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Chapter Authors: Christopher Foote, Kristopher Gerardi, Lorenz Goette, Paul Willen

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Reducing Foreclosures: No Easy Answers

Christopher Foote, *Federal Reserve Bank of Boston*
Kristopher Gerardi, *Federal Reserve Bank of Atlanta*
Lorenz Goette, *University of Lausanne*
Paul Willen, *Federal Reserve Bank of Boston and NBER*

I. Introduction

One of the most important challenges now facing U.S. policy makers 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,

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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%–11%, depending on the borrower.[2] By contrast, a 1-percentage-point increase in the unemployment rate raises this probability by 10%–20%, while a 10-percentage-point fall in house prices raises it by more than half.

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% 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 data set that includes both securitized and nonsecuritized 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 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 II outlines a simple model of the default decision that helps organize ideas about potential sources of the foreclosure crisis. Section III 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 IV 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 V concludes with some lessons for foreclosure reduction policy that are suggested by our results.

II. 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, a loan that would have been sustainable" (Harnick 2009, 5).

The claim that the foreclosure crisis results from unaffordable or unsustainable loans has been endorsed by a number of influential policy analysts.[6] 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 noneconomist might say, "For me, the dry-aged rib eye at Whole Foods ($19.99 a pound) is unaffordable." The problem is that, for most Americans, a regular diet of rib eye steaks is attainable; a consumption bundle that includes 2 pounds of rib eye every night is not impossible for most families. They do not choose this bundle because of relative prices: the trade-off between the rib eye and other consumption is unappealing (e.g., the family might prefer a new car). In this case, economists, if they were being precise, would say that the rib eye 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."

A. 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 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.[7]

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:[8]

$$\text{Default} \Leftrightarrow \frac{\alpha_G(P_2^G - M_2) + \Lambda}{mM_1 - \text{rent}_1} < 1 + r. \tag{1}$$

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 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 (see, e.g., Kau, Keenan, and Kim 1994).

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

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

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

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

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

2. *High monthly payments*. All else equal, higher m makes the mortgage less attractive. This is consistent with the views expressed in the Harnick quotation at the beginning of 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 Harnick quotation 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 is more likely to have a high shadow riskless rate.

B. 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 affordibility" 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 policy maker needs to forecast the evolution of stochastic variables such as income, payments, 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,

one 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 2 years, after which the payment is determined by the so-called fully indexed rate, typically hundreds of basis points over the 6-month London interbank offered rate (Libor).[9] We assume that the initial rate is 8.5% (the average initial rate for a sample of 2/28 ARMs originated in 2005) and that the first adjustment occurred in 2007, when the 6-month Libor was 5.25%. A spread over Libor of 600 basis points was typical during this period and would imply a fully indexed rate of 11.25%, 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 they have accounted for a hugely disproportionate share of delinquencies and foreclosures in the past 2 years. Other loans, like option ARMs, allow for negative amortization and have far higher payment shocks at reset, but these 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% of borrowers will end up with unaffordable mortgages at some point in the first 3 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% of income.

The second finding is that resets are of only limited importance. Many commentators have put the resets at the heart of the crisis, but

Table 1
Probability (%) That a Loan Will Become "Unaffordable" at Least Once in the First 3 Years, Where Unaffordability Is Defined as DTI above a Certain Threshold

	(1)	(2)	(3)	(4)
SD (η_t)	15	15	0	15
SD (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	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	38.3
38%	36.5	51.8	.0	54.8
50%	69.7	81.4	100.0	72.0

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% 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% of the loans will become unaffordable even without the reset. The reset only raises that figure to about 80%. If, however, 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 of table 1 shows that, if the ex post criterion is 50%, then loans with 31% DTI at origination become unaffordable only about 16% of the time, whereas those with 50% DTI do so roughly 70% 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 (2002). 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% DTI to 31% DTI only lowers the number of borrowers who will face ex post unaffordability by 30% from 54% to 38%. Put another way, if our goal is "sustainable" mortgages, neither 31% nor 38% would fit that definition.

III. 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.

A. Data

The data used in this paper come from loan-level records, compiled by LPS Applied Analytics, Incorporated, from large loan-servicing organizations.[10] This data set 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 at a fixed rate or an 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 (i.e., current or 30, 60, or 90 days delinquent or in foreclosure, etc.). We also know whether a loan ended in payment, prepayment, or default.

As of December 2008, the LPS data set covered nearly 60% of the active residential mortgages in the United States, representing about 29 million loans with a total outstanding balance of nearly $6.5 trillion.[11] Nine of the top 10 servicers in the United States are present in our data, including Bank of America/Countrywide and Wells Fargo. Cordell et al. (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.[12] Additionally, we usually have access to other variables reflecting risk, including the borrower's credit (i.e., FICO) score, loan-to-value at origination, and so forth. This allows us to condition on several factors affecting loan quality.

One of the strengths of the LPS data set 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, etc.). About 33% of the mortgages in the data set are held in the securities of Fannie Mae, with another 22% held in Freddie Mac securities. Around 18% of the loans are held in "private securitized" pools; these are the loans that are also covered by the well-known LoanPerformance data set.[13] A little less than 10% of the loans in the LPS data are held in the portfolio of the servicer itself.

