# Prepayment of Fixed Rate Home Equity Loans: A Loan-Level Empirical Study*

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**Abstract**

Although extensive studies have been done to examine the prepayment of primary mortgages, not much has been done to analyze the prepayment of home equity loans. This paper studies the prepayment of fixed-rate home equity loans using a large loan-level sample for the period 1995 to 1998. We find that prepayment of home equity loans is sensitive to changes in market interest rates, indicating that borrowers refinance their loans when market interest rates are lower than coupon interest rates. We also find that trends in interest rate changes play an important role in borrower prepayment decisions. When borrowers expect market interest rates to decrease further, they will wait for better opportunities to prepay their home equity loans even when the loans are already "in the money." Loan size and borrower creditworthiness also affect the prepayment of home equity loans. However, the loan-to-value ratio, an important factor in primary mortgage prepayment, has little effect on the prepayment of home equity loans. This paper also documents the effect of payment delinquencies on prepayment behavior. Borrowers with either minor or major delinquencies in making monthly payments are less likely to prepay their home equity loans.

## Introduction

The purpose of this paper is to study the factors that affect prepayment of fixed-rate home equity loans. While most studies of prepayment have focused on conventional primary mortgages, few published studies have analyzed the prepayment of home equity loans, especially at the loan level. In this paper, we study the prepayment behavior of home equity loans empirically using a large loan-level data set.

Home equity loans have changed over the past 10 years. Prior to the mid-1990s, home equity loans generally referred to second-lien mortgage loans that were originated to consolidate debt or finance large expenditures, such as education, home improvement or medical treatment. Although home equity loans may have a fixed or floating rate or a hybrid of the two, fixed rate home equity loans dominated issuance during much of the mid-1990s. During this period, home equity loans usually took the form of home equity lines of credit, and were usually open-ended. After the mid-1990s, the home equity loan market moved towards longer (and fixed) terms, larger loan balances, and more first liens (Schorin, Heins, and Prasad 2003). The home equity loans studied in this paper were issued between 1995 and 1998. Given this timing, the loans have some features of both the older and the newer characteristics of home equity loans; they are 15-year, fixed-rate second-lien mortgages to both prime and sub-prime borrowers.

In the analysis of prepayment of primary mortgages, both theoretical models and empirical studies suggest that market interest rate changes, loan size, loan-to-value ratios, borrower credit and other variables have a significant impact on prepayment behavior. There is no *a priori* reason to expect different prepayment behavior for home equity loans. However, smaller loan sizes, higher coupon rates and borrower motivation for taking out home equity loans may affect prepayment behavior.

The data set used in the analysis in this paper contains 54,999 fixed-rate home equity loans originated by a major US bank. The detailed loan-level data provide a good opportunity to assess

which factors affect home equity loan prepayment. In this paper, we focus on variables such as interest rate changes, trends in interest rate changes, loan size, and loan-to-value ratios that previous studies have found to affect the prepayment of primary mortgages. Because home equity loans are similar to other mortgage loans in many ways, we expect these variables to also influence the prepayment of home equity loans. In addition, we examine some monthly payment patterns for home equity loans to see whether delinquencies are an indicator of the probability of home equity loan prepayment.

To investigate the impact of borrower creditworthiness on home equity loan prepayment, we include FICO scores as an independent variable.[1] The FICO score is also used to decide whether a borrower qualifies for a prime loan. In this paper, we create two sub-samples based on borrower FICO scores to investigate whether creditworthy borrowers are more likely to take advantage of lower interest rates.

Empirical results obtained from proportional hazard models show that the prepayment of home equity loans is sensitive to market interest rate changes, original loan sizes, FICO scores and delinquencies. However, the loan-to-value ratio has little impact on the prepayment of home equity loans. We find that trends in interest rate changes have very significant impacts on prepayment. When borrowers expect market interest rates to decline further, they will wait to prepay their home equity loans even when the loans are already "in the money." We also find that previous delinquencies affect the likelihood of prepayment when home equity loans are "out of the money." Empirical results obtained from the sub-samples show that prime borrowers are more sensitive to changes in interest rates than are sub-prime borrowers.

The next section of the paper reviews the existing literature on prepayment and discusses major factors expected to affect prepayment behavior for home equity loans. Following

[1] The FICO score is a generally used measure of borrower creditworthiness in the mortgage, personal loan, and credit card industries. Scores range from 360 to 840, with higher scores indicating better credit history. A borrower with a FICO score equal to or above 660 is considered to be a prime borrower, and would generally qualify for a lower interest rate and/or a larger loan amount.

descriptions of the data and methodology, we report and discuss the empirical results. We then conclude with a summary of the findings.

**Related Studies**

Numerous studies have examined the relationship between the prepayment of primary mortgages and various loan, borrower, and economic factors, such as market interest rate changes, homeowner characteristics, the macroeconomic environment, and other factors. Empirical studies have also been conducted to test theoretical models, especially option-based models.

Changes in interest rates are generally regarded as the primary motivation for mortgage prepayment. In option-based models, there is a call option embedded in mortgage loans because borrowers can prepay their mortgage loans with little or no penalty. Once the market interest rate falls below the coupon rate, borrowers would prepay their current mortgages and borrow another loan with a lower coupon rate. In an early study, Dunn and McConnell (1981a, 1981b) developed a prepayment model to show how interest rate variations affected mortgage prepayment. Following them, other theoretical models were developed to consider both interest rate changes and various other factors hypothesized to affect mortgage prepayment.[2] Borrower heterogeneity is one of the most important factors affecting prepayment decisions. Both Archer and Ling's (1993), and Stanton's (1995) models considered heterogeneous transactions costs of borrowers in their exercise of call options. Archer, Ling, and McGill (1996, 1997) developed a framework that emphasized the role of borrower characteristics in mortgage prepayment.

Extensive empirical research has been done to study the determinants of mortgage prepayment. Consistent with theoretical models, most empirical studies have found that changes

[2] See, for example, Hilliard, Kau and Slawson (1998), Stanton (1995), McConnell and Singh (1994), Kau and Kim (1992), Kau et al. (1992), Follain, Scott and Yang (1992), etc.

in interest rates were a key reason that borrowers prepaid their mortgages. For example, Green and Shoven (1986) estimated the sensitivity of mortgage prepayments to prevailing interest rates using a proportional hazard model. Their results indicate that market interest rates were a significant determinant of prepayment probabilities, and average time to prepayment was highly dependent on interest rates.

