OFHEO WORKING PAPERS

Working Paper 02-1

Patterns of Default and Prepayment for Prime and Nonprime Mortgages

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March 2002

* The views expressed in this research are those of the author and do not represent policies or positions of the Office of Federal Housing Enterprise Oversight or other officers, agencies, or instrumentalities of the United States Government. This is a work in progress.

Summary

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While nonprime lending has experienced steady if not explosive growth over the last decade very little is known about the performance characteristics of these mortgages. Private data vendors publish estimates that nonprime mortgages default and prepay at elevated levels, but no published research (as far as the author is aware) exists on the performance of nonprime mortgages.

Using data from Fannie Mae and Freddie Mac, this paper estimates a competing risks proportional hazard model popularized by McCall (1996). The analysis examines the performance 30 year fixed rate mortgages from February 1995 to the end of 1999 and compares nonprime and prime loan default and prepayment behavior. Nonprime loans are identified by relatively higher mortgage interest rates.

Results indicate that nonprime borrowers do not have the same risk characteristics as prime borrowers at origination, default and prepay at elevated levels, and respond differently to the incentives to prepay and default. For example, model results indicate that in the 28th month of the loan the conditional monthly probability of defaulting is 0.098% for typical nonprime borrower and 0.012% for the typical prime borrower. The typical conditional monthly probability of prepaying is also estimated as 3.12% for nonprime and 2.44% for prime borrowers.

While on average nonprime borrowers do prepay at a higher rate, the model results indicate that prepayment rates of nonprime borrowers are less responsive to how much the option to call the mortgage or refinance is in the money but are more responsive to credit scores. Default rates of nonprime borrowers are also less responsive to homeowner equity than prime borrowers.

In summary, the findings of this paper confirm that nonprime borrowers are generally more likely to prepay and default. However, the econometric findings indicate that the extent of those relative tendencies vary substantially and (with respect to prepayments) may be reversed depending on loan age, credit scores, down payments, interest rates, house prices, and labor market conditions.

Patterns of Default and Prepayments for Prime and Nonprime Mortgages

I. Introduction

In recent years there has been a concerted effort by traditional mortgage market participants to increase lending to non-prime borrowers, that is borrowers who may not qualify for the cheapest loans. These borrowers typically pay higher origination fees and interest rates to reflect the potential risk of default and prepayment. Data on the performance of nonprime loans are sparse. While some private companies (for instance, the Loan Performance Corporation and University Financial Associates) publish summary statistics indicating that nonprime loans prepay and default at substantially higher rates than prime loans, little is known about why this occurs. Models that explain such performance of nonprime loans may be used to better price risk and assess the market value of such loans and related pools.

Using a competing risk framework, this paper focuses on the prepayment and default of individual nonprime loans originated from February 1995 through February 1998 and compares the behavior of these loans to prime loans originated over the same time period. Model results are consistent with previous estimates of nonprime loan default and prepayment rates. For instance, the results indicate that non-prime borrowers are 8.2 times more likely to default and 1.3 times more likely to prepay than prime loans when evaluated in the 28th month of the loan. Despite these elevated levels of default and prepayment, non-prime borrowers are less responsive to the standard economic incentives (option values) to prepay and default.

II. Background on Nonprime Loans

Most research and commentary on nonprime lending has relied on a list of lenders provided by the Department of Housing and Urban Development. This list consists of lenders who HUD identifies as being primarily 'subprime' lenders from trade magazines and publications. This list is then applied to an existing database that identifies the lender, such as the Home Mortgage Disclosure Act data set. This data has been used by HUD to show that, at least for refinance loans, subprime lenders tend to be the primary form of mortgage financing used in many lower income and minority census tracts (HUD 2000). In contrast, Pennington-Cross & Yezer (2000) showed that the subprime market niche for home purchase mortgages is not low income, low wealth, minority households, but instead households with substantial wealth to help compensate for other weaknesses in the loan application.

Private corporations, such as the University Financial Associates LLC (UFA) have examined the sensitivity of borrowers with low credit scores to stressful economic conditions. They find that low credit score borrowers default at twice the rate as high credit score borrowers in both good and bad economic conditions.[1] In addition, the Loan Performance Corporation (LPC) has shown that subprime loans recently have been seriously delinquent (90 days or more delinquent or in foreclosure) at least 10 times more often than prime mortgages and have prepaid at least twice as fast as prime mortgages (LPC 2000).

III. Prime & Nonprime Comparison

This paper uses data from Fannie Mae and Freddie Mac. Since both have been only limited participants in the subprime market and are unique institutions the results should not be applied to the subprime market as a whole. To identify single-family owner occupied loans that should be characterized as nonprime the interest rate at origination is used. Loans are categorized as high interest rate if the contract rate at origination is 100 basis points greater than the monthly rate reported by Primary Mortgage Market Survey by Freddie Mac[2]. The advantage of this approach is that it allows the market place to identify the riskiness of the loan through the price being charged to the borrower rather than rely on a list of lenders who may originate heterogeneous sets of mortgage products. The non-prime borrowers identified here are not necessarily are greater lending risks. Their selection is based solely on the interest rate they pay. After restricting the sample to 30 year fixed rate loans originated from February of 1995 through February of 1998,

[1] While private companies provide free of charge general characterizations of their results they do not provide actual estimates, econometric results, or the methodology used to estimate them. These details are presumably available to companies that use their services.