While the LPS data set now covers more than half of the U.S. mortgage market, coverage was not as extensive in earlier years. The LPS data set 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 data set, that servicer's existing portfolio is incorporated into the data set. 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.[14] 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 the 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 II would predict. A final concern about the LPS data is that we do not know whether there are other loans on the

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
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
B. Percentages:						
GSE securitized:						
Fannie Mae	32.73	.03	.17	.00	.00	32.93
Freddie Mac	22.06	.01	.03	.00	.00	22.10
Ginnie Mae	16.38	.00	.00	.00	.00	16.38
Private securitized	14.69	.73	1.69	.42	.00	17.54
Portfolio	7.74	1.44	.31	.04	.11	9.63
Unknown	.42	.01	.03	.00	.00	.46
Other	.95	.01	.00	.00	.00	.96
Total	94.98	2.22	2.22	.47	.11	100.00

Note: 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

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 data set, 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.[15]

B. 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.[16] 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% 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%, whereas 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%. 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%, with additional bunching at multiplies of five lying between 80% and 100%. Recall that, in the LPS data, an LTV of 80% does not necessarily correspond to 20% 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 data set, nor is there a flag to denote whether any given loan is the only lien on the property. The large number of 80% 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%.[17]

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.[18] Figures 2 and 3 present the distributions for these data; unlike the figures

Table 4
Summary Statistics: Loans Originated from 2005 to 2008

	Prime		Subprime	
	Mean	SD	Mean	SD
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	

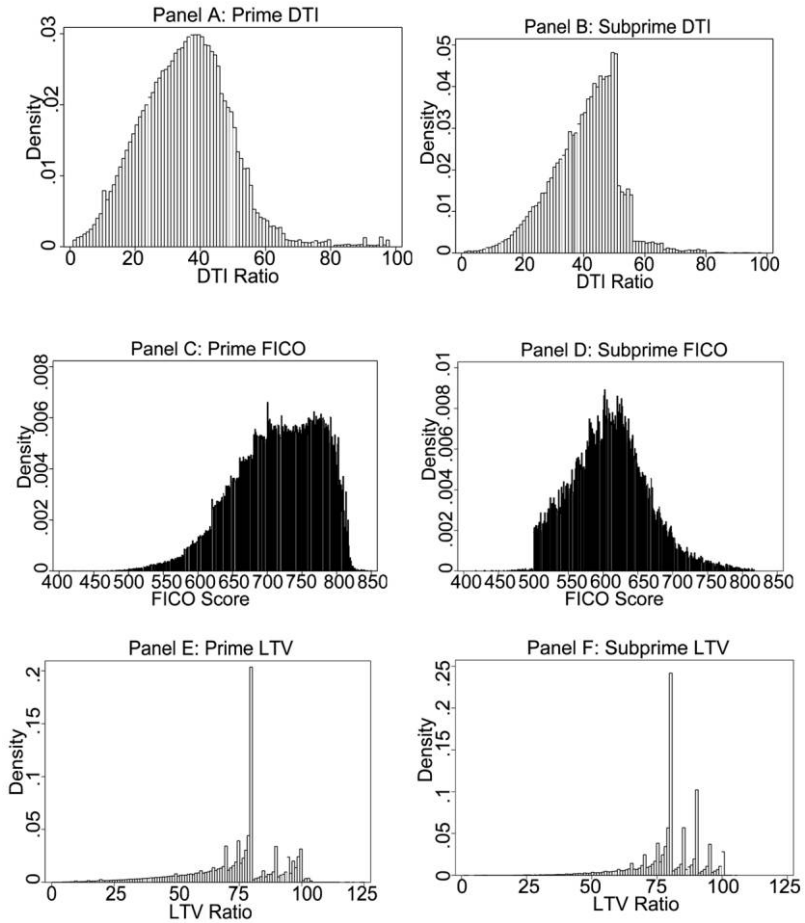

Fig. 1. Loan-specific characteristics in LPS sample

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 and 2006), when house prices were rising. In our empirical work, we allow positive price changes to have different effects than negative price changes.[19]

