceedings (as reported by the servicer).

A.4 Principal Balance Increases

For interest-only and fully-amortizing mortgages, identifying an increase in the principal balance due to the addition of arrears is relatively straightforward. It becomes trickier for mortgages that allow for negative amortization, as the principal balance is allowed to increase over the course of the contract, by definition. For interest-only and fully-amortizing mortgages our criterion is: The month-to-month principal balance must increase by at least 0.5 percent (to rule out measurement error in the data); the loan must have been at least 30-days delinquent at the time of the balance increase; and, finally, the month-to-month payment change must be positive unless there is also a corresponding increase in the term of the loan. For mortgages that allow for negative amortization, the criterion is similar, except that the balance increase must be at least 1 percent and there must be a positive change in the delinquency status of the loan.

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Table 1: Examples of modifications in the data.

Example 1: Servicer cuts interest rate, capitalizes arrears in the balance of the loan and extends term to 40 years.

Date	MBA Delinq. Stat.	Interest Rate	Monthly Payment	Outstanding Balance	Remaining Term in Months
2008m10	9	6.5	907	141,323	340
2008m11	9	6.5	907	141,323	339
2008m12	9	6.5	907	141,323	338
2009m1	C	4.5	660	146,686	479

Example 2: Servicer capitalizes arrears into the balance of the loan but otherwise leaves the loan unchanged.

Date	MBA Delinq. Stat.	Interest Rate	Monthly Payment	Outstanding Balance	Remaining Term in Months
2008m5	6	9.25	1,726	208,192	346
2008m6	9	9.25	1,726	208,192	346
2008m7	9	9.25	1,726	208,192	346
2008m8	C	9.25	1,815	218,316	341
2008m9	C	9.25	1,815	218,184	340

Table 2: Robustness of the modifications algorithm

False positives by type of modifications

	# of Modifications Using WF CTS Data	False Positives
FRM Rate Reduction	5,381	8.0%
ARM Rate Reduction	8,951	22.0%
Principal Reductions	470	1.9%
Principal Increases	13,010	12.8%
Term Increases	394	2.3%

Overall success of algorithm

	No Mod Using Our Algorithm	Mod Using Our Algorithm	Total
No Mod in WF Data	2,329,187	3,559	2,332,746
Mod in WF Data	3,627	17,514	21,141
Total	2,332,814	21,073	2,353,887

Notes: We test our algorithm on a dataset of securitized mortgages in which the trustee has identified modifications (data is from Wells Fargo Trustee Services). The lower panel shows that about 17.2% of our modifications are false positives, meaning that we identify modifications but the trustee does not and about 16.9% are false negatives, meaning that the trustee identifies a modification but we do not.

Table 3: Modification Statistics

(1) By Type of Modification: 2007:Q1–2008:Q4

	# Loans Modified	Interest Rate Reductions		Principal Balance Reductions		Principal Balance Increases		Term Extensions	
		#	(% total)	#	(% total)	#	(% total)	#	(% total)
2007:Q1	10,940	600	5.3	700	6.2	8,660	76.4	1,380	12.2
2007:Q2	14,600	820	5.4	550	3.7	11,630	77.3	2,050	13.6
2007:Q3	17,720	770	4.1	810	4.3	15,170	81.2	1,940	10.4
2007:Q4	27,150	2,990	9.7	700	2.3	22,520	72.8	4,740	15.3
2008:Q1	36,230	6,010	13.8	900	2.1	32,100	73.8	4,500	10.3
2008:Q2	44,750	9,050	16.4	1,300	2.4	39,750	72.1	5,030	9.1
2008:Q3	62,190	16,280	20.3	940	1.2	56,940	70.9	6,110	7.6
2008:Q4	74,800	28,630	26.7	1,450	1.4	65,960	61.5	11,230	10.5

(2) By Payment Change

	Payment Decreases					Payment Increases				
	#	mean Δ		median Δ		#	mean Δ		median Δ	
		$	%	$	%		$	%	$	%
2007:Q1	2,080	-492	-13.2	-157	-10.0	5,020	106	6.7	62	4.4
2007:Q2	2,060	-464	-12.7	-141	-9.6	7,710	120	7.0	63	4.4
2007:Q3	2,470	-290	-12.9	-125	-9.7	10,380	110	6.7	60	4.3
2007:Q4	5,600	-367	-15.3	-159	-11.7	14,540	100	5.9	59	3.9
2008:Q1	11,500	-358	-14.0	-210	-13.2	18,720	108	6.5	62	4.3
2008:Q2	18,660	-425	-16.1	-239	-14.1	20,770	124	7.4	69	4.1
2008:Q3	31,770	-562	-21.5	-365	-20.2	26,400	124	6.3	63	3.6
2008:Q4	48,000	-503	-22.9	-315	-21.7	22,520	104	6.0	53	3.6