Other factors, such as loan and borrower characteristics, and the macroeconomic environment have also been found to be important in mortgage prepayment. Campbell and Dietrich (1983) examined the determinants of prepayment and default on insured conventional residential mortgage loans using a multinomial logit model. They found that prepayment was significantly influenced by the loan-to-value (LTV) ratio, the payment-to-income ratio, regional unemployment rates, and changes in interest rates. Quigley (1986) found that household size, the age of the household head, and the education of the household head had a significant influence on household mobility. Schwartz and Torous (1989) analyzed various explanatory variables in mortgage prepayment, and found that mortgage age, proxies for the cost of refinancing, demographic variables, and geographic factors were significant. Cunningham and Capone (1990) summarized previous empirical studies on prepayment. They used a multinomial logit model to analyze and compare the termination experience of adjustable- and fixed-rate mortgages. They found that the loan-to-value ratio, the mortgage age, changes in interest rates, and borrower net worth had significant impacts on prepayment. Peristiani, et al.(1997) found that borrower credit history was an important determinant of refinancing behavior. The rationale was that borrowers with good credit history would be more likely to take advantage of a decrease in interest rates because their credit ratings could help them to find refinancing resources easily. Borrowers with unfavorable credit ratings, however, would be unable to exercise the call option embedded in the mortgage contracts even when the option was “in the money.”

Borrower heterogeneity has been examined in the context of sub-optimal prepayment decisions. Archer, Ling, and McGill (1996, 1997) developed a model to incorporate sub-optimal prepayment behavior of mortgage loans by incorporating heterogeneous borrower transactions costs. Stanton (1995) and Archer, Ling and McGill (1997) assumed that transactions costs as a percentage of current loan balances were not uniformly distributed across borrowers. Archer, Ling and McGill (1996) found that household demographic characteristics were only important to the extent that they were predictive of whether a household was income or collateral constrained. In a more recent study, Deng, Quigley and Van Order (2000) reported significant heterogeneity among mortgage borrowers and found that unobserved borrower heterogeneity was quite important in accounting for prepayment. They also found that the loan-to-value ratio was important in determining the probability of prepayment. Calhoun and Deng (2002) used a multinomial logit model to examine prepayment and default and found that a number of factors, including interest rate changes, the loan-to-value ratio, seasonal effects, and borrower income were significant.

Despite these extensive studies of primary mortgage prepayment, there are few studies examining the prepayment of home equity loans, especially at the loan level. Among the few published studies of home equity loan prepayment, Westhoff and Feldman (1997) found that borrower creditworthiness affected prepayment behavior in the presence of interest rate changes. Other important variables affecting the prepayment of home equity loans included the loan-to-value ratio, loan size, and lien position. Gjaja, Hayre and Rajan (2001) found that, in addition to loan age and interest rate, the amount and term of prepayment penalties, borrower's credit, average loan size, LTV, loan term, geographical distribution, loan purpose and borrower's debt-to-income ratio were important factors affecting prepayment of home equity loans. Also, home equity loan prepayment was less sensitive to declining interest rates than was primary loan prepayment.

In summary, previous empirical studies chiefly focused on the prepayment behavior of primary mortgages, and found that prepayments were affected by four types of factors: (1) the value of the underlying call option, measured by changes in interest rates; (2) mortgage characteristics, such as loan size, loan age, and loan-to-value ratio; (3) borrower characteristics, including borrower age, education and credit history; and (4) other exogenous factors, such as seasonal, geographic, and some macroeconomic factors.

As compared with primary mortgages, home equity loans are generally smaller and have higher coupon rates. Because of these features, a different set of factors may influence home equity loan prepayment. Moreover, the motivation for prepaying home equity loans may also differ. For example, a borrower may refinance her or his primary mortgage and pay off the home equity loan if the weighted average coupon rate on the current first and second lien is higher than the current market coupon on the new first lien mortgage. This may lead to prepayment of home equity loans even when they are "out of the money."

## Data and Methodology

### *Data*

A major US bank provided the data used in this paper. The original data set included approximately 84,000 fixed-rate, 15-year home equity loans originated between 1983 and 1998. A continuous record was maintained for each mortgage until the end of the sample period (September 1998) or until the mortgage matured, prepaid or defaulted. Although the data set included a variable indicating when prepayments were made, this variable was only reported from 1995 on.

Since there is no record in the data of termination of payments prior to March 1995, the status of those loans is unknown. Therefore, the data set used in the analysis excludes all home equity loans originated before March 1995, reducing the sample size to 55,114 loans. Since the number

of defaults in the sample is small (just 15 loans), we do not analyze default behavior and exclude these loans from the final sample, resulting in a total of 54,999 home equity loans. A total of 19,020 loans—34.6% of the loans in the analysis set—were prepaid during the sample period.

The home equity loans in the sample were originated in 46 states plus Washington D.C. California alone accounts for 18.9 percent of the loans in the sample. Fewer than five individual loans were originated in Arkansas, Hawaii, Montana, New Mexico, Vermont, and West Virginia.

The sample includes most of the variables commonly used to analyze mortgage prepayment: the original loan amount, the coupon interest rate, the original loan-to-value ratio, the origination date, and the termination date. In addition, borrower FICO scores are reported at origination. The sample also includes counters for payment delinquencies which we use to create two indicators of delinquency. Our minor delinquency indicator equals 1 if the borrower was 30 or 60 days late with at least one payment, and equals 0 otherwise. The major delinquency indicator equals 1 if the borrower was 90 or more days late with at least one payment, and equals 0 otherwise. These indicators are used to distinguish borrowers who are "sloppy" in making monthly payments from borrowers who are in financial trouble. Table 1 provides descriptive statistics for these variables.

< Table 1: Descriptive Statistics >

In the sample, the average original home equity loan amount is $41,779, with the smallest loan being $7,800 and the largest loan $565,000. The average loan size is much smaller than the average primary mortgage loan originated during this time period.[3] The average original LTV in the sample is 82.5%, which is a little higher than the average LTV of standard primary mortgage loans. This is not surprising given that the LTV in the sample is computed for the combination of the primary mortgage and the home equity loan. Usually, the LTV ratio does not exceed 100%, but in home equity loans, LTV can sometimes be much higher. The highest LTV ratio in the sample is 175%, and only 6 loans have LTV greater than 100%.

[3] The average loan size for primary mortgage is reported to be $124,000 in Westhoff and Feldman (1997).

The average coupon rate for the sample is 9.58%, which is much higher than the coupon interest rate of primary mortgages of the same term in the same time period. Figure 1 shows the average coupon interest rates for the sample and two benchmark interest rates for the same time period, 15-year and 30-year fixed primary mortgage rates from Freddie Mac. We can see that the interest rates follow the same pattern, with the average coupon rate of home equity loans in the sample is about 220 basis points higher than the 15-year mortgage rate in each month.

