EFFECTS OF HOUSEHOLD CREDITWORTHINESS ON MORTGAGE REFINANCINGS

STAVROS PERISTIANI, PAUL BENNETT, GORDON MONSEN, RICHARD PEACH, AND JONATHAN RAIFF

Homeowners typically have the option to prepay all or part of the outstanding balance of their mortgage loans at any time, usually without penalty. Unless they have sufficient wealth to pay off the balance, however, exercising this option requires obtaining a new loan. Evidence is accumulating that variations in homeowners' ability to qualify for new mortgage credit and in the cost of that credit account for a significant part of the observed variation in refinancing behavior. It follows that individual homeowner and property characteristics, such as personal credit ratings and changes in home equity, must be considered systematically along with changes in mortgage interest rates in the analysis and prediction of mortgage prepayments.

Initial research into the factors influencing prepayments focuses almost exclusively on the difference between the interest rate on the homeowner's current mortgage and rates available on new loans, largely because the data sets used to investigate this issue have been aggregate data on the pools of mortgages serving as the underlying collateral for mortgage-backed securities. More recent research has relied upon loan-level data sets that allow the factoring in of individual property, loan, and borrower characteristics (see Cunningham and Capone [1990], Caplin, Freeman, and Tracy [1993], Archer, Ling, and McGill [1995], and Abrahams [1997]).

Our research represents a significant advance in the literature on mortgage prepayments, as it is the first study to introduce quantitative measures of individual homeowner credit histories into a loan-level analysis of the factors influencing the probability that a homeowner will refinance. In addition, we use county-level repeat sales home price indexes to estimate changes in individual homeowner equity over time. Our findings

STAVROS PERISTIANI, PAUL BENNETT, and **RICHARD PEACH** are economists at the Federal Reserve Bank of New York.

GORDON MONSEN is managing director at PaineWebber, Inc., in New York.

JONATHAN RAIFF is first vice president at PaineWebber, Inc., in New York.

strongly support the hypothesis that, other things equal, the worse the credit rating, the lower the probability that a loan will be refinanced. In addition, we provide further reinforcement of the finding that changes in home equity also strongly influence that probability.

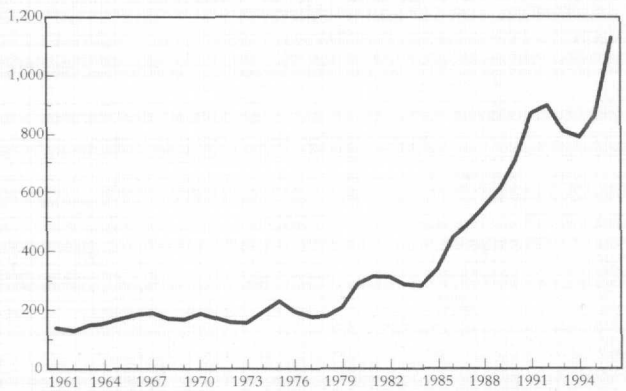
These findings are important from an investment risk management perspective because they confirm that mortgage cash flow responsiveness to changes in interest rates will be significantly influenced by credit and equity conditions of individual borrowers. The evidence is overwhelming that these conditions are subject to dramatic changes.

For example, as Exhibit 1 shows, personal bankruptcies have risen quite sharply since the mid-1980s. While this partly reflects changes in laws and attitudes, it suggests nonetheless that credit histories for a growing segment of the population are deteriorating.

Furthermore, as shown in Exhibit 2, home price movements, the key determinant of changes in homeowners' equity, have been considerably different both over time and in different regions of the country. For example, home price appreciation was quite rapid in the Middle Atlantic and Pacific states in the mid- to late 1980s, but then prices actually declined during much of the first half of the 1990s. Rates of home price appreciation in the East North Central and South Atlantic states by contrast were significantly less volatile over this same period.