(3) Loan Characteristics of Modified Mortgages

	All Loans					Modifications				
	#	mean	p25	p50	p75	#	mean	p25	p50	p75
FICO (at origination)	1,892,777	706	660	713	762	17,533	622	580	621	662
LTV (at origination)	2,250,162	75	67	79	85	21,675	82	78	80	90
DTI (at origination)	1,346,093	37	28	38	45	13,945	41	35	41	47
Mortgage balance (at origination)	2,267,497	231K	121K	185K	288K	21K	234K	121K	186K	294K
% characterized as										
LTV = 80	14.4					21.7				
Subprime	6.8					47.4				
Fixed	71.2					39.7				
Hybrid ARM	7.7					26.2				
IO-ARM	11.3					13.1				
IO-Fixed	2.1					2.7				
Option-ARM	5.1					12.0				
Option-Fixed	0.3					1.4				
Owner	89.3					96.0				
Investor	7.1					2.6				
Vacation Home	3.7					1.1				
Purchase	51.9					49.0				
Low/no documentation	29.2					20.4				

Notes: These statistics were computed using a 10% random sample of the LPS data. Quantities obtained from the data are multiplied by a factor of 10. The percentages in panels (1) and (2) are taken with respect to the total number of modifications, and *not* loans modified. Thus, there is double-counting in the sense that some loans received multiple types of modifications in a given quarter.

Table 4: Modification Comparison by Payment Change

Private-label Modifications

	Payment Decreases					Payment Increases				
	#	mean		median		#	mean		median	
		$	%	$	%		$	%	$	%
2007:Q1	106	-614	-14.42	-162	-10.85	239	121	6.02	76	3.37
2007:Q2	110	-505	-12.02	-222	-9.30	364	168	7.96	76	3.49
2007:Q3	128	-261	-11.82	-131	-8.42	558	145	7.52	75	3.65
2007:Q4	288	-313	-13.38	-163	-12.36	741	125	6.24	74	3.52
2008:Q1	634	-393	-16.12	-261	-15.65	938	133	6.76	79	4.08
2008:Q2	1,014	-540	-18.94	-334	-17.89	1,241	152	8.14	83	4.08
2008:Q3	1,778	-641	-22.01	-423	-19.95	1,805	137	6.22	70	3.31
2008:Q4	1,993	-565	-21.73	-367	-20.13	1,398	118	5.91	61	3.23

Portfolio Modifications

	Payment Decreases					Payment Increases				
	#	mean		median		#	mean		median	
		$	%	$	%		$	%	$	%
2007:Q1	28	-759	-20.90	-428	-17.19	128	106	7.78	52	5.46
2007:Q2	19	-1172	-25.17	-656	-28.07	222	81	6.11	55	5.28
2007:Q3	31	-395	-17.13	-168	-15.29	255	71	6.13	43	5.37
2007:Q4	90	-474	-11.11	-90	-2.48	292	70	5.50	37	4.29
2008:Q1	187	-369	-10.00	-183	-8.08	331	80	6.59	33	3.97
2008:Q2	309	-304	-10.90	-117	-6.64	405	63	5.59	34	3.56
2008:Q3	376	-585	-25.19	-295	-17.85	359	105	7.04	39	4.26
2008:Q4	616	-794	-31.91	-384	-25.04	389	59	5.48	35	3.51

Table 5: Modifications (Main Sample)

Panel A: Unconditional Percentages

	Concessionary Mods	All Mods	All Mods + Prepayments
Portfolio	0.032	0.087	0.147
Private-label	0.026	0.084	0.155

Panel B: Logit Regressions (12 month horizon)

	Concessionary Mods	All Mods	All Mods + Prepayments
Private-label	-0.003	0.002	0.009
	-1.69	0.58	1.95
Initial Rate	0.001	-0.004	-0.007
	1.45	-5.7	-7.25
LTV Ratio	0	0	-0.002
	-0.24	-1.68	-11.14
$LTV = 80$	0	-0.014	-0.034
	-0.18	-6.25	-11.7
$FICO$	0	0	-0.002
	-0.02	-0.43	-4.62
$FICO^2$	0	0	0
	-0.39	-0.08	3.95
$FICO < 620$	0.002	0.029	0.034
	0.53	3.43	3.42
$620 \leq FICO < 680$	0.005	0.017	0.024
	1.46	2.95	3.41
Log Original Amount	0.004	0.007	0.022
	3.12	2.96	7.47
Equity at Delinquency	-0.001	-0.003	0
	-0.4	-1.09	0
Negative Equity	-0.006	-0.022	-0.022
	-1.6	-3.17	-1.77
Unemployment	0	-0.002	-0.005
	-0.37	-3.13	-4.37
Refi	0.006	0.015	0.04
	4.14	5.98	11.67
Subprime	0.02	0.037	0.042
	9.32	11.71	10.87
Other Controls	Y	Y	Y
# Mortgages	66,541	66,541	66,541