< Figure 1: Average Coupon Interest Rates of Home Equity Loans in the Sample and Benchmark Interest Rates between March 1995 and September 1998 >

The average FICO score of the borrowers in the sample is about 690. The distribution of the FICO scores is illustrated in Figure 2. We can see that most of the FICO scores are between 620 and 780. Using a score of 660 as the cutoff between prime and sub-prime results in 37,840—or 68.8% of the borrowers in the sample—being classified as prime borrowers.

<Figure 2: FICO Score Distribution of Home Equity Loan Borrowers >

Our minor and major delinquency indicators show that 41% of borrowers paid their loan late (but within 60 days of the due date) at least once. Only 1% of borrowers were delinquent for 90 days or more.

Of the 54,999 home equity loans in the final sample, 19,020 loans were prepaid during the sample period. Figure 3 illustrates the prepayment rate and cumulative prepayments of the home equity loan sample. The prepayment rate for each month is calculated as the number of loans prepaid during that month divided by the number of loans active at the beginning of the month. The cumulative prepayment rate is the total number of home equity loans ever prepaid divided by the total number of loans in the sample. The prepayment rate accelerates in early 1998, a time when interest rates declined sharply.

< Figure 3: Prepayment Rate and Cumulative Prepayment Rate of Home Equity Loans in the Sample >

*Methodology*

Proportional hazard models have been used in many previous studies analyzing the prepayment of primary mortgages.[4] Basically, a proportional hazard model assumes that the prepayment risk is a function of two parts, the "baseline hazard," which is the purely time-dependent factor, and other exogenous variables. Proportional hazard models have the advantage of considering the timing of prepayment and can include as many exogenous variables as necessary.

A standard specification of a proportional hazard is:

$$\lambda(x,t) = \lambda_0(t)e^{X\beta}$$

where $\lambda(x,t)$ is the hazard function at time t for an individual with covariates $X$. $\lambda_0(t)$ is an arbitrary unspecified base-line hazard function for continuous time $t$. $e^{X\beta}$ is the exponential function that specifies how the exogenous variables $(x_1, x_2, \ldots x_n)$ affect $\lambda(x,t)$. When analyzing prepayment, $\lambda(x,t)$ represents the probability of prepayment at time $t$ given the exogenous factors $x_1, x_2, \ldots x_n$. The assumption is that if $x_1, x_2, \ldots x_n$ make prepayment more likely at one time, they have the same proportional impact in all time periods. In this paper, we use a Cox regression for estimation.[5]

*Variable Selection*

Since many features of home equity loans are similar to those of primary mortgages, we expect that many of the same variables that affect the prepayment of primary mortgages will also affect the prepayment of home equity loans. The primary motivation for prepayment of primary loans is a change in interest rates. In option-based models, borrowers are assumed to maximize

[4] See for example, Green and Shoven (1986), Schwartz and Torous (1989), Deng, Quigley and Van Order (1999).
[5] For details on the Cox regression for proportional hazard models, see Cox (1972). Allison (1995) provides a detailed estimation method for the Cox regression.

the value of the underlying call options of their mortgage loans. In the absence of transactions costs, borrowers will prepay and refinance their mortgage loans whenever the current refinancing rate is lower than the coupon rate of their existing loan. In the presence of transactions costs, borrowers will decide to prepay when the savings from refinancing are greater than the transactions costs. A decrease in interest rates provides borrowers an incentive to prepay their mortgage loans. Since mortgage loans are amortized, we can estimate the value of a mortgage loan as an annuity.[6] Given that the remaining age of a loan is $t$ months, we have:

$$MV_t = \sum_{i=1}^{t} \frac{PAY}{(1+r_m)^i} \qquad (1)$$

where $MV_t$ is the market value of a mortgage loan with a remaining life of $t$ months, $PAY$ is the monthly payment and $r_m$ is the current market mortgage rate (expressed as a monthly rate). Equation (1) can be also written as:

$$MV_t = PAY \frac{1 - \frac{1}{(1+r_m)^t}}{r_m} = \rho_{mt} PAY \qquad (2)$$

Similarly, the remaining balance of a mortgage loan ($MB_t$) is

$$MB_t = PAY \frac{1 - \frac{1}{(1+r_c)^t}}{r_c} = \rho_{ct} PAY \qquad (3)$$

where $r_c$ is the coupon rate of the mortgage loan.

Suppose the current refinancing rate, $r_m$, drops below the coupon rate, $r_c$, and the borrower decides to refinance the loan at time $t$, then the savings from refinancing the loan can be expressed as:

[6]Since the cost of servicing a mortgage loan is proportional to the remaining balance, the monthly payment declines as the remaining mortgage balance declines. Since the servicing fees are a very small portion of the monthly payment, we can ignore service fees and approximate the value of a mortgage loan as an annuity.

$$S_t = MV_t - MB_t = PAY(\rho_{mt} - \rho_{ct}) \qquad (4)$$

From equation (4) we can see that the savings from refinancing depends on changes in interest rates, the monthly payment and the remaining age of the loan. When we consider the transactions costs of refinancing,[7] the borrower will refinance the loan when

$$S_t - C_j > 0 \qquad (5)$$

where $C_j$ is the refinancing cost for borrower $j$. The subscript $j$ is used to indicate the heterogeneity feature of transactions costs mentioned by Stanton (1995) and Deng, Quigley and Van Order (2000). The equations above indicate that a borrower's prepayment decision depends on the following factors: the scheduled monthly payment on the mortgage loan, the remaining age of the loan, the transactions costs of refinancing, and the interest difference between the coupon rate and the refinancing rate. Moreover, the scheduled payment of a mortgage loan depends on the term, the coupon rate, and the original balance of the loan.

Many researchers have attempted to capture the effect of interest rate changes on mortgage prepayment. Richard and Roll (1989) considered the savings per dollar of refinancing, hence

$$P = \frac{1 - \frac{1}{(1+r_c)^t}}{r_c} \qquad (6)$$

and

$$A = \frac{1 - \frac{1}{(1+r_m)^t}}{r_m} \qquad (7)$$

where $P$ is the remaining balance per dollar of monthly payment (MB/PAY from equation 3) and $A$ is the value of the loan per dollar of monthly payment (or MV/PAY from equation 2). In the

[7]Actually, the cost of refinancing includes both a fixed amount and an amount that is proportional to the remaining balance of the loan.

early years of the mortgage, P and A can be approximated by $1/r_c$ and to $1/r_m$, respectively. Based on this, Richard and Roll (1989) used $r_c/r_m$ as an explanatory variable. They assumed that refinancing costs were proportional to the remaining balance. The measure used by Richard and Roll would not be appropriate if either the remaining term of the mortgage were short or refinancing costs were independent of the size of the loan.