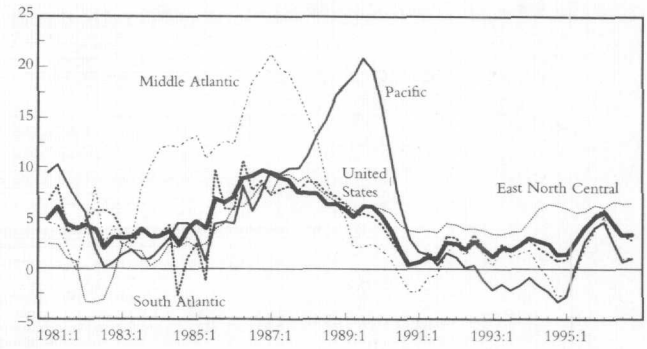
As mortgage rates fell during the first half of the 1990s, many households likely found it difficult, if not impossible, to refinance existing mortgages because of poor credit ratings or erosion of home equity.

EXHIBIT 1 ■ Total Personal Bankruptcies



Source: Administrative Office of the United States Courts.

EXHIBIT 2 ■ Fannie Mae-Freddie Mac Repeat Sales House Price Index for the United States and Selected Regions



Source: Office of Federal Housing Enterprise Oversight.

Consequently, the prepayment experience of otherwise similar pools of mortgage loans may be vastly different depending on their proportions of credit- and/or collateral-constrained borrowers.

I. DATA

The data for this study were provided by the Mortgage Research Group (MRG) of Jersey City, which entered into a strategic alliance with TRW — one of the three large national credit bureaus — to provide data for research on mortgage finance issues. MRG maintains a data base covering roughly 42 million residential properties located in 396 counties in 36 states.

The data base is arranged into tables. The primary table is the transaction table, which is based on the TRW "Redi Property" data base. This table is organized by properties, with a detailed listing of the major characteristics of all transactions pertaining to each property. For the roughly 42 million properties covered, information is provided for between 150 and 200 million transactions. A separate table gives periodic snapshots of the credit histories of the occupants of those properties. The data on credit histories are derived from TRW Information Services, the consumer credit information side of that organization. Individual records in the credit table can be linked to records in the transaction table on the basis of property identification numbers.

The sample used in this study was constructed in

several stages. First, we selected groups of counties representing the four major regions of the country. In the East, we chose four counties surrounding New York City (Orange County in New York State, and Essex, Bergen, and Monmouth Counties in New Jersey). In the South, we chose six counties in central Florida (Citrus, Clay, Escambia, Hernando, Manatee, and Marion). In the Midwest, we chose Cook and five surrounding counties in Illinois (Dekalb, DuPage, Kane, McHenry, and Ogle). Finally, in the West we selected Los Angeles, Ventura, and Riverside Counties in California. Inclusion of these four diverse areas assures that our statistical findings are general rather than specific to a particular housing market. Furthermore, over the past decade the behavior of home prices in these four regions has been quite different.

In these counties, we identify for each property the most recent purchase transaction, scanning as far back as January 1984. The mortgages on some of these properties were subsequently refinanced, in some cases more than once, while for the others there were no further transactions recorded through the end of our sample period, December 1994. (Loans that subsequently defaulted are excluded from the sample.) Thus, the sample consists of loans that were refinanced and loans that were not refinanced as of the end of the sample period, establishing the zero-one, refinance-no refinance, dependent variable we then try to explain. (For loans refinanced, the new loan could be greater than, equal to, or less than the remaining balance on the old loan.) We then limited the sample to properties originally financed with fixed-rate loans outstanding for a year or more.

In the final step, the snapshots of credit histories were linked to a random sample of these properties by MRG. The resulting sample consists of 12,855 observations, of which slightly under one-third were refinanced.

The resulting sample is an extensive cross-section; each observation in the sample represents the experience of an individual mortgage loan over a well-defined time period. For example, assume that an individual purchased a house in January 1991 and subsequently refinanced in December 1993, an interval of thirty-six months. This "window" represents one observation or experiment in our sample. Unlike most other studies on this topic, the starting dates, ending dates, and time intervals between are unique for each observation.

Starting dates (purchases) range from January 1984 through December 1993, while time intervals (loan ages) range from 12 to 120 months. This means that the sample includes refinancings that occurred in the 1986-early 1987 "refi wave" as well as in the 1993-early 1994 wave, although most are from the latter period. This allows us to investigate whether the propensity to refinance has changed over time.