[2] There is no information in the data set on the points paid by the borrower to buy down the interest rate. It is possible that borrowers who are paying higher rates are only doing so because they have not paid points or other origination fees. Therefore, it is possible to argue that any differences in prepayment rates could be partially attributable to interest rate buy downs, not alternative risk characteristics. The additional 100 basis point spread requirement should mitigate this potential problem. In fact, it is also likely that the standard interest rate group of borrowers will include high risk borrowers who have received explicitly subsidized interest rates or have qualified for special lending programs designed to increase lending to low income or minority households.

and eliminating loans which some data was missing, a sample of 25,695 nonprime loans is randomly selected. These are studied through the end of 1999 with respect to default, prepayment, and survival. For comparison purposes, 23,746 prime loans are randomly selected during same time period. Models are estimated for each group and the results are compared.

Before examining model results, it is useful to look at the general characteristics of this data. Table 1 shows that nonprime loans look much different at origination and perform differently on average than prime loans. For instance, nonprime FICO credit scores are 36 points lower and down payments are 6.6 percentage points higher. Given these characteristics it should be no surprise that the conditional (conditioned on not prepaying or defaulting in any previous months) monthly default rate is substantially higher for nonprime borrowers. It is less obvious why the prepayment rates are also substantially higher since both types of loans experience the same interest rate environment. Other factors than just interest rates; such as demographic factors, job loss, relocation, and death can affect prepayment rates. Since many of these factors are not directly observed at the individual borrower level, proxies must be used that make it challenging to create precise estimates of prepayment rates.

Caution must be used in any attempt to generalize the results of this paper because it examines 30 year fixed rate whole loan purchases by only two major secondary market participants, who did not serve the whole mortgage market in the mid to late 1990s. Ideally a broader database should be used when it becomes available. The purchasing patterns of these two loan purchasing institutions does not reflect the entire subprime market. The sample used in this study should include primarily A and A-, and Alternative A grade loans. Therefore, results represent the performance characteristics of the upper end or least risky portion of the nonprime mortgage market.

Given this caveat, it is particularly noteworthy that this sample provides evidence that identifies critical differences in loan performance in even this narrow portion of the subprime market. It is reasonable, therefore, to assume that the differences in performance between subprime and prime loan performance may be even more dramatic for the overall subprime market. In addition, the loans may have characteristics that are specific only to the institutions included and the servicers of the mortgages. Lastly, important segments of the mortgage market such as Veterans Administration, Federal Housing Authority, and jumbo loans are not included in the analysis because the study examines the performance of only non-government loans that fall within the conventional conforming loan limits.

IV. Motivations for Prepaying and Defaulting

Mortgages are typically prepaid because the borrower is refinancing or moving. The motivations to refinance are primarily driven by changes in market interest rates or some other event that may require a household to take equity out of the home through a refinance. The motivations to move can be derived from factors such as relocation, change in family structure, or a change in employment conditions or wages. While it is impossible using the data set in this study to separate prepayments between refinances and moves, the majority of prepayments are associated with refinances and this will be the focus of the analysis of prepayments.

If the savings from the new mortgage (refinancing) outweigh any transaction costs, changes in interest rates can motivate borrowers to prepay the loan, even if they just received the loan in the last few months. But, when the option to prepay, or call the mortgage, is ‘in the money’ not all borrowers will automatically prepay the mortgage. One explanation for the sluggishness of the response of borrowers to the call option is that transaction costs can vary across borrowers so that some borrowers will require the mortgage to be more in the money than others to activate the option. But the ability and desire to refinance can be constrained by other factors than just transaction costs. For instance, it may be difficult to obtain financing if credit scores are low, the homeowner has little or negative equity in the house, or is unemployed or earning substantially less money than when the original loan was made (Mattey & Wallace 2001, Green & LaCour-Little 1997, Peristiana et al 1997, LaCour-Little 1997). Alternatively, some borrowers in need of cash may be more likely to prepay even if the transactions costs are high. In this case the call option may be “out of the money”, but the borrower may decide to refinance anyway, strictly for cash flow. In general, house price dynamics, the credit history of the borrower, interest rate changes and the local unemployment rate should all play a strong role in determining prepayment rates.

From the default perspective, home owners can be driven to default by trigger events such as a loss in income or job that make it impossible for the household to meet its financial obligations. Therefore, indicators such as the area unemployment rate provide a proxy for some of the trigger events. But, some borrowers are more predisposed before they purchase a home to pay bills on time and to accumulate manageable amounts of debt. This information or the credit history of the borrower is captured by the credit bureau's credit score. Lastly, when the house is worth less than the outstanding mortgage or is in negative equity the borrower can save financial resources by defaulting. Since there are substantial and persistent costs associated with defaulting, it is likely to require a substantial negative equity position for most borrowers to put the mortgage and default without a trigger event. Borrowers who have positive equity in a house and experience a trigger event can alternatively sell the property instead of defaulting.

V. The McCall Competing Risk Model

This paper uses a version of the competing risk model introduced by McCall (1996) in a study of unemployment duration. In this approach, borrowers consider the default, prepayment, and continuation of the mortgage as options. The probability of one event is necessarily tied to the others and is estimated jointly using a proportional hazard model with grouped duration data. The outcomes of default and prepayment compete with each other to be the first event to occur (the observed event).

The benefit of the McCall approach is that it uses information typically ignored in more traditional models that require independence and separability. Separate models treat all outcomes not included as being censored observations (examples of this approach include, Green and Shoven 1986 and Deng 1997). This produces demonstrable effects on estimated coefficients and can result in large type I and II out of sample forecasting errors. Another approach, the multinomial logit specification, assumes outcomes are independent from each other. This produces similar symptoms to the separability assumption and for specific samples may result in inefficient and imprecise estimation. This is commonly referred to as the "independence of irrelevant alternatives assumption."