Calhoun and Deng (2000) used virtually the same measure in their study. Following Deng, Quigley and Van Order (1996), Calhoun and Deng established a measure to approximate the value of the call option. They argued that if the remaining life of a mortgage is relatively long, then the mortgage premium could be approximated by the following expression:

$$MP_t = \frac{r_{ct} - r_{mt}}{r_{mt}} \qquad (8)$$

where $MP_t$ is the mortgage premium resulting from a change in the interest rate, $r_{mt}$ is the current market interest rate on mortgages and $r_{ct}$ is the coupon rate on the existing mortgage. Lundstedt (1999) also used this measure.

In this paper, we employ the measure defined by equation (8) to compute the value of the underlying call option, and refer to this variable as RATE_DIFF in the models. Since we analyze prepayment behavior in the first 43 months of 15-year fixed rate home equity loans, the relatively long remaining term allows us to use equation (8) as a proxy for the value of the underlying call option. According to option-based models and previous studies of primary mortgage prepayment, the variable RATE_DIFF is expected to have a positive sign in the model. To calculate RATE_DIFF, we use the coupon interest rate on each home equity loan as $r_{ct}$ and the average coupon rate of the home equity loans in the sample each month as a proxy for the market interest rate, $r_{mt}$. There are several reasons that we choose this proxy. First, the bank that provided us the data is a large national bank, which provides competitive rates for its products. Second, the loans were originated in 47 states, and thus can be considered to be representative of home equity

interest rates nationwide. Third, we find the *pattern* of average interest rate on home equity loans to be identical to the pattern of interest rates on primary mortgages.[8] Finally, the sample size is sufficiently large—more than one thousand loans are originated each month in the data, so the average should be representative.

For our empirical analysis, we also create a variable IN_MONEY to indicate whether a home equity loan is "in the money." IN_MONEY equals 1 if RATE_DIFF is positive and equals 0 otherwise. In the regressions, we also include an interaction term (IN_MONEY multiplied by RATE_DIFF.)

In addition to the spread between the coupon interest rate and the market interest rate, trends in interest rate changes also affect prepayment behavior. When a borrower expects market interest rates to be lower in the future, s/he may not prepay her/his home equity loan immediately even if the loan is "in the money." The borrower can hold on and wait for the best timing to execute the underlying call option of the home equity loan. Therefore, when interest rates are trending downward, we expect to observe borrowers waiting to prepay their loans even when the market interest rate is already lower than the coupon interest rate of their loan. In this paper, we create a variable, RATE_TREND, to capture borrower expectations of interest rate changes. The variable is defined as:

$$RATE_TREND = \frac{r_{fmac30} - r_{fmac15}}{r_{fmac30}} \times 100 \qquad (9)$$

where $r_{fmac30}$ is the 30-year interest rate and $r_{fmac15}$ is the corresponding 15-year interest rate on primary mortgages as reported by Freddie Mac for each month in the sample period. When the interest rate is expected to increase, the gap between the 30-year and the 15-year mortgage rate tends to widen. Analogously, when rates are expected to decrease, the gap tends to narrow. We

[8] Figure 1 compares home equity loan interest rates in the sample to other benchmark rates on primary mortgages. As demonstrated in the figure, the average coupon rate in the sample appears to be a good proxy of the market interest rate for home equity loans.

expect RATE_TREND to have a positive sign in the model, indicating that borrowers wait to prepay their loans when they expect interest rates to be lower in the near future.

Loan characteristics can influence the benefits (relative to the costs) of prepaying of a loan while borrower characteristics are expected to influence the ability and desire to prepay a loan. Conceptually, a wide range of characteristics could influence prepayment, but data constraints often limit the types of variables available for analysis. Loan size is important in explaining mortgage prepayment because total savings from refinancing are directly related to loan size. The larger the loan, the more the homeowner can save by refinancing to a lower interest rate. Also, larger loans are more likely to be targeted by other financial institutions for refinancing. In the empirical models, we use natural log of original loan amount (ORIG_AMT) and expect this variable to have a positive sign.

Historically, borrowers with low loan-to-value (LTV) ratios exhibit higher prepayment rates, all else equal. The lower the LTV, the higher is the borrower's equity. Higher equity in the property enhances the borrower's ability to turn over or to take equity out of the property through refinancing.

Borrower credit rating also affects prepayment behavior. Westhoff and Feldman (1996) argue that the borrowers with good credit ratings are more able to take advantage of refinancing opportunities. Less creditworthy borrowers are less likely to refinance their loans because they are less able to pay transactions costs and usually have fewer refinancing alternatives available. Further, in their marketing, lenders usually target creditworthy borrowers with large loan balances before lower credit borrowers. Therefore we would expect prepayment for creditworthy borrowers to be more sensitive to changes in interest rates and would expect a positive coefficient for the credit quality variable. In this paper, we use FICO score (FICO), a widely used measure of borrower creditworthiness, as an independent variable in the regression models.

Borrowers' previous payment behavior is also expected to be an indicator of their ability to prepay and refinance their home equity loans. The dataset includes the monthly payment history for all borrowers. Based on their payment history, we create two dummy variables to indicate prior delinquencies on the loan. The variable MINOR equals one if a borrower has at least one minor delinquency in her/his previous monthly payment history, where a minor delinquency is a 30- or 60-day delinquency. Similarly, the indicator variable MAJOR equals one if the borrower has at least one payment delinquency of 90 days or more. Borrowers with minor delinquencies are considered to be "sloppy" payers. We expect that "sloppy" payers are not financially sensitive, and are less likely to be aware of and take advantage of refinancing opportunities. Borrowers with major delinquencies are those who have financial trouble and cannot make scheduled monthly payments. Such borrowers would have a difficult time finding a new loan at an advantageous rate to replace their existing home equity loan. Therefore, we expect both dummy variables to have negative signs in the model.

Borrower demographic characteristics are often included in prepayment models because those characteristics are proxies for heterogeneous borrower transactions costs (Archer and Ling, 1993). However, these variables are not available in the home equity loan sample.

Previous research has found that other variables also influence mortgage loan prepayment. One of these factors is regional variation. For example, Deng, Quigley and Van Order (1999) analyzed loan samples from California and Texas separately to consider how geography affected mortgage termination. The home equity loan data analyzed here includes the state in which the property is located, and 18.9% of the loans are originated in California. In this paper, we create a dummy variable CA to indicate home equity loans originated in California. Table 2 summarizes the independent variables used in the regression analysis.

< Table 2: Variables Used in Regression Analysis >

## Empirical Results

Proportional hazard models are frequently used in analyzing prepayment of mortgage loans. In this paper, we estimate proportional hazard models using the partial likelihood method (Cox regression). Table 3 reports the regression results from the proportional hazard model for the whole sample. For each independent variable in the model, four regression statistics are reported: the estimated parameter, its standard error, the p-value, and the hazard ratio. The hazard ratio is a measure of the sensitivity of the changes in the dependent variable to changes in an independent variable.[9]

### *Full Sample*

In the regression results for the full sample, all independent variables are statistically significant and most of them have the expected signs.