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

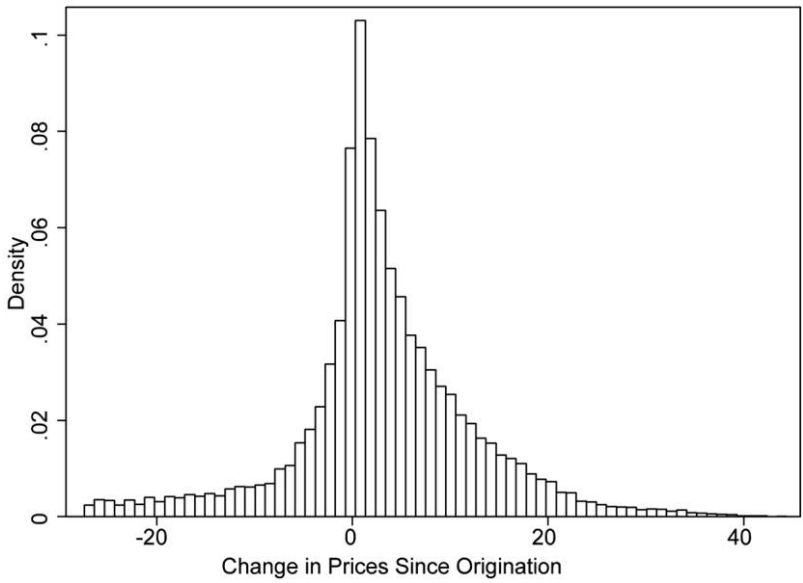

Fig. 2. Cumulative changes in state-level house prices for LPS loans

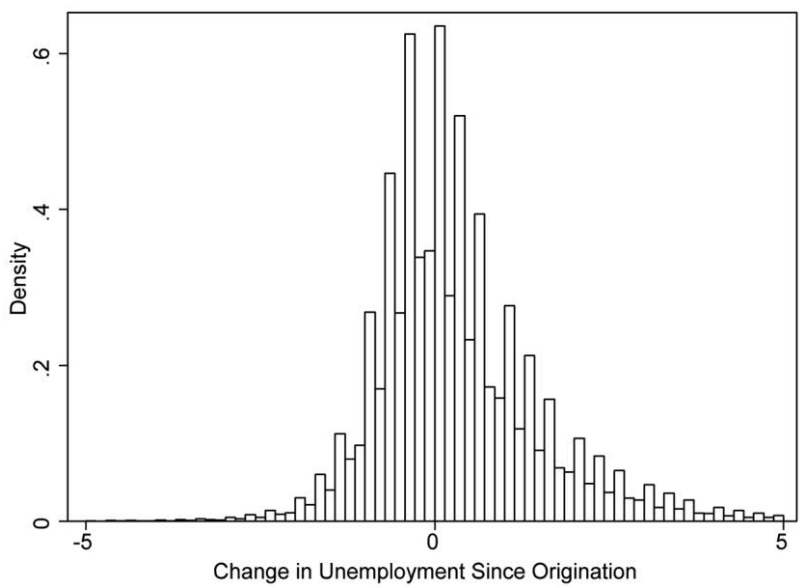

Fig. 3. Cumulative changes in county-level unemployment for LPS loans

default or a prepayment, conditional on a vector of covariates 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 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

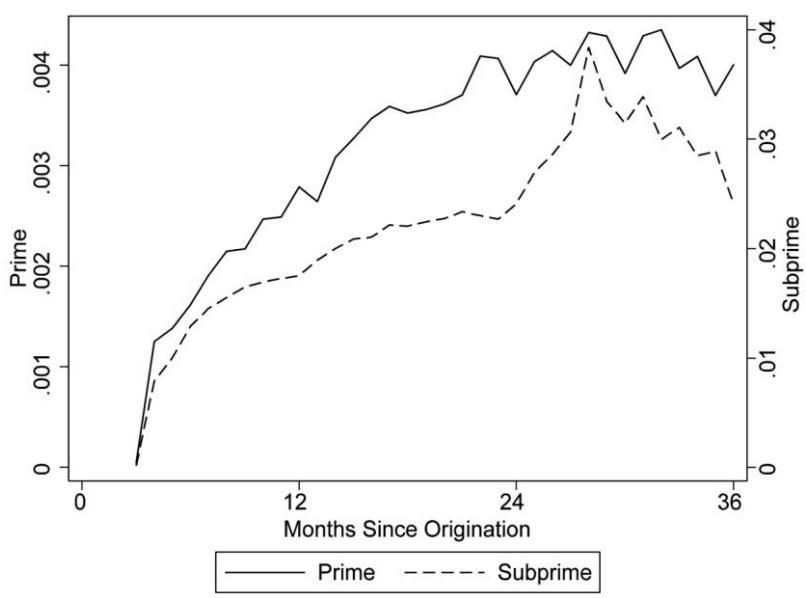

Fig. 4. Baseline default hazards, prime and subprime loans

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 (see Foote et al. 2008; Mayer and Pence 2008; Sherlund 2008).

Table 5 presents the coefficients from the Cox models. The model for prime defaults (col. 1) 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