II. MODELING THE DECISION TO REFINANCE

To refinance a mortgage is to exercise the call option imbedded in the standard residential mortgage contract. In theory, a borrower will exercise this option when it is "in the money," meaning that refinancing would reduce the current market value of the borrower's liabilities by an amount equal to or greater than the costs of carrying out the transaction. In fact, many borrowers with apparently in-the-money options fail to exercise them, while others exercise the option when it apparently is not in the money.

This heterogeneity of behavior appears to be due in large part to homeowners' ability to secure replacement financing. If the individual cannot qualify for a new mortgage, or can qualify only at an interest rate much higher than that available to the best credit risks, then refinancing may not be possible or worthwhile, even though at first glance the option appears to be in the money.

Our hypothesis is that, in addition to a decline in equity resulting from a decline in the property value, refinancing may not be possible or worthwhile because the borrower's personal credit history is marginal or poor. This either prevents the borrower from obtaining replacement financing or raises the cost of that financing so that the present value of the benefits does not exceed transaction costs.

Of course, equity and credit are not the sole factors behind this heterogeneity of behavior. Homeowners often refinance when the option is not in the money in order to take equity out of the property. After all, mortgage debt is typically the lowest-cost debt that consumers can obtain, particularly on an after-tax basis.

Conversely, homeowners who are not equity-, credit-, or income-constrained often do not exercise options that appear to be in the money. There are many possible reasons for such behavior, including the fact that the homeowner expects to move in the

near future, so there would not be enough time to recoup the transaction costs of refinancing.

In short, in our model the dependent variable is a discrete binary indicator that assumes the value of one when the homeowner refinances and the value of zero otherwise. We use logit analysis to estimate the effect of various explanatory variables on the probability that a loan will be refinanced. The explanatory variables may be categorized as 1) market interest rates and other factors in the lending environment affecting the cost, both financial and non-financial, of carrying out a refinancing transaction; 2) the credit history of the homeowner; and 3) an estimate of the post-origination LTV. In addition, as in most prepayment models, we include the number of months since origination or the age of the mortgage to capture age-correlated effects not stemming from equity, credit, or the other explanatory variables.

More details about the definitions and specification of these variables follow, while Exhibit 3 presents summary statistics.

The Incentives to Refinance

Theory suggests that homeowners will refinance if the benefits of doing so, in terms of lower after-tax mortgage interest payments over the expected life of the loan, exceed the costs of obtaining a new loan. Accordingly, the strength of the incentive to refinance is determined

EXHIBIT 3 ■ Summary Statistics for Explanatory Variables

Explanatory Variable	Description	Mean Refinancings	Mean Non-Refinancings
WRSTNOW	Worst current delinquency (1 = good credit, 30, 60, 90, 120, 150, 180, 400 = default)	26.5	42.5
WRSTEVER	Worst delinquency ever (1 = good credit, 30, 60, 90, 120, 150, 180, 400 = default)	64.9	101
WRSTCRD	Worst delinquency ever on credit cards (1 = good credit, 30, 60, 90, 120, 150, 180, 400 = default)	23.1	35.4
TDEROG	Total number of derogatories	0.34	0.58
SPREAD	Coupon rate minus prevailing market rate (percent)	1.66	1.30
PROBIN	Probability of being in the money (decimal)	0.50	0.39
INMONEY	Proportion in the money (decimal)	0.18	0.12
PVALUE	Present value ratio (decimal)	1.17	1.08
LTV	Current loan to value ratio (percent)	67.6	74.3
HSD	Historical standard deviation (percent)	0.11	0.11
AGE	Loan maturity (years)	4.90	5.44
LE	Lending environment measured by change in transaction costs (percent)	0.24	0.13
Other Related Variables	Original purchase price of house (thousands of dollars)	150	129
	Original loan balance (thousands of dollars)	104	103
	Monthly payment on first mortgage (dollars)	1,150	948
	Balance-to-limit on all credit lines (percent)	76.8	77.3

Source: Authors' calculations.

by comparing the contract rate on the existing mortgage with the rate that could be obtained on a new mortgage. This comparison must also take into account transaction costs such as discount points and assorted closing costs as well as the opportunity cost of the time spent shopping for and qualifying for a new loan.