As expected, the prepayment of home equity loans in the sample is very sensitive to interest rate changes and trends. The hazard ratios for both RATE_DIFF * IN_MONEY and RATE_TREND greatly exceed one (4.0 and 6.3 respectively) indicating that the option value and the rate spread have the largest effects on prepayments.

< Table 3: Regression Result of Home Equity Loan Prepayment >

Loan size also affects home equity loan prepayment. Consistent with the discussion above, a positive parameter suggests that larger home equity loans are more likely to be prepaid, although the hazard ratio is relatively small (1.09) as compared with the hazard ratios for the interest rate variables.

The loan-to-value ratio is also significant in the model, but in contrast to expectations based on previous studies, it has a positive sign. However, the hazard ratio is only slightly above 1. A possible reason for a positive relationship between LTV and home equity loan prepayment is the

[9] For example, a hazard ratio of 0.8 means a one-unit increase in the independent variable causes the dependent variable to drop by 20%. On the other hand, a hazard ratio of 1.2 means that a one-unit increase in the independent variable causes the dependent variable to increase by 20%.

use of the combined LTV ratio. For primary mortgages, low LTV loans are more likely to be prepaid because borrowers with low LTV loans are more likely to trade up or are more able to refinance to access funds at lower rates than through other types of borrowing. However, in the case of home equity loans, borrowers have already originated new loans against their home equity and have, on average, relatively high LTV ratios. Therefore, the way that LTV affects home equity loan prepayment may differ from the way in which it affects primary mortgage prepayment. It would be very interesting to see how the impact of home equity loans varies with their share of the total loan amount. However, since the corresponding information on primary mortgages is not available, we are not able to investigate this further with the current data set.

The coefficient on the FICO score also has the expected positive sign, suggesting that more creditworthy borrowers—those with higher FICO scores—are more likely to prepay their home equity loans. However, the hazard ratio is just above 1.0, so the effect in the full sample is small. To further investigate the effect of FICO scores, we divided the sample into two groups based on FICO scores at origination. This analysis is discussed below.

Both the minor and major delinquency indicators have the expected negative signs. This indicates that borrowers with late payments in their home equity loan payment history are less likely to prepay their loans. Borrowers with minor delinquencies—so-called “sloppy” payers—appear to be less likely to take the advantage of falling interest rates. The hazard ratio for this variable is 0.79, meaning that borrowers with minor delinquencies are about 20% less likely to prepay their home equity loans than are otherwise equivalent borrowers. Not surprisingly, major delinquencies have a more dramatic effect on prepayment of home equity loans. The hazard ratio for major delinquencies is just .36, indicating that such borrowers are only about one-third as likely to prepay their home equity loans as other borrowers, all else equal.

The indicator variable for loans originated in California, CA, has a positive coefficient and a hazard ratio of 1.4, indicating that California loans are more likely to be prepaid.

*“Out of the Money” Sub-sample*

To further investigate the factors that affect home equity loan prepayment, we run a regression on the sub-sample of the data set in which home equity loans are “out of the money.” The sub-sample contains 25,976 loans, and 7,602 or about 29% of the loans are prepaid. (In the full sample, 34.6% of the loans were prepaid.) Table 3 also reports the results of this regression.

We expect the prepayment of “out of the money” home equity loans to be higher than the prepayment rate for “out of the money” primary mortgages for a number of reasons. Some prepayment is always expected because of such factors as borrower moves. Home equity loans may also be prepaid when primary mortgages are prepaid or refinanced for reasons such as debt consolidation when the primary loan may be “in the money” even if the home equity loan is not.

The regressions show similar results for “out of the money” loans as for all home equity loans, with a few differences. Not surprisingly, the hazard ratios for the interest rate variables (RATE_DIFF and RATE_TREND) are smaller than the ratios for the full sample. The LTV variable has a negative sign in the regression for the “out of the money” subsample, but it is not statistically significant and the hazard ratio for this variable is still close to 1.

*Sub-samples by FICO Score*

Financial companies frequently use FICO scores to assess the creditworthiness of potential borrowers. Borrowers with FICO scores equal to or greater than 660 are regarded as prime borrowers, often qualifying for lower interest rate products and higher loan amounts. Therefore we expect that prime borrowers would be more able to take advantage of falling interest rates and refinance or prepay their mortgages. To further analyze the effects of FICO scores, we divided the full sample into two sub-groups. Borrowers with FICO scores equal to or greater than 660 are assigned to the prime sub-sample. Table 4 reports the regression results for the two sub-samples.

< Table 4: Regression Result of Home Equity Loan Prepayment for Sub-samples Divided by FICO Score >

The prepayment rates in the sample are similar for the two subgroups. In the prime sub-group, there are 37,840 home equity loans and 12,850 prepayments (34.96%) and in the group with lower FICO scores, 35.96% (6,170 of 17,159 loans) prepaid during the sample period.

The regression results show that all variables are significant in the prime sub-model. In the sub-prime sample, the coefficient on the original loan amount is not significant. The most important difference between the two models is that the hazard ratio for interest rate changes in the prime sub-sample is 6.69, about 6 times as high as that of sub-prime sub-sample. This result suggests that creditworthy borrowers are more likely to take advantage of lower interest rates by prepaying their home equity loans.

**Conclusion**

Numerous studies have examined prepayment of primary mortgages, but much less has been done to investigate the prepayment of home equity loans, particularly at the loan level. Even though many features of fixed-rate home equity loans are similar to those of primary mortgage loans, we cannot assume that the variables that affect the prepayment of home equity loans and primary mortgages are the same. Generally, home equity loans are smaller and have higher coupon interest rates than do primary mortgage loans. These features may alter the set of factors that impact the prepayment of home equity loans. The motivations for prepaying home equity loans and primary mortgages may be different. For example, borrowers may obtain a larger mortgage loan to pay off their higher-rate home equity loans and consolidate their debt. As long as the interest rate spreads between primary mortgages and home equity loans are large enough, borrowers may prepay their home equity loans even when the loan is out of the money. Unfortunately, we cannot investigate this issue further with the existing data set because of a lack of information on the primary mortgages.

Previous studies of mortgage prepayment focused on four sets of factors that may also affect the prepayment of home equity loans – interest rate changes, loan characteristics, borrower

characteristics, and other factors such as seasonal and geographic factors. In this paper, we examined the effect of interest rate changes and trends, the original loan amount, the loan-to-value ratio, the borrower's FICO score at origination, indicators of payment delinquencies, and a dummy variable for California loans, on prepayment behavior.