An alternative approach used by Ambrose & Capone (2000) assumes constant time dependence when estimating the exponential baseline hazard, but then includes more time variables as additional covariates (the age of the loan) to augment the baseline hazard as a multiplicative shift function. This approach provides the basis for extending the original McCall model.

A version of the proportional hazard model as popularized by Deng, Quigley, and Van Order (2000) and used in a prepayment model by Ambrose and LaCour-Little (2001) is used in this paper.[3] The estimation is conducted in STATA by defining the maximum likelihood and numerically searching for the global maximum. See Appendix B of McCall (1996) for more details on the definition of the likelihood function. In summary the outcome determines the contribution of the observation to the likelihood and an adjustment factor is used because duration is measured in discrete time.

Define the time to prepayment as T_p and the time to default as T_d which are random variables that have a continuous probability distribution, f(t_w), where t_w is a realization of $T_w(w=p,d)$. The joint survivor function for loan j is then $S_j(t_p,t_d)=\mathrm{pr}(T_p>t_p,\ T_d>t_d \mid x_{tj})$. The joint survivor function has the following form:

$$(1) \qquad S_j\left(t_p, t_d\right) = \exp\left(-\sum_{t=0}^{t_p}\exp\left(\beta_p^{'} x_{jt}\right) - \sum_{t=0}^{t_d}\exp\left(\beta_d^{'} x_{jt}\right)\right)$$

Note t indexes time in months for outcome p, d, or c which indicates whether the loan is prepaid, defaulted, or continued and j indexes the N individual loans. The baseline hazard function is one element of the matrix x_{jt} and is parameterized by a constant, age, and age squared. The coefficients (β_w) can be used to approximate the underlying continuous time baseline hazard for the default and prepayment probabilities. The vector of parameters (β_w) also represents other time varying and time constant effects of regressors on the probability of terminating. Only the shortest mortgage duration is observed, $T_j=\min(T_p,T_d,T_c)$. The hazard probabilities of mortgage prepayment, $A_{pj}(t)$, default $A_{dj}(t)$, or continuing $A_{cj}(t)$ in time period t are defined as:

[3] The McCall (1996) paper also includes issues of selectivity correction and the grouping of individuals to reduce individual heterogeneity issues. This paper instead estimates separate models for the nonprime and prime groups and thus explicitly identifies the importance of at least one source of heterogeneity. In addition, the fairly short time frame of the analysis may not lend itself to the identification of the changing composition of the pool of borrowers, which is the focus of the Deng, Quigley, and Van Order (2000) approach.

$$(2)\quad A_{pj}(t)=S_j(t,t)-S_j(t+1,t)-.5\left(S_j(t,t)+S_j(t+1,t+1)-S_j(t,t+1)-S_j(t+1,t)\right)$$
$$A_{dj}(t)=S_j(t,t)-S_j(t,t+1)-.5\left(S_j(t,t)+S_j(t+1,t+1)-S_j(t,t+1)-S_j(t+1,t)\right)$$
$$A_{cj}(t)=S_j(t,t)$$

The term multiplied by 1/2 is the adjustment made because duration is measured in months instead of continuously. Using the above and taking logs the log likelihood of the proportional competing risks model is summed across all N loans.

$$(3)\qquad \sum_{j=1}^{N}\delta_{pj}\log\left(A_{pj}(T_j)\right)+\delta_{dj}\log\left(A_{dj}(T_j)\right)+\delta_{cj}\log\left(A_{cj}(T_j)\right)$$

δ_{oj}, o=p,d,c indicate if the j^{th} loan is terminated by prepayment, default, or censoring.

Specification and Summary Statistics

Table 2 provides a brief description and summary statistics for all variables used in the estimation of the hazard functions. The data reported are in levels but the estimation itself is done on mean adjusted variables (actual value - mean of variable) for all continuous variables so that the means of the actual regressors are equal to zero.

The summary or descriptive statistics in table 2 are based on a univariate analysis. They reinforce the fact that the nonprime loans have riskier characteristics (shorter age, more age volatility, higher probability of negative equity, lower credit scores, and are located in higher unemployment metropolitan areas). Nonprime loans also prepay and default at substantially higher rates.

To determine if it makes sense for the borrower to refinance a mortgage, the present discounted cost (pdc) of all future payments for the current mortgage is compared to the pdc of all future payments if the borrower refinances. Ignoring transaction costs, if the cost of refinancing is lower than the costs of continuing to pay the current mortgage then the option to refinance or prepay is 'in the money'. To address the refinance option, assume that the borrower uses the same term for the new refinance mortgage as the original term on the mortgage, but does so at current market interest rates. The discounted term is assumed to be the 10-year constant maturity Treasury bill reported for each month.