Fig. 5. Baseline prepayment hazards, prime and subprime loans

Table 5
Estimates from Cox Proportional Hazard Models

	Prime Defaults (1)	Subprime Defaults (2)	Prime Prepayments (3)	Subprime Prepayments (4)
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 ≠ 80 dummy	−.2973**	−.1836*	.1126**	.2447**
	(.0453)	(.0738)	(.0219)	(.0286)
Adjustable rate dummy	.7521**	.5074**	.6465**	.5605**
	(.0539)	(.0354)	(.0568)	(.0537)
ΔUR	.2068**	.1007**	−.0344	−.0476
	(.0207)	(.0156)	(.0210)	(.0345)
ΔHP ≥ 0	−.0571**	−.0516**	.0236**	.0384**
	(.0061)	(.0071)	(.0032)	(.0043)
ΔHP < 0	−.0592**	−.0451**	.0555**	.0925**
	(.0051)	(.0049)	(.0062)	(.0088)
ΔHP × ΔUR	.0061**	.0069**	.0015	.0019
	(.0009)	(.0008)	(.0012)	(.0016)
ΔHP × LTV	−.0001	−.0003**	.0007**	.0009**
	(.0001)	(.0001)	(.0001)	(.0001)
ΔHP × DTI	−.0000	.0001	.00010*	.0001
	(.0001)	(.0001)	(.00004)	(.0001)
ΔHP × FICO	−.0000	−.0000	−.00012**	.0000
	(.0000)	(.0000)	(.00002)	(.0000)
ΔUR × FICO	.0010**	.0003**	.0002	-.0000
	(.0001)	(.0001)	(.0001)	(.0000)
FICO × DTI	.0000	−.000055**	−.0000	−.00004**
	(.0000)	(.000017)	(.0000)	(.00001)
DTI × ΔUR	−.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

Note: Standard errors are clustered by state. A negative value of a house price change (HP < 0) is entered directly in the regression (not as an absolute value.)
*Significant at the 5% level.
**Significant at the 1% level.

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 1-percentage-point increase in DTI shifts the default hazard up by 1.05%.[20] While statistically significant, the effect is small as a practical matter. Recall that table 4

showed that the SD 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 $\exp(13.8 \times 0.0105) \approx 1.156$. 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 $\exp(-61.6 \times -0.0124) \approx 2.147$.

Other coefficients in column 1 of table 5 also have reasonable signs and magnitudes. More defaults are to be expected among loans with high LTVs as well as loans with LTVs that are exactly 80% (and which thus suggest the presence of a second mortgage). The unemployment rate enters the regression with a large coefficient (.2068), so that a 1-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).[21] These estimates indicate that a 10-percentage-point increase in housing prices shifts the hazard down by about 44%. 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 et al. 2007).

Column 2 of table 5 presents the estimates from the subprime default model.[22] 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 1-SD increase in DTI results in a hazard ratio of $\exp(.0072 \times 11.1) = 1.083$. 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% rather than 8.3%.

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.[23] A second, more serious potential 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 the 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%. Our DTI coefficients again become smaller when we do so. However, better data are 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.[24] 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 are 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 columns 3 and 4 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, 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.[25] 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% for prime loans). The dashed line just above

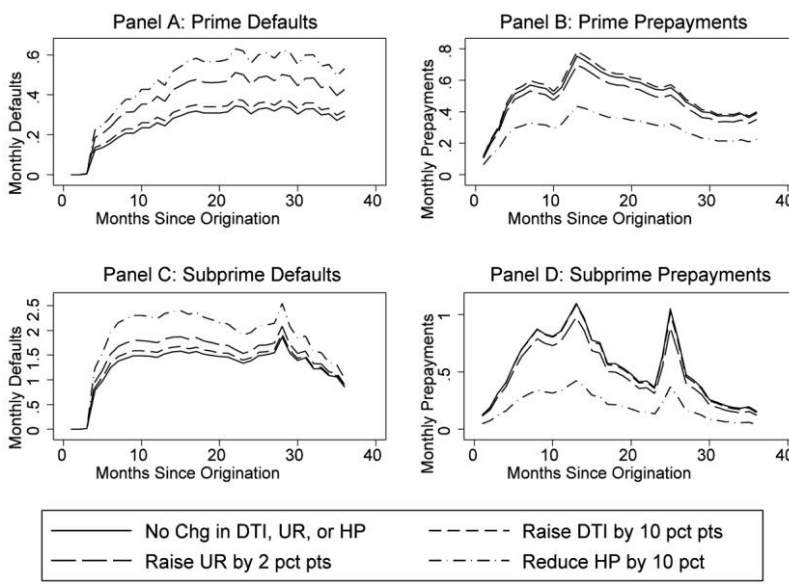

Fig. 6. Model-generated monthly defaults and prepayments (per 100 loans originated) under various assumptions.

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%. 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 of figure 6.

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% to 50%. 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 II. 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.

C. 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 II 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 et al. (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.[26] 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). However, 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 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.[27] Panel A considers people who begin a month in current status. Since January 2001, about 1%–2% 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