The empirical results were generally consistent with expectations, although loans that were not "in the money" were frequently prepaid. Key factors that affect the prepayment of primary mortgages, including interest rate changes, the original loan amount and borrower credit worthiness, were all significant in the home equity loan prepayment model. Prepayment of home equity loans was also sensitive to interest rate trends. The regression results showed that when borrowers expect market interest rates to decrease further in the future, they may wait for interest rates to fall further before they prepay their current home equity loans. The LTV ratio—one of the most important factors affecting the prepayment of primary mortgages — took an unexpected sign, but had a very small coefficient in the model. This was likely due to the fact that the LTV ratios in the dataset were for a combination of primary mortgages and home equity loans, and thus showed less power in the model. We found that delinquencies in monthly payment history were a strong indicator of the (lower) likelihood of home equity loan prepayment. Borrowers with minor delinquencies were usually not financially sensitive and thus less likely to refinance their home equity loans when market interest rate dropped. Borrowers with major delinquencies were those in financial trouble, and appeared to be less able to find new loans to refinance their current home equity loans. The empirical results also showed that interest rate changes still played a role in home equity loan prepayment even when the loan was out of the money. Our results also indicated that prime borrowers were markedly more sensitive to interest rate changes than were sub-prime borrowers and were thus more likely to prepay their home equity loans when the market interest rate declined.

In this paper, we have documented important factors that affect the prepayment of home equity loans. The result of this analysis suggests that standard mortgage prepayment models are

insufficient to explain home equity loan prepayment behavior. Future work would benefit from a data set that includes both primary and home equity loans so that researchers can examine how prepayment of one type of loan may affect the other.

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**Table 1: Descriptive Statistics**

The coupon rate is the coupon interest rate of the 15-year fixed interest rate home equity loans in the analysis sample. The original loan-to-value ratio is the sum of the primary mortgage and the home equity loan divided by the appraised value of the house when the home equity loan was originated. The original loan amount is the dollar value of the home equity loan. FICO score is the FICO score of the borrower when the loan was originated. Loan age is the number of months between the origination month and the termination month. If the loan is not terminated during the sample period, the loan age is the number of months between the origination month and September 1998. The minor delinquency indicator equals one when the payment history of the borrower shows at least one 30- or 60-day late payment. The major delinquency indicator equals 1when the borrower's payment history shows at least one delinquency of 90 days or more.

| Variable | Number of Observations | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Coupon Rate | 54,999 | 9.58% | 9.5% | 0.0690 | 6.9% | 17.99% |
| Original Loan-to-Value Ratio | 54,999 | 82.51% | 85% | 0.1169 | 10% | 175% |
| Original Loan Amount | 54,999 | $41,779 | $34,500 | 30426.1 | $7,800 | 565,000 |
| FICO Score | 54,999 | 690.17 | 697 | 63.26 | 366 | 836 |
| Loan Age (in months) | 54,999 | 18.12 | 17 | 11.18 | 0 | 43 |
| Minor Delinquency Indicator | 54,999 | 0.41 | 0 | 0.19 | 0 | 1 |
| Major Delinquency Indicator | 54,999 | 0.01 | 0 | 0.10 | 0 | 1 |

**Table 2: Independent Variables Used in the Regressions**

| Variable Name | Definition | Expected Sign |
|---|---|---|
| RATE_DIFF | $= (r_c - r_m)/r_m$, where $r_c$ is the coupon rate and $r_m$ is a proxy for the market interest rate (equal to the average coupon rate of home equity loans in the sample). | + |
| RATE_TREND | $100 \times (r_{fmac30} - r_{fmac15})/r_{fmac30}$ ,where $r_{fmac30}$ is the 30-year and $r_{fmac15}$ is the 15-year fixed interest rate on primary mortgages as reported by Freddie Mac. | + |
| ORIG_AMT | Natural log of the original balance of the loan. | + |
| IN_MONEY | Dummy variable, if RATE_DIFF > 0, then IN_MONEY = 1, otherwise IN_MONEY = 0 | |
| LTV | Loan-to-value ratio | - |
| FICO | FICO score (reported at origination) | + |
| MINOR | Dummy variable that equals 1 if a borrower has previous 30-or 60-day delinquencies in monthly payments. | - |
| MAJOR | Dummy variable that equals 1 if a borrower has previous delinquencies of 90 days or more in monthly payment. | - |
| CA | Dummy variable. = 1 if a loan is originated in California. = 0 otherwise. | ? |

## Table 3: Regression Results

See Table 2 for descriptions of the variables.

| Variable/Model | | All | Out of the Money |
|---|---|---|---|
| # of Observations | | 54,999 | 25,976 |
| RATE_DIFF | Parameter | - | 1.1703 |
| | Standard Error | | 0.2325 |
| | p-value | | <0.0001 |
| | Hazard Ratio | | 3.223 |
| RATE_DIFF * IN_MONEY | Parameter | 1.4499 | - |
| | Standard Error | 0.1258 | |
| | p-value | <0.0001 | |
| | Hazard Ratio | 4.263 | |
| RATE_TREND | Parameter | 1.7959 | 0.3131 |
| | Standard Error | 0.0150 | 0.03572 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 6.025 | 1.368 |
| ORIG_AMT | Parameter | 0.0829 | 0.0673 |
| | Standard Error | 0.0132 | 0.0209 |
| | p-value | <0.0001 | 0.0013 |
| | Hazard Ratio | 1.086 | 1.070 |
| LTV | Parameter | 0.0035 | -0.0007 |
| | Standard Error | 0.0006 | 0.0009 |
| | p-value | <0.0001 | 0.4365 |
| | Hazard Ratio | 1.004 | 0.999 |
| FICO | Parameter | 0.0014 | 0.0010 |
| | Standard Error | 0.0001 | 0.0002 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 1.001 | 1.001 |
| MINOR | Parameter | -0.2312 | -0.1524 |
| | Standard Error | 0.0157 | 0.0246 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 0.794 | 0.859 |
| MAJOR | Parameter | -1.0307 | -0.8462 |
| | Standard Error | 0.0977 | 0.1752 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 0.357 | 0.429 |
| CA | Parameter | 0.3481 | 0.1554 |
| | Standard Error | 0.0198 | 0.0360 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 1.416 | 1.168 |

**Table 4: Regression Results for FICO Score Sub-samples**

See Table 2 for descriptions of the variables.