For fixed rate mortgages given the original balance (*O*), the term of the mortgage (*TM*), and the interest rate on the mortgage (*i*), the monthly payments can be calculated for each borrower, j.

$$P_j = i_j * O\left[\frac{(1+i_j)^{TM}}{(1+i_j)^{TM} - 1}\right] \tag{4}$$

The monthly payments (P_j) are constant through the life of the loan and are discounted by d in each month (m) until the mortgage is fully paid in TM months:

$$PDC_{jc} = \sum_{m=0}^{TM} \frac{P_j}{(1+d_j)^m} \tag{5}$$

The PDC_{jc} is then recalculated for each month for each borrower for as long as the loan exists. This process is then repeated for the refinanced mortgage to calculate PDC_{jr} in which the unpaid balance of the current mortgage becomes the original balance in equation 4 and the interest rate on the refinanced mortgage is the market rate as defined by the Freddie Mac Primary Mortgage Market Survey in that month. The call option is defined as:

$$refi_{jt} = 100 * \left[\frac{(PDC_{jc} - PDC_{jr})}{PDC_{jc}}\right] \tag{6}$$

The variable $refi_{jt}$ is defined as the percentage reduction in the present value of future payments the borrower, j, will gain in time period t if the mortgage is refinanced. This specification of the call option is likely to be a good representation of how much the option to prepay is in the money for prime borrowers. But, since the interest rate that is used to identify the market interest rate is a prime rate, the above specification will show all nonprime borrowers to be in the money - even at origination. This is due to the higher rate the nonprime borrower pays due to deficiencies in the mortgage application. To reflect the credit impairment of the borrower the market rate used for the refinance option is adjusted up in each month in equation 1 by the fraction that the borrowers contract rate was above the prime contract rate at origination. Therefore, the call option ($refi_{jt}$) will reflect solely changes in interest rates not difference in the credit worthiness of the borrower. This approach implicitly holds the borrowers credit quality constant.

Some borrowers may be more responsive to changes in interest rates than others. To measure the extent that a borrower has missed opportunities to refinance, positive values of ref_{jt} are summed up to the last payment. This measure of burnout ($burn_{jt}$) represents the total reduction in borrowing costs that have been missed by the borrower, ignoring transaction costs. If this variable is not included then the time dependant portion of the burnout should be incorporated into the baseline hazard.

To determine whether the borrower is likely to be constrained by the lack of equity in the home, the loan-to-value ratio is updated in each month to estimate the current loan-to-value ($ltvc_{jt}$). To calculate $ltvc_{jt}$ the outstanding balance of the mortgage and the value or current price of the house must be updated through time. The unpaid balance of the mortgage is calculated assuming that payments are received on time and the house price is updated using the Office of Federal Housing and Enterprise Oversight repeat sales price index at the metropolitan area level. But since the actual value of the home is estimated, not observed, it may be more accurate to estimate the probability that the household is in negative equity. As in Deng, Quigley, and Van Order (2000) using standard error (*se*) estimates reported by the Office of Federal Housing Enterprise Oversight (OFHEO), which are derived from the repeat sales house price index estimation procedure, we can, using the cumulative normal density function (Φ), calculate the probability that the house has more debt than value -- the probability of negative equity ($pneq_{jt}$). The standard error estimates depend on how long ago the home was purchased. Let s index the date of the transaction and t the current date so that s-t is the time since the transaction. In general, the larger is s-t the higher the estimated standard error from the house price index estimation procedure. Therefore, $pneq_{jt}$ is sensitive to changes in house prices, mortgage payments, and the standard errors.

$$pneq_{jt} = \Phi\left(ltvc_{jt} / se_{s-t}\right) \tag{7}$$

To indicate the level of credit impairment, the Fair Isaac FICO score measured at origination is included for the borrower of each loan. It is expected that borrowers with very poor credit histories, and hence credit scores, will have a difficult time finding refinance options and may have more difficulty identifying whether the call option is in the money. In addition, for borrowers who have poor credit scores but still have managed to obtain a prime loan it is likely that their interest rate is either implicitly or explicitly subsidized and will then only find refinancing attractive when interest rates have dropped dramatically. From the default perspective borrowers with poor credit scores are likely to continue poor credit management and default on a mortgage.

The ability of a borrower to continue making the mortgage payments in large part depends on being employed. Data on individual job status is seldom available to directly include in the specification of the likelihood function. This study uses monthly metropolitan level unemployment rates as a proxy. It is expected that borrowers in locations with higher unemployment rates are more likely to experience negative events and are therefore more likely to have trouble making payments on time. One possible outcome besides defaulting on the mortgage is for the borrower and lender to work out a new payment plan, which may include prepaying the current mortgage. Another alternative is that borrowers who lose their jobs will not be able to refinance due to job status.

Results

Table 3 presents the estimated coefficients and z statistics for the prime and nonprime loans. The first two columns provide the competing risk results for prime loans and the second two for nonprime loans. In general the results fulfill expectations in that most variables have the "correct" sign and are significant.

For instance, as it becomes more in the money to refinance a loan ($refi_{jt}$>0) both prime and nonprime become more likely to prepay. But the coefficient for the nonprime loans is approximately 3/4 of the coefficient for the prime loans. This means that under ceteris paribus conditions the likelihood for prepayment is less responsive for nonprime borrowers than for prime borrowers. Figures 1-4 show the conditional (conditioned on surviving the previous month) monthly probability of the event (prepay or default) occurring in the 28th month of the loan while evaluating all other variables at their mean. The conditional probability of borrower j prepaying the mortgage in period t is modeled by:

(8) $$\pi\left(p = 1 \middle| x_{jt}\right) = 1 - \exp\left(-\exp\left(x_{jt}\beta_p\right)\right)$$

where x_{jt} represents the matrix of regressors and β is a vector of parameters measuring the effects of the regressors on the probability (π) of prepaying (p=1) the mortgage.