Panel C: Duration Model

	Concessionary Mods	All Mods	All Mods + Prepayments
Private-label	0.921	1.002	1.018
	-1.41	0.07	0.68
# Mortgages	87,343	87,343	87,343

Notes: Other controls include indicator variables for Jumbo, Option, Hybrid and Interest-Only mortgages, as well as for condos and multifamily homes. Panel B shows the marginal effects of logit regressions with a 12-month horizon, t-statistics shown below the coefficients. Standard errors are clustered at the zip code level. Panel C shows hazard ratio estimates from a Cox proportional hazards model.

Table 6: Modifications (Robustness tests with alternative samples)

Panel A: Concessionary Modifications

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.032	0.047	0.034	0.028	0.023
Private-label Mean	0.026	0.037	0.031	0.033	0.037
Marginal Effect	-0.003	-0.004	-0.003	0	0.007
(private-label)	-1.69	-0.94	-0.77	-0.14	1.46
# Mortgages	66,541	33,719	27,639	25,543	18,097

Panel B: All Modifications

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.087	0.111	0.097	0.092	0.077
Private-label Mean	0.084	0.103	0.109	0.107	0.124
Marginal Effect	0.002	0.004	0.007	0.006	0.025
(private-label)	0.58	0.61	1.06	0.97	2.94
# Mortgages	66,541	33,719	27,639	25,543	18,097

Notes: Portfolio and private-label means are unconditional probabilities of modification in each sample. Marginal effects are computed from logit models with a 12-month horizon that include all the controls in Table 5. Standard errors are clustered at the zip code level. t-statistics are reported below the marginal effects.

Table 7: Modifications Conditional on 30 Days Delinquency (Logits)

Panel A: Concessionary Mods

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.014	0.025	0.016	0.014	0.012
Private-label Mean	0.014	0.021	0.016	0.017	0.019
Marginal Effect	-0.003	-0.005	-0.001	-0.002	0.001
(Logit)	-2.72	-2.31	-0.55	-1.57	0.37
Hazard Ratio	1.03	1.147	1.027	0.969	1.237
(Cox)	0.59	1.83	0.31	-0.42	2.34
# Mortgages	120,558	51,285	43,550	47,993	34,403

Panel B: All Mods

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.038	0.056	0.051	0.042	0.052
Private-label Mean	0.042	0.055	0.051	0.047	0.035
Marginal effect	-0.004	-0.007	-0.004	-0.008	-0.001
(Logit)	-2.39	-1.79	-1.22	-3.16	-0.2
Hazard Ratio	1.043	0.951	1.008	0.909	1.065
(Cox)	1.42	-1.05	0.17	-2.23	1.21
# Mortgages	120,558	51,285	43,550	47,993	34,403

Panel C: All Mods + Prepayment

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.145	0.195	0.152	0.147	0.13
Private-label Mean	0.174	0.211	0.218	0.185	0.198
Marginal effect	0.023	0.021	0.044	0.016	0.029
(Logit)	7.31	2.98	6.46	3.47	4.54
Hazard Ratio	1.158	1.05	1.181	1.098	1.202
(Cox)	9.09	1.69	5.72	3.88	6.56
# Mortgages	120,558	51,285	43,550	47,993	34,403

Notes: Portfolio and private-label means are unconditional probabilities of modification in each sample. Marginal effects are computed from logit models with a 12-month horizon that include all the controls in Table 5. Hazard ratios are computed from Cox proportional hazard models with the same controls as in Table 5. z-statistics are shown below the coefficients, and t-statistics are reported below the marginal effects. Standard errors are clustered at the zip code level. Sample sizes refer to the logit regressions. The sample sizes for the Cox models are slightly larger.

Table 8: redefault Conditional on Modification

Panel A: Payment Reducing Mods

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.308	0.386	0.332	0.228	0.249
Private-label Mean	0.358	0.392	0.371	0.362	0.359
Marginal effect	0.016	-0.001	-0.015	0.03	-0.004
(Logit)	0.66	-0.03	-0.35	0.81	-0.1
# Mortgages	4,626	2,514	1,562	1,475	1,135

Panel B: All Mods

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.393	0.53	0.444	0.404	0.403
Private-label Mean	0.449	0.5	0.501	0.482	0.482
Marginal effect	0.008	-0.023	-0.009	-0.021	-0.033
(Logit)	0.58	-0.84	-0.38	-0.97	-1.24
# Mortgages	14,796	7,073	5,344	4,594	3,620

Notes: redefault is defined as loans that are 60 days delinquent, 90 days delinquent, in the process of foreclosure or in REO 6 months after the modification. Marginal Effects refer to the marginal effects of a logit model with a horizon of 6 months. t-statistics shown below the marginal effects. Standard errors are clustered at the zip code level.