There are numerous alternative measures that can be used to measure the strength of the incentive to refinance, none of them perfect. For our study, a key issue is whether the effects of creditworthiness and/or home equity on the probability of refinancing are significantly altered by how the incentive to refinance is specified. In order to provide a rigorous test of the effect of creditworthiness and home equity, we use four alternatives, which range from the simple to the complex. These alternatives can be categorized as discrete measures and as continuous measures. The effects of creditworthiness and home equity are insensitive to the measure employed.

Discrete Measures. The simplest measure of the net benefit provided by refinancing is the spread between the contract rate on the existing loan (C) and the prevailing market rate (R); that is:

$$SPREAD_t = C - R_t \quad (1)$$

where t represents the time period.

While it is not explicitly treated in this measure, one could imagine that, due to transaction costs, there is an implicit critical threshold of SPREAD, say, 100 to 150 basis points, that must be exceeded in order to trigger a refinancing. This threshold would likely vary across borrowers and over time (see Follain, Scott, and Yang [1992] and Follain and Tzang [1988]).

Another drawback of SPREAD is that it does not take into account the fact that the financial benefit of refinancing is a function of the expected life of the new loan. Richard and Roll [1989] propose an alternative measure that accounts for this expected life by comparing the present values of the existing mortgage over its remaining maturity evaluated at the competing interest rates C and R. More specifically, define

$$PV_t(C) = \frac{[1-(1+C)^{t-360}]}{C} \quad (2)$$

$$PV_t(R) = \frac{[1-(1+R)^{t-360}]}{R} \quad (3)$$

The variables PV(C) and PV(R) represent the per dollar annuity of monthly payments at interest rates C and R over the remainder of the original thirty-year maturity. The ratio of PV(C) and PV(R) offers a simple criterion for refinancing:

$$PVALUE_t = \left(\frac{C}{R}\right)\left(\frac{1-(1+R)^{t-360}}{1-(1+C)^{t-360}}\right) = \left(\frac{C}{R}\right)\gamma_t \quad (4)$$

Again ignoring transaction costs, we would expect that the incentive to refinance strengthens, the more PVALUE exceeds 1.

For all observations in our sample, C is the Freddie Mac national average commitment (contract) rate on fixed-rate loans for the month the loan was closed.[1] This is the so-called A paper rate or the rate available to the best credit risks. Likewise, for those homeowners who did refinance, R is also the national average A paper contract rate for the month the new loan was closed.

An important issue that arises when using discrete measures such as SPREAD and PVALUE in cross-sectional analysis is assigning a value of R to the people who did not refinance. An infinite number of possibilities exist, and there is a certain amount of arbitrariness in selecting any particular one.[2] In tackling this problem, we observed that those who did refinance rarely did so at the highest spread [lowest value of (R)] that occurred over the period from their original purchase to the date they refinanced. If all the values of spread observed over that period were ranked from highest to lowest, on average those who did refinance did so at about the seventy-fifth percentile. Accordingly, we assigned non-refinancers the value of R associated with the seventy-fifth percentile of spreads observed over the period from date of original purchase to the end of the sample period (December 1994).

It should be noted that by basing C and R on the A paper rate, we explicitly exclude from these measures of the incentive to refinance any influences that individual borrower characteristics may have on the actual values of those measures faced by a particular borrower. The effects of those individual characteristics are captured by the credit and equity variables, as well as the error term. We also ignore the fact that the values of C and R for any one individual are likely to deviate somewhat from the national average due to regional differences in interest rate and the fact that, all

else equal, some people are better shoppers and bargainers than others. By assigning the A paper rate to each individual at the time of purchase, we are able to attain the best comparison of the value of the option embedded in the mortgage.