| Variable/Model | | FICO ≥ 660 | FICO < 660 |
|---|---|---|---|
| # of Observations | | 37,840 | 17,159 |
| RATE_DIFF * IN_MONEY | Parameter | 1.9001 | 0.2220 |
| | Standard Error | 0.1118 | 0.1258 |
| | p-value | <0.0001 | 0.0775 |
| | Hazard Ratio | 6.687 | 1.249 |
| RATE_TREND | Parameter | 1.6506 | 2.0760 |
| | Standard Error | 0.0184 | 0.0261 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 5.210 | 7.973 |
| ORIG_AMT | Parameter | 0.1624 | -0.0112 |
| | Standard Error | 0.0166 | 0.0218 |
| | p-value | <0.0001 | 0.6083 |
| | Hazard Ratio | 1.176 | 0.989 |
| LTV | Parameter | 0.0046 | 0.0006 |
| | Standard Error | 0.0008 | 0.0011 |
| | p-value | <0.0001 | 0.5810 |
| | Hazard Ratio | 1.005 | 1.001 |
| MINOR | Parameter | -0.2427 | -0.2629 |
| | Standard Error | 0.0187 | 0.0277 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 0.785 | 0.769 |
| MAJOR | Parameter | -1.0551 | -0.9710 |
| | Standard Error | 0.2048 | 0.1113 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 0.348 | 0.379 |
| CA | Parameter | 0.3405 | 0.3275 |
| | Standard Error | 0.0208 | 0.0593 |
| | p-value | <0.0001 | <0.0001 |
| | Hazard Ratio | 1.406 | 1.387 |

**Figure 1: Average Coupon Interest Rates of Home Equity Loans in the Sample and Benchmark Interest Rates during March 1995 and September 1998**