Figure 1 represents how the average prime or nonprime loan reacts to different levels of cost savings available from refinancing. Because the coefficient of $refi_{jt}$ is larger for prime borrowers, the curve slopes upward more steeply for prime borrowers. But, it is not until the cost savings are substantial ($refi_{jt}$>0.11 or 11%) that prime borrowers are more likely to refinance than nonprime borrowers. In fact, on average, nonprime borrowers refinance more often than prime borrowers. But the use of averages can misleading when analyzing grouped data duration models, because when the event (prepay or default) occurs the loan drops out of the data set therefore skewing any averages towards values when events do not occur. Since the interest of any hazard estimation is to understand when these events happen it is important to examine estimated probabilities well outside the sample means. All the presented figures do this by indicating where the means exist as well as one standard deviation from the mean across the full spectrum of values observed in the data set. Therefore, it is shown in figure 1 that when the option to refinance is deeply in the money the probability of prepaying is higher for prime borrowers than nonprime borrowers. In contrast when it is out of the money to refinance nonprime borrowers are more likely to prepay.

In addition, the magnitude of the response for both prime and nonprime borrowers is dampened when earlier opportunities have been missed to refinance ($burn_{jt}$) the mortgage at a lower interest rate. Individuals who do not initially react tend not to react later when the same opportunities present themselves once again. This affect is stronger for nonprime borrowers.

The responsiveness of prepayment rates to credit scores ($fico_j$) follows the opposite pattern -- nonprime borrowers are more responsive to different levels of credit scores than prime borrowers. Figure 2 illustrates that when borrowers have low credit scores ($fico_j$<560), prime borrowers are more likely to prepay than nonprime borrowers. But for borrowers with credit scores of 800, nonprime borrowers are 1.6 more times more likely to prepay than prime borrowers.

Nonprime borrowers are also more constrained than prime borrowers in their ability to prepay when they have less equity in the home. Lastly, the ability of nonprime borrowers is also more retarded by high local unemployment rates than prime borrowers.

Model results suggest that the prime and nonprime borrowers default differently, and the probabilities vascillate dramatically with credit scores, age of loans, and other variables. In the 28th month of the loan, the typical nonprime loan defaults more than 8 times more often than the typical prime loan. This is illustrated in figure 3, which shows the conditional monthly probability of default in the 28th month for the average prime and nonprime borrower. It shows that for all values of $pneq_{jt}$, nonprime borrowers default much more often than prime borrowers, but the coefficient on $pneq_{jt}$ is larger for prime than nonprime borrowers (4.6 versus 3.3).

The larger coefficient on $pneq_{jt}$ implies that an increase in $pneq_{jt}$ leads to a larger percent increase in probability of default for prime borrowers. The underlying model is curvilinear and the effects of $pneq_{jt}$ on the probability of default depend on where the individual borrower resides -- the baseline rate. Figure 4 shows that as credit scores improve nonprime and prime default rates drop dramatically. As a result, a nonprime borrower with excellent credit history ($fico_j$≈800) has almost the same default probability as a prime borrower with a good credit score ($fico_j$≈720). In addition, while perhaps counterintuitive, prime borrower default rates are more responsive to higher unemployment rates than nonprime borrower rates. While a more extensive time series might reveal other baseline hazard patterns, the baseline default hazard for prime loans is found not to be related to the passage of time.

Another way to illustrate the results is presented in table 4a and 4b. Prime and nonprime borrowers are made to have exactly the same characteristics – those of the average prime borrowers. Using the nonprime and prime model estimates, the probability of prepaying or defaulting is simulated for a variety $fico_j$, $pneq_{jt}$, and $refi_{jt}$ values. The ratio of the nonprime to prime probabilities are then calculated ($\pi^{nonprime}/\pi^{prime}$) and compared. Therefore any number greater then one indicates that the probability is higher for nonprime than prime after making all of the characteristics the same.

Note the lack of uniformity in the results - sometimes the nonprime probability is higher, at other times the prime probability is higher. To examine prepayment behavior table 4a reports, for example, simulated probability ratios for two different time periods. In the 12th month the table shows that when credit scores are high and the option to refinance is out of the money nonprime borrowers are up to 2.42 times more likely to prepay. But as credit scores deteriorate or as the option to refinance becomes more in the money nonprime borrowers are up to 27 percent less likely to prepay. Therefore, while nonprime borrowers may prepay more quickly on average this is not always true. In fact, nonprime borrowers tend to prepay slower than prime borrowers when interest rates have dropped considerably and when they have low credit scores.

As the loan ages, nonprime borrowers become less likely to prepay relative to prime borrowers. For instance, in the 12th month when the option to prepay is in the money by 5% and the borrower has a 700 fico score the probability of prepaying is 38 percent (probability ratio=1.38) higher for nonprime, but by the 48th month the probability of prepaying is 464 percent (probability ratio=4.64) higher for nonprime.

Table 4b reports the same style of simulated probability ratios for default rates. For the variable ranges shown, nonprime borrowers default at least 3.50 times more often than prime borrowers. This difference is larger when credit scores are higher and the probability of negative equity is lower. At the most extreme nonprime loans default approximately 12 times more often. The table also presents simulated results for the 12th month of the loan and the 48th month of the loan.

VI. Conclusion

This paper provides a competing risk analysis of the patterns of prepayment and default for prime and nonprime borrowers. Results indicate that prime borrowers do not have the same risk characteristics at origination, default and prepay at elevated levels, and respond differently to the incentives to prepay and default.

The estimated conditional monthly default and prepayment rate for nonprime loans in the 28th month of the loan is approximately 8.2 and 1.3 times higher than prime loans. This finding is consistent with the lower down payments and lower credit scores of nonprime borrowers. But, the prepayment rates of nonprime borrowers are less responsive to how much the option to call the mortgage is in the money and more responsive to credit scores than prime borrowers. In addition, nonprime borrowers are less responsive to the incentives to default.