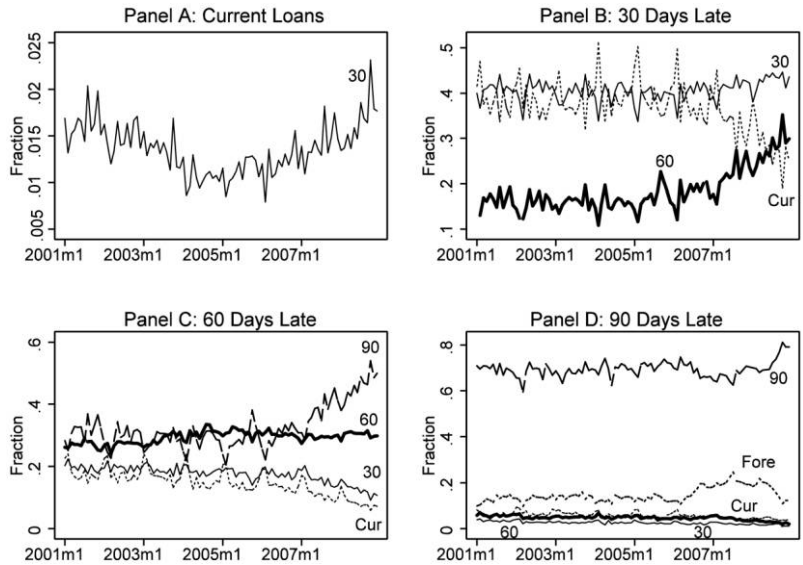

Fig. 7. Roll rates by initial delinquency status

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% of these borrowers make their next payment to remain 30 days late the next month. Until 2007, about 40% of borrowers who were 30 days late made two payments to become current again, with the remaining 20% 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 2 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 that status or they 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 3 consecutive months, then registers a 30-day, a 60-day, and a 90-day delinquency in succession during the next 3 months.
- The borrower had never been seriously delinquent before this 6-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 year in which the default occurred.

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

	Year of Default						
	2003	2004	2005	2006	2007	2008	Total
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 originating years	11.4	10.3	13.1	14.5	26.6	41.6	30.8
B. AZ, CA, FL, and 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 originating years	9.4	5.5	6.0	15.4	36.8	55.1	44.8
C. 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 originating years	11.8	11.2	14.1	14.3	20.7	30.4	22.7

Among all mortgages for the years 2003 through 2008 that defaulted in 2008, fewer than half, 41.6%, were direct defaults. This percentage was higher for loans made at the height of the housing boom, as 44.6% 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.[28] Panel B of table 6 uses data from four states that have had particularly severe price declines and thus are more likely to have ruthless defaulters.[29] As we would expect, the share of direct defaulters is higher in these states, reaching 55.1% 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% 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 that ruthless default is not the main reason why falling house prices have caused so many foreclosures.

IV. 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% 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 data set and the historical record to see how the different explanations square with the data.

A. 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 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. (White 2009, 1119)

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 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.[30] 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.[31] The actions of a servicer working for a trust are 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.[32]

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, 292) 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."[33]

B. 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.[34] A 2007 study by Credit Suisse of approximately 30 PSAs concluded that fewer than 10% of them completely ruled out modifications. About 40% of the PSAs allowed modifications but with some restrictions. These restrictions included a limit on the percentage of mortgages in the pool that could be modified without permission from the trustee of the mortgage-backed security (often 5%) 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% 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% caps and found that

none had yet approached this cap (COP 2009, 44). 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 et al., "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?'" (Cordell et al. 2008, 19).

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.[35] 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 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" (8).

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 bondholder can block a deal that is in the interests of all other stakeholders in the firm (see "A Chrysler Creditor Finds Himself Torn," *Wall Street Journal*, April 30, 2009). 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 but also 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.[36] For a dollar figure, we can multiply this number of preventable foreclosures by the $120,000 that White (2009) claims is lost by investors for each foreclosure performed. 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.[37] 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 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.

C. *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.[38]

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 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.[39]

The possibility that borrowers will redefault 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 redefault when $\alpha_1 > 0$. Some simple arithmetic shows that renegotiation occurs when

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

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 who take advantage of principal reduction to reduce their debt burden.

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 one, then equation (4) becomes

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

This is the case that White (2009, 1119) 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." In White's extreme example of 100% loss given default, even a modification that reduces the probability of default from one to anything even infinitesimally less than one and in which the lender recovers infinitesimally more than zero 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 that the expected loss is 57% and that the likelihood of default is 50%; then the lender can only reduce the value of the loan by 28.5%.

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

D. 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 nonagency private institution. With this information, when 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 would expect to see in the data relatively few modifications among securitized loans as compared with loans held in portfolio.

The LPS data set 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).[40] 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.[41]

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% random sample and scaled up the numbers we found. The first column simply reports the total 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.[42] 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

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

	No. Loans Modified	Interest Rate Reductions		Principal Balance Reductions		Principal Balance Increases		Term Extensions	
		No.	% Total	No.	% Total	No.	% Total	No.	% 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

Note: 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 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.