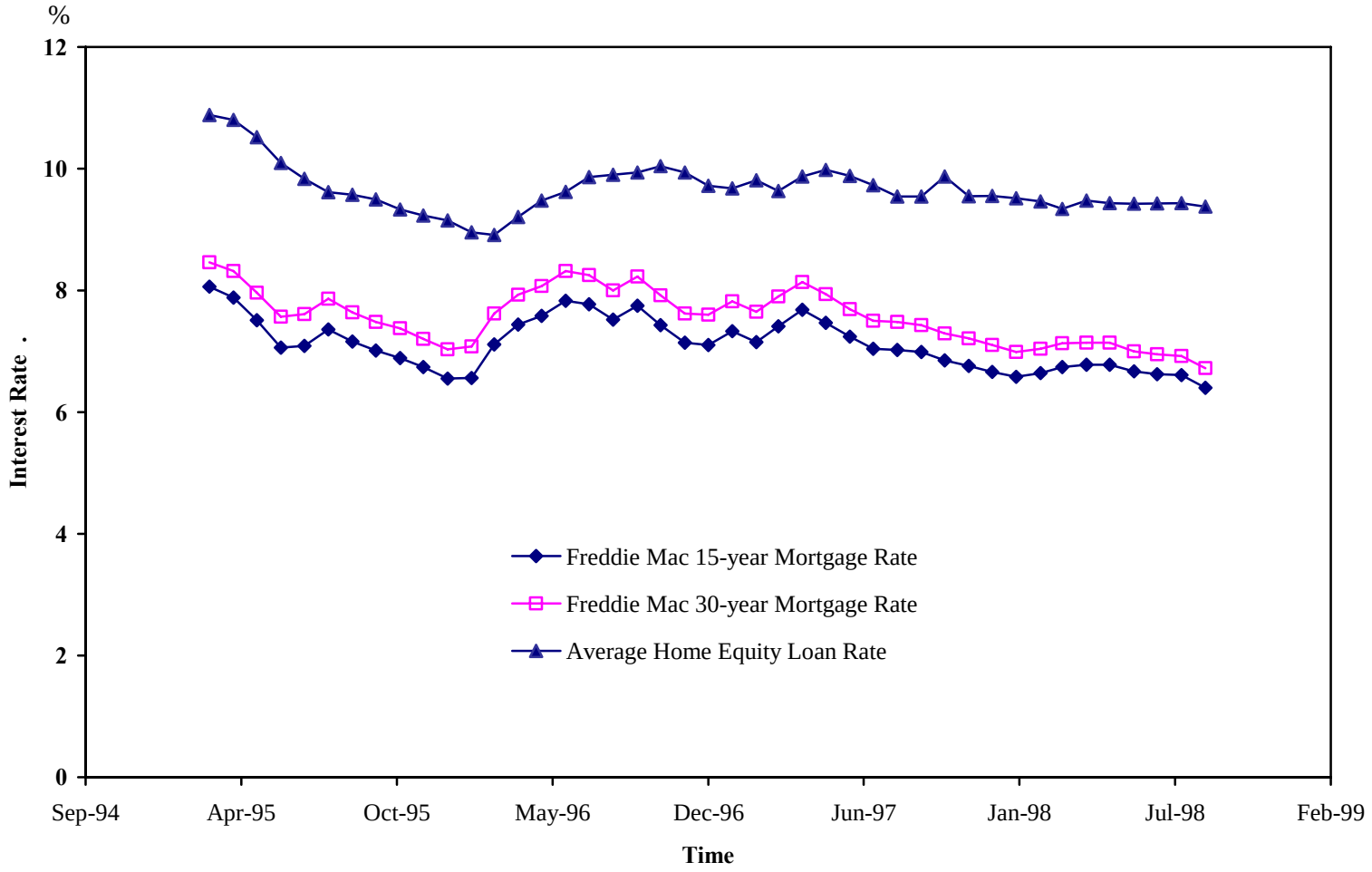


**Figure 2: FICO Score Distribution of Home Equity Loan Borrowers**

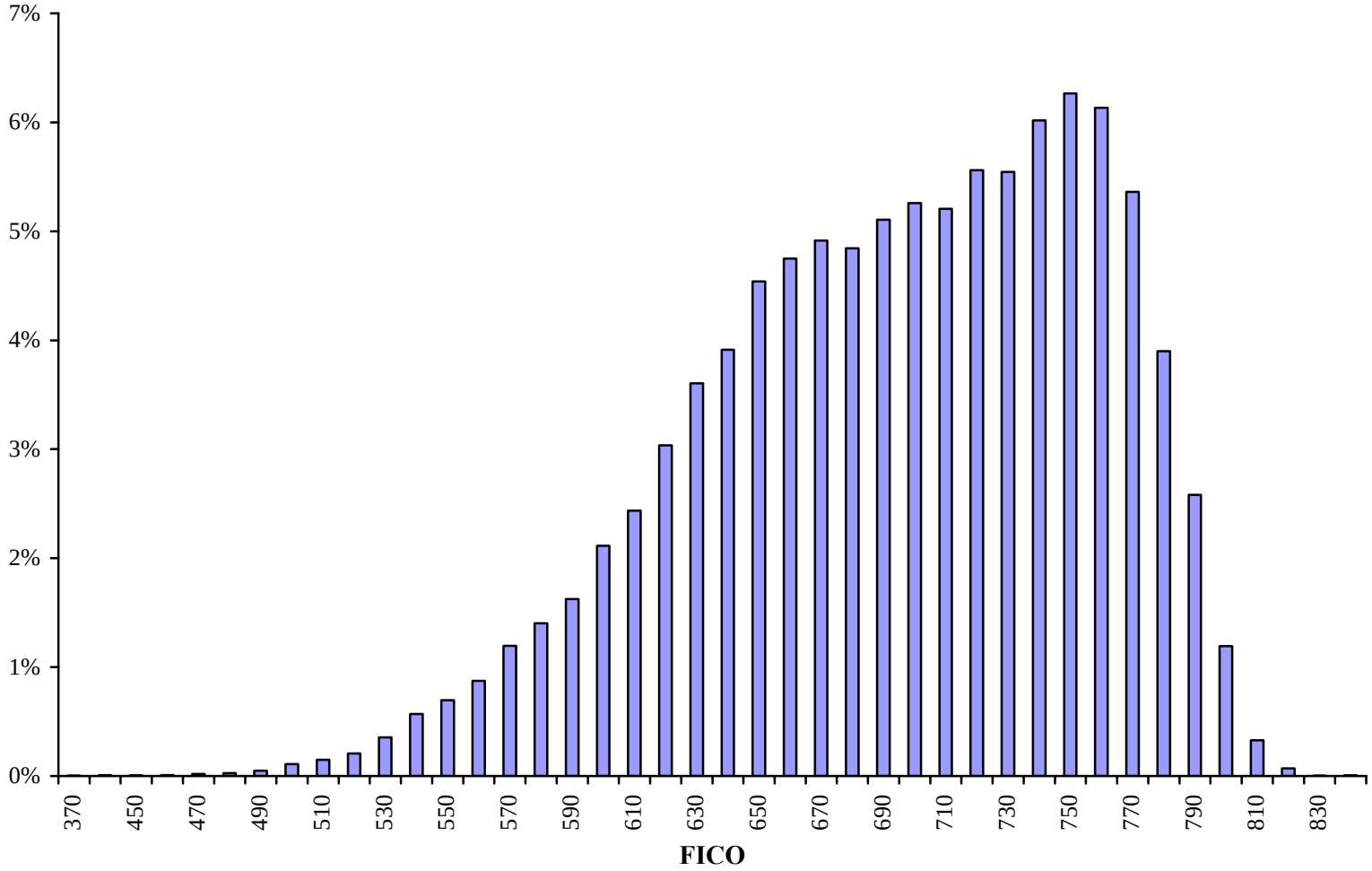
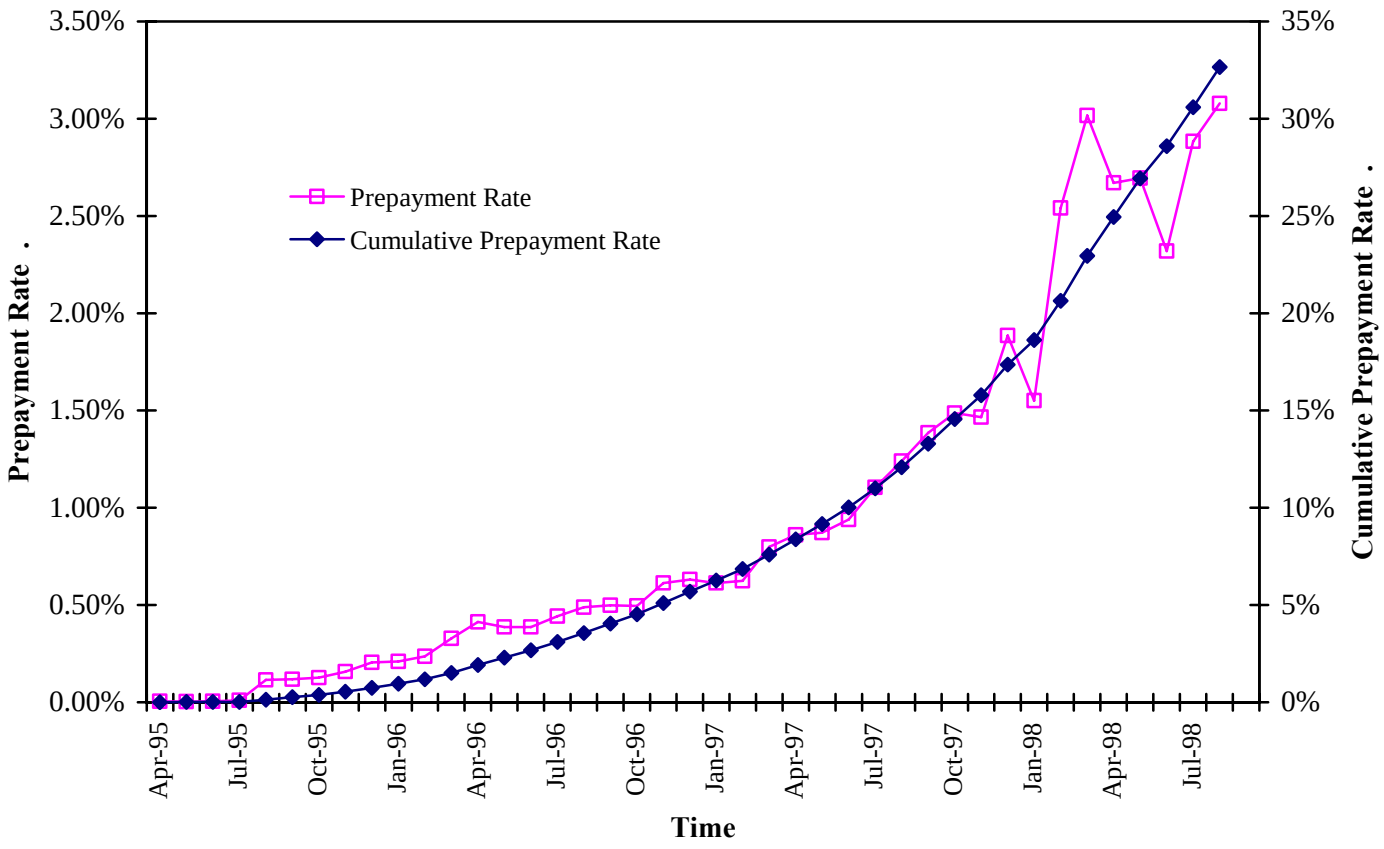


**Figure 3: Prepayment Rates and Cumulative Prepayment Rates of Home Equity Loans**

Prepayment rate is total number of loans prepaid of a month divided by total number of active loans at the beginning of the month. Cumulative prepayment rate of the loans is total number of loans ever prepaid divided by total number of loans in the sample.