In summary, the findings of this paper have confirmed that, generally, nonprime borrowers prepay and default more often than prime borrowers. But, this does not always hold true. For instance, when interest rates drop substantially prime borrowers refinance at a higher rate than nonprime borrowers. In addition, while both prime and nonprime borrowers respond in the same direction (positive or negative) to economic stimuli (house prices, interest rates, or unemployment) and other indictors of risk (credit history and down payments) the magnitude of the responses can vary substantially.

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Table 1: Mortgage Risk Indicators

Variable	Mortgage Type: Nonprime	Prime
Monthly Prepayment Rate[1]	2.03%	1.51%
Monthly Default Rate[1]	0.166%	0.029%
Cumulative Prepayment Rate[2]	57.72%	45.19%
Cumulative Default Rate[2]	4.72%	0.87%
Loan to Value[3]	88.8%	82.2%
Contract Interest Rate[3]	8.94%	7.95%
Credit Score (FICO)[3]	678	714

1: Calculated as the average rate of the event (prepay or default) occurring conditioned on the loan surviving the previous month. 2: Cumulative rates are calculated by dividing the number of terminated loans (prepay or default) by the total number of loans originated. 3: Reported at the date of origination. Therefore, these averages may differ from those reported in table 2.

Table 2: Summary Statistics

		Prime				Nonprime			
Variable	**Description**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
$prepay_{jt}$	If the loan is prepaid =1, else =0.	0.015	0.122	0	1	0.020	0.141	0	1
$default_{jt}$	If the loan is foreclosed =1, else =0.	0.0003	0.017	0	1	0.0017	0.041	0	1
age_{jt}	The number of months that the loan has existed.	17.873	11.847	1	58	18.098	12.431	1	58
$pneq_{jt}$	The probability of negative equity (loan>value of home).	0.090	0.108	0	1	0.161	0.120	0	1
$refi_{jt}$	Percent reduction in loan costs of loan if refinanced.	-0.015	0.062	-0.30	0.16	-0.022	0.064	-0.30	0.17
$burn_{jt}$	Burnout – Sum of missed refinance opportunities ($\Sigma refi$, if $refi$>0).	0.307	0.402	0	4.30	0.298	0.403	0	4.56
$fico_j$	FICO score at origination	713.13	55.61	442	834	675.16	60.88	453	900
$urate_t$	The unemployment rate in the metropolitan area.	4.207	1.825	0.8	41	4.698	1.959	0.8	41

There are 710,234 prime observations (total loan months) and 730,358 nonprime observations (total loan months) representing 23,746 prime loans and 25,695 nonprime loans. The data set is created as an unbalanced panel where each month that a loan exists it contributes one observation. The loans are spread fairly evenly across all years and months. In addition, the distribution of loans across states and metropolitan areas is similar for both prime and nonprime loans. In estimation all variables are mean adjusted so that the mean is equal to zero. In addition, *fico* is divided by 1000 and *urate* by 100.

Table 3: Proportional Hazard Competing Risks Results

	Prime		Nonprime	
Variable	Coef	Z stat	Coef	Z stat
Prepay				
age_{jt}	0.124	34.17	0.101	36.76
age_{jt}^2	-0.001	-17.95	-0.001	-20.25
$refi_{jt}$	12.359	46.87	9.093	46.00
$burn_{jt}$	-0.176	-7.16	-0.295	-12.98
$pneq_{jt}$	-0.220	-2.39	-0.725	-9.64
$fico_j$	0.674	3.70	3.069	21.82
$urate_t$	-9.128	-13.63	-11.128	-20.68
constant	-4.525	-341.50	-4.118	-401.17
Default				
age_{jt}	0.005	0.21	0.006	0.66
age_{jt}^2	0.000	-0.32	0.000	-0.69
$pneq_{jt}$	4.560	6.83	3.313	11.16
$fico_j$	-18.087	-16.10	-14.963	-31.61
$urat_{jt}$	10.190	5.23	6.382	5.83
constant	-9.027	-77.06	-6.943	-164.12
Log of Likelihood	-54,333		-27,483	

All coefficients are significant at the 5% level except for age and age^2 in the default results. To aid estimation all variables from table 2 are mean adjusted (actual – mean) except the constant. *Fico* is divided by 1000 and *urate* is divided by 100. *j* indexes the individual loans and *t* indexes time in months.

Table 4: Probability Ratios ($\pi^{Nonprime}/\pi^{Prime}$) for Identical Observed Borrower and Loan Characteristics

4a. Conditional Monthly Prepayment Rate

		credit score ($fico_j$)			
age of loan	$refi_{jt}$	500	600	700	800
12th month	-5%	1.18	1.50	1.91	2.42
	0%	1.01	1.28	1.62	2.05
	5%	0.85	1.08	1.38	1.74
	10%	0.73	0.92	1.17	1.48
48th month	-5%	4.06	5.14	6.51	8.24
	0%	3.44	4.35	5.50	6.95
	5%	2.91	3.68	4.64	5.84
	10%	2.46	3.10	3.90	4.88

4b. Conditional Monthly Default Rate

		credit score ($fico_j$)			
age of loan	$pneq_{jt}$	500	600	700	800
12th month	0%	4.52	6.20	8.49	11.61
	5%	4.24	5.83	7.98	10.90
	10%	3.98	5.47	7.49	10.24
	20%	3.50	4.83	6.61	9.04
48th month	0%	5.01	6.89	9.42	12.88
	5%	4.70	6.47	8.85	12.10
	10%	4.41	6.07	8.32	11.37
	20%	3.89	5.36	7.34	10.04

Note that prime and nonprime borrowers have identical characteristics in this table. If the ratio equals one then the probability is equal for prime and nonprime borrowers. If the ratio is greater (less) than one then nonprime borrowers have a higher (lower) probability. For instance, a ratio of 1.1 indicates that nonprime borrowers have a 10 percent higher probability. And a ratio of 0.4 indicated that nonprime borrowers have a 60 percent lower probability. This statistic is also referred to as an odds ratio. j indexes the individual loans and t indexes time in months.