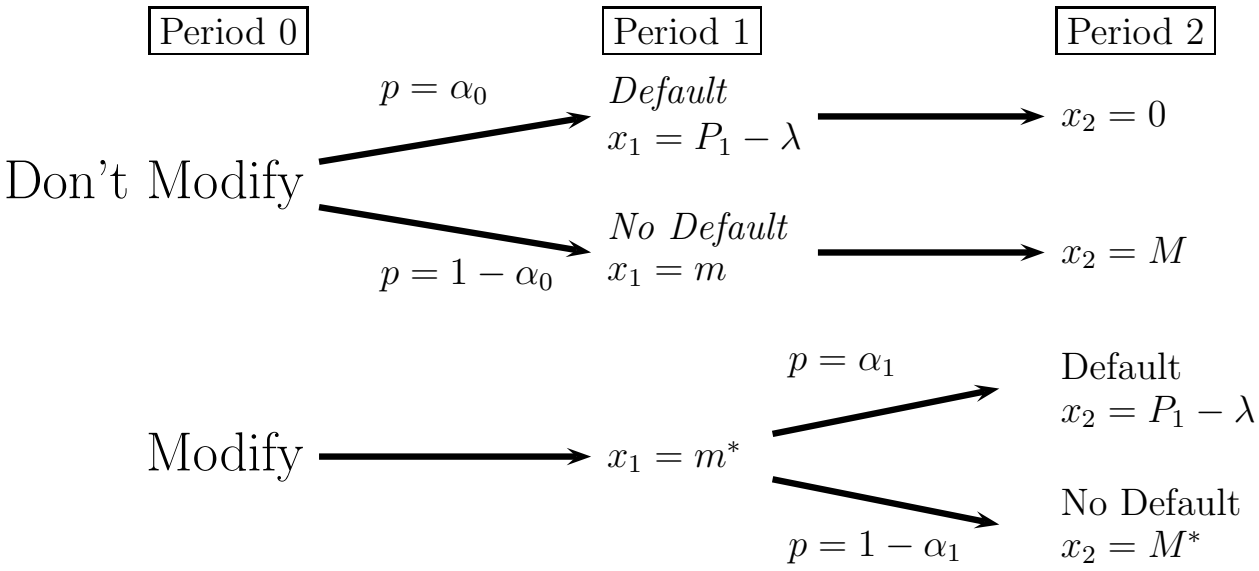
Table 9: Cure Conditional on 60 Days Delinquency

	All Loans	Subprime	$FICO < 620$	Non-missing Documentation and DTI	Fully Documented
Portfolio Mean	0.300	0.257	0.320	0.280	0.299
Private-label Mean	0.256	0.289	0.328	0.289	0.324
Marginal effect	-0.022	0.043	0.004	0.022	0.025
(Logit)	-4.32	4.31	0.44	2.8	2.43
# Mortgages	66,451	33,719	27,639	25,543	18,097

Notes: The dependent variable ("Cure") is defined as a loan that is either current, 30 days delinquent, or prepaid 12 months after the first 60-day delinquency. Portfolio and Private-label means are unconditional probabilities of modification in each sample. Marginal effects are computed from logit models with a 12-month horizon that include all the controls in Table 5. Standard errors are clustered at the zip code level. t-statistics are reported below the marginal effects.

Figure 1:

(1) Model of loan modification



(2) Understanding the lender's gains from modification

Share of borrowers	$1 - \alpha_0$	$\alpha_0 - \alpha_1$	α_1
Description	Borrower always repays Lender loses because borrower would have paid in full	Modification effective Lender gains because modified payments worth more than foreclosure	Borrower never repays Foreclosure is delayed May or may not help lender
Net gain	$m^* + \frac{1}{R}M^* - (m + \frac{1}{R}M)$	$m^* + \frac{1}{R}M^* - (P_1 - \lambda)$	$m^* + \frac{1}{R}(P_2 - \lambda) - (P_1 - \lambda)$
Error	"Type II error" Costly assistance to borrowers who can pay	"Type I error" Don't help borrowers who would have defaulted	"Type III error" Lender loses if R is large or if $P_1 - P_2$ is big