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% of all modifications performed in 2008:Q4. Adelino et al. (2009) provide further information regarding the behavior of monthly mortgage payments for loans that have undergone a modification. The authors find that, until the third 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% in the period between 2007:Q1 and 2008:Q2 to approximately 20% 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 nonparametric survival estimates (also known as the product limit estimator) of the transition from modification to default.[43] The figure considers a loan to be in default when it becomes 90 days delinquent (approximately three missed payments). The figure shows that modifications involving a decrease in the monthly payment are far more successful than those involving an

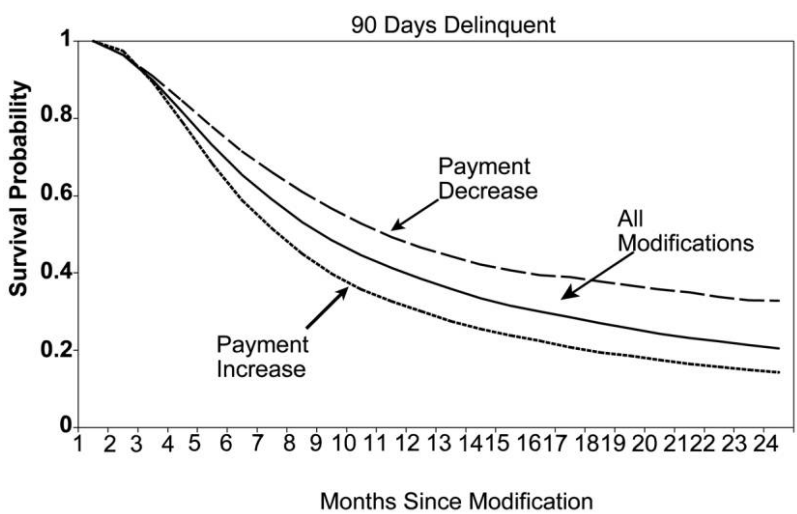

Fig. 8. Kaplan-Meier survival estimates, transition from modification to default

increase in the payment. For example, after 1 year, the probability that a modified loan involving a payment increase becomes 90 days delinquent is approximately 69%. In contrast, a modified loan involving a payment decrease has a probability of becoming 90 days delinquent of approximately 52%.[44] 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 2008 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 underrepresent the subprime mortgage market.[45] A few servicers that focus almost exclusively on subprime mortgages have recently begun modification programs that involve principal reduction.[46] 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 et al. (2009) provide evidence to support this claim, as they show that modified loans in the LPS data set 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 (i.e., 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.[47] Finally, each panel in 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

Table 8
Modification Statistics by Loan Holder

	Modification % of											
	All Loans Outstanding				30 Days Delinquent or Worse				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
A. All loans types:												
GNMA	.04	.04	.03	.03	.39	.36	.31	.27	.80	.74	.64	.51
FNMA	.10	.06	.05	.04	2.32	1.30	.88	.61	4.87	2.51	1.58	1.03
FHLMC	.05	.05	.16	.23	1.95	1.75	4.72	5.26	4.56	3.74	9.06	9.30
Private securitized	.55	.84	1.25	1.42	3.45	4.63	6.28	6.23	5.03	6.41	8.49	8.31
Portfolio	.53	.65	.69	1.05	6.31	7.53	6.81	8.55	10.23	11.47	10.32	12.57
B. Subprime/Alt-A loans (LPS definition):												
FNMA	.80	.42	.37	.19	3.42	1.70	1.32	.56	6.01	3.05	2.24	.87
FHLMC	.23	.12	2.48	1.70	1.30	.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

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% were modified in the third quarter of 2008 and 8.55% in the fourth quarter of 2008. In comparison, 6.28% and 6.23% 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 takeaway 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 for both but portfolio-held loans were modified more quickly than privately securitized loans, table 8 would show more portfolio-held loans being modified (since the 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