Figure 1*

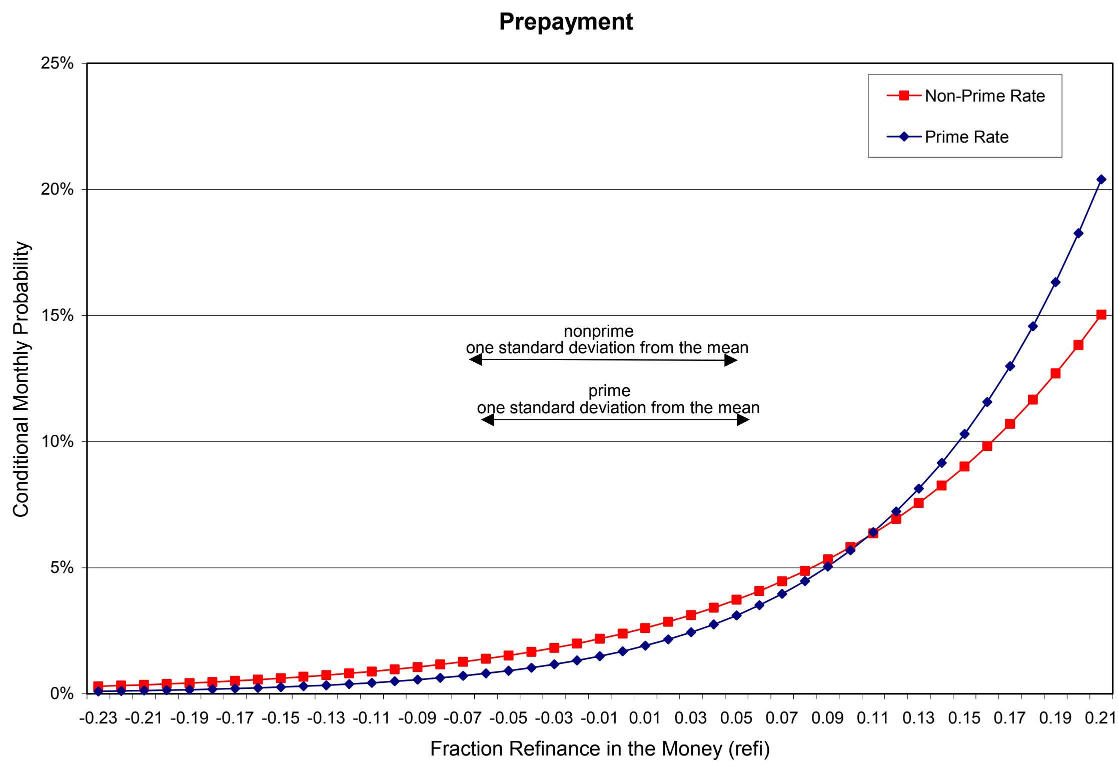
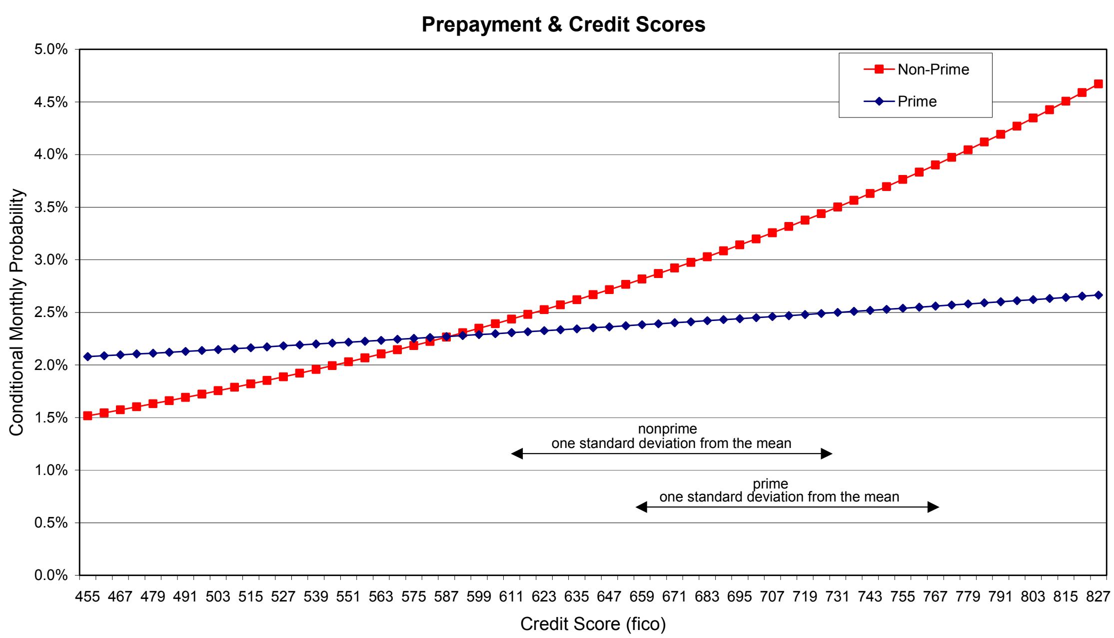


Figure 2*



* Baseline evaluated at the 28th month. All other variables are evaluated at their means.