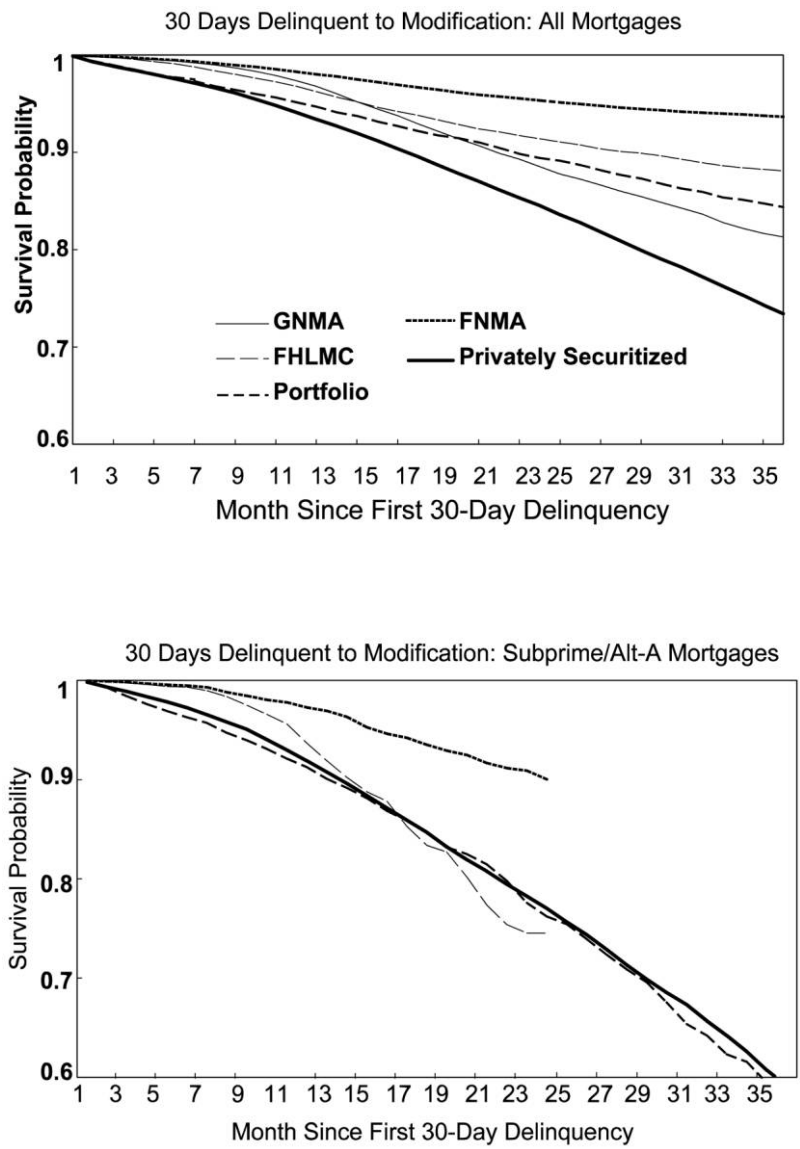

Fig. 9. Kaplan-Meier survival estimates, transition from delinquency to modification

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.[48] 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 data set, 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% probability of being modified after 2 years and a 26% probability after 3 years, compared with 11% and 16% for loans held in portfolio, respectively. Over a shorter horizon, (less than 1 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.[49]

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 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.[50] 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 et al. (2009) show that the sheer number of modifications among all types of seriously delinquent loans (about 7%) 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 (i.e., fewer foreclosures) but also more good outcomes (e.g., 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.[51] All told, the likely explanation for the Piskorski et al. finding of fewer foreclosures among delinquent portfolio 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.

E. Historical Evidence on Loan Modifications

In addition to comparing securitized versus nonsecuritized 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 possible" (COP 2009, 2). Other authors, including Geanakoplos and Koniak (2008) and Zingales (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 (U.S. Census of Housing, 2000, table DP-4, and 1950, part 1, table J). 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% of loans originated by life insurance companies ended in foreclosure, 20% of S&L mortgages ended in

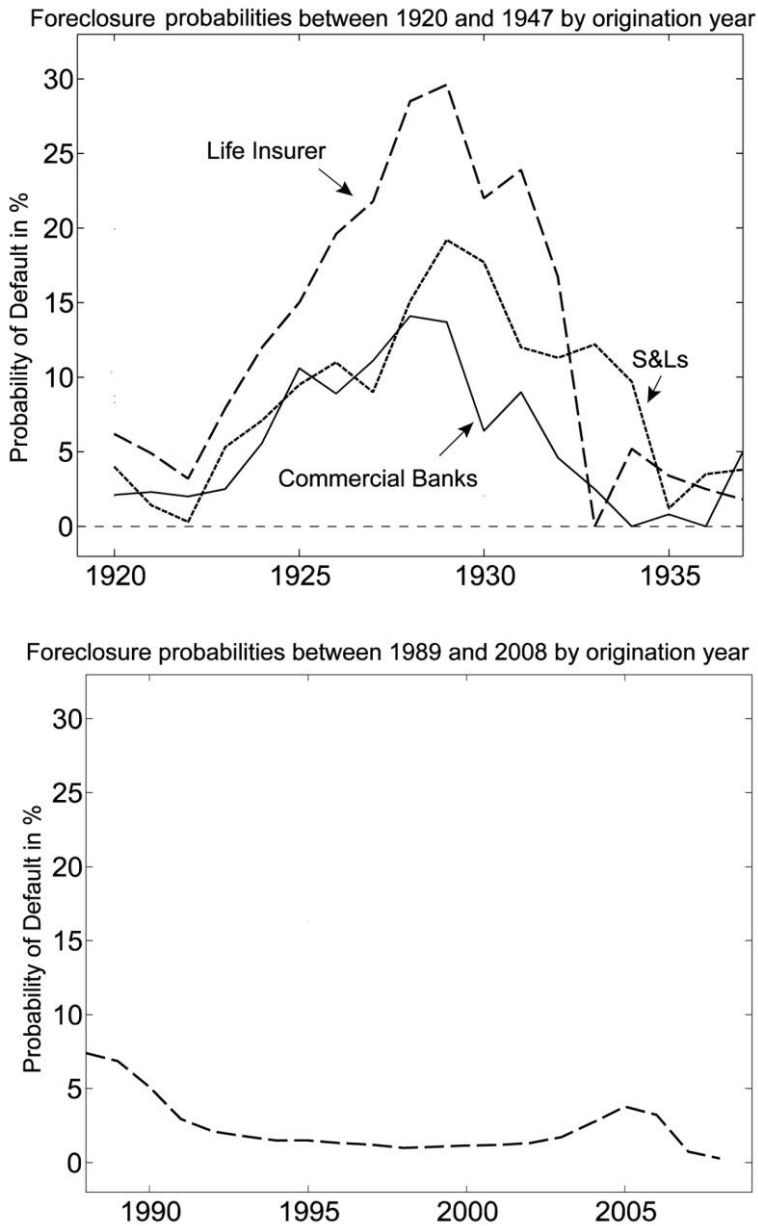

Fig. 10. Default probability by year. The top panel reports foreclosures on loans originated in that year. Loans may be for purchase or refinance. Data come from Morton (1956). The bottom panel reports foreclosures on homes purchased with mortgages in that year. For these data, we count a loan as foreclosed 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, and about 15% 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.[52] 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 reunderwrite 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% 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.[53] 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% 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" (56).

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 it recommends turning the problem over to an attorney (Pease and Cherrington 1953). The author 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 nonconcessionary modifications

and foreclosed on almost 20% of the borrowers to whom it lent (Harriss 1951).

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 United States was eventually forced out of his home. A man named Comly Rich took out a mortgage on April 11, 1831, but he "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 (see Bodfish 1931, 66–72).

V. 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 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" (i.e., 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 1 or 2 years, through a program of loans or grants to individual homeowners.[54] 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.

Endnotes

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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 is 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% 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.

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.

4. A foreclosure imposes externalities on society when, for instance, 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 Dell'Ariccia, Igan, and Laeven (2009) and Mian and Sufi (2009).

6. A recent report from the Congressional Oversight Panel of the Troubled Asset Recovery Program (hereafter denoted COP) states that "the underlying problem in the foreclosure crisis is that many Americans have unaffordable mortgages" (COP 2009, 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.

7. See Deng, Quigley, and Order (2000), Danis and Pennington-Cross (2008), and Sherlund (2008) 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.

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

9. This spread is determined by the risk characteristics of the borrower.

10. The data set was originally created by a company called McDash Analytics; LPS acquired McDash in mid-2008. Among housing researchers, the data set is still generally called the "McDash data." The description of the LPS data set in this section draws heavily from Cordell, Watson, and Thomson (2008). The data set 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.

11. 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 sizes from the servers of the Federal Reserve Bank of Kansas City.

12. Subprime loans are defined by the servicers themselves as loans with a grade of either B or C.

13. The data set from LoanPerformance FirstAmerican Corporation 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 nonconforming (i.e., jumbo loans). The coverage of private securitized loans is broader in the LoanPerformance data than it is in LPS, as LoanPerformance has about 90% of the private-label market.

14. Most loans in our sample were included in the data 1 or 2 months after origination.

15. 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.

16. For details about hazard models, see Kiefer (1988).

17. For ease of interpretation, we define this variable to equal one if the borrower does not have an LTV of 80%.

18. 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).

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

20. 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%.

21. Negative price changes are entered as a negative numbers, not as absolute values.

22. 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%, and a 40% DTI.

23. The subprime coefficient became slightly larger, rising from .0072 to .0127, but Fannie and Freddie hold only about 12% of the subprime loans in our regression sample.

24. 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.

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

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

27. As was the case with the duration models, the roll rates are based on a random 5% sample of the LPS data.

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

29. The states are Arizona, California, Nevada, and Florida.

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

31. For example, the authors of the COP (2009, 50) report write that "restrictions on mortgage servicers' ability to modify loans are an obstacle that has contributed to foreclosure that destroys value for homeowners and investors alike."

32. The authors of the COP report write that "servicers may also be reluctant to engage in more active loan modification efforts because of litigation risk" (COP 2009, 46).

33. Other policy analysts have adopted a similar view. For example, the COP writes in its recent report: "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 2009, 2).

34. For a discussion of the role of PSAs in reducing modifications, see Cordell et al. (2008), which also discusses the incentives faced by servicers more generally.

35. 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.

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

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

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

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

40. The Office of Thrift Supervision (OTS) and the 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.

41. 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 (e.g., a mistake in the updated balance or interest rate) or some endogenous behavior on the part of the borrower (e.g., 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.

42. 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.

43. The Kaplan-Meier estimate of the survival function for delinquency is given by

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

where $\hat{S}_t$ 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, i.e., the number of loans that are still active and that have not defaulted before time t_i.

44. 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%, while modifications involving a payment decrease have an associated probability of about 17%.

45. The majority of subprime mortgages are securitized by nonagency firms, and for the period of interest the LPS data set includes approximately 35% of mortgages securitized by nonagency corporations.

46. 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 contributes to the LPS data set.

47. The definition of subprime and Alt-A comes directly from the servicers that contribute to the LPS data set. There is no additional distinction between subprime and Alt-A in the LPS data set.

48. Adelino et al. (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 they find results that support the patterns in fig. 9.

49. 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 2 years, and thus we decided to truncate the graph for these types of loans after 1 year.

50. The Piskorski et al. (2009) paper never tries to identify modifications directly, as we do.

51. 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.

52. See Gerardi et al. (2007) for details regarding the Massachusetts data.

53. See Harriss (1951) for details about HOLC.

54. For details of such a plan, see http://bosfed.org/economic/paymentsharingproposal.pdf.

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