Figure 3*

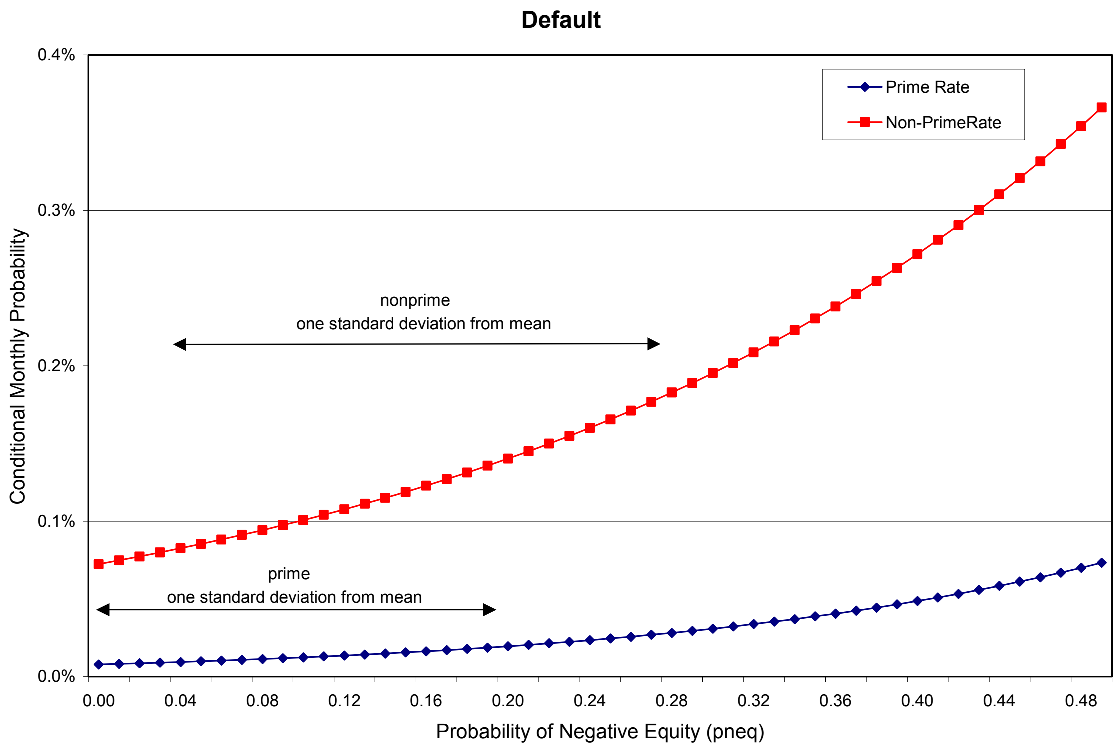
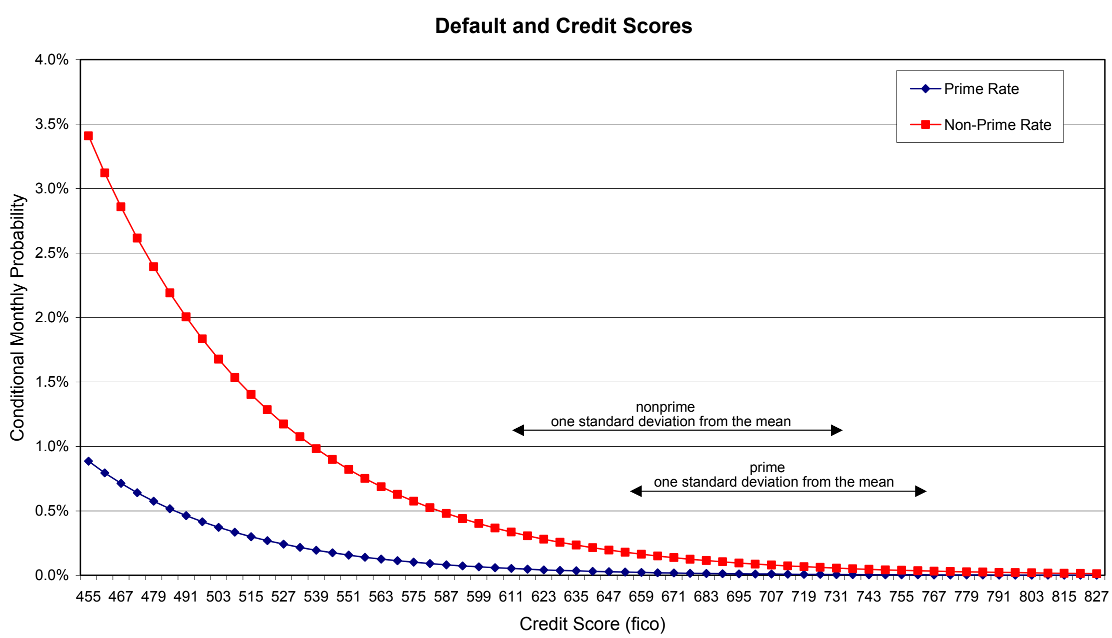


Figure 4*



* Baseline evaluated at the 28^{th} month. All other variables are evaluated at their means.