Cumulative Measures. An alternative approach to measuring the strength of the incentive to refinance is to construct a measure that cumulates the individual values of each period in the relevant time interval. An advantage of these cumulative measures is that the issue of the values to assign to those who did not refinance is much more clear-cut. We use two such measures. The first is labeled INMONEY, which is defined as the proportion of time periods since the date of purchase that the homeowner's option has been in the money. More specifically, the option is defined as being in the money when this condition holds:

$$PV_t(R) - PV_t(C) > TC_t \quad (5)$$

where the present value terms are defined by Equations (2) and (3), and TC is a measure of transaction costs.[3]

For simplicity, let y_t be a binary 0-1 variable measuring when the homeowner is in the money:

$$\begin{aligned} y_t &= 1 \quad \text{if} \quad PV_t(R) - PV_t(C) > TC_t \\ y_t &= 0 \quad \text{if} \quad \text{otherwise} \end{aligned} \quad (6)$$

INMONEY is then defined as:

$$INMONEY = \frac{1}{T}\sum_{t=1}^{T} y_t \quad (7)$$

where T represents the length of the interval (in months).[4]

A problem with the variable INMONEY is that it requires that the present value difference $[PV_t(R) - PV_t(C)]$ exceed transaction costs (TC_t) in order to be in the money. Since INMONEY averages binary events, it does not gauge by how much the present value difference exceeds transaction costs.

Assume there is a homeowner with a sufficiently large net present value difference that is just below the transaction cost threshold. Although INMONEY is zero in this case, we would expect that this homeowner would have a positive propensity to refinance. To overcome this deficiency, we construct a second cumulative measure that assigns a probability to the likelihood of refinancing at each time period since the date of purchase:

$$\begin{aligned} PROBIN &= \frac{1}{T}\sum_{t=1}^{T} P(PV_t(R) - PV_t(C) > TC_t) \\ &= \frac{1}{T}\sum_{t=1}^{T} P(d_t > 0) \end{aligned} \quad (8)$$

where $d_t = \{[PV_t(R) - PV_t(C)] - TC\}$.

Essentially, the variable PROBIN measures the average probability that a homeowner is in the money by comparing the present value gains to the fixed costs of refinancing at each period. To estimate PROBIN, we simply use the empirical mean and variance of d_t, and assume that the probability distribution P(·) is normal.

Other Interest Rate Effects and Lending Environment

In addition to the incentive to refinance, several studies have noted that under standard options theory there is a value associated with not exercising the option to refinance that should be positively related to the expected future volatility of interest rates. Assuming that one is able to measure expected future volatility correctly, in a model such as ours theory suggests it should have a negative sign. Instead, the bulk of the literature on this topic has found that, pretty much regardless of how specified, the volatility measure is either insignificant or has a positive sign. For example, Caplin, Freeman, and Tracy [1993] find their measure of expected future volatility to be insignificant and drop it from their analysis.

While it is difficult to find the predicted effect of expected future volatility, we nonetheless believe that historical volatility matters. That is, for a given value of the incentive to refinance, if during the relevant time interval market rates were relatively volatile, a homeowner is more likely to observe an opportunity to refinance than if rates were relatively stable. To capture this effect, we include as an explanatory variable the historical standard deviation (HSD) of market rates during the time interval from purchase to refinance or from purchase to end of sample period. HSD is measured as the standard deviation of the ten-year Treasury bond rate. We expect this variable to be directly related to the probability that a loan is refinanced.[5]

A third and related explanatory variable is lending environment (LE), defined as the change in the

average level of points and fees (expressed as a percentage of the loan amount) on conventional fixed-rate loans closed over the time period from original purchase to either refinancing or the end of the sample period. This variable is intended to capture the fact that, as noted by many industry experts, starting in the late 1980s the mortgage lending industry became much more competitive in general and much more aggressive with regard to soliciting refinancings. Mortgage servicers began to contact customers with spreads greater than some threshold, often as low as 50 basis points, to encourage them to refinance.

Transaction costs declined, as competition reduced points and fees. Indeed, many lenders began offering loans with no out-of-pocket costs. Psychic transaction costs were also reduced as lenders introduced "no doc" (documentation) and "low doc" loan programs and drastically shortened the period from application to approval and then from approval to closing. This change in lending environment likely increased the probability of a refinancing, all else equal.

Personal Creditworthiness

We have noted that we matched complete TRW credit reports to the individual records of the property transaction table that make up our sample of loans. This matching is based on record identification numbers; any information that would enable an individual or a property to be identified is masked. The full credit report provides a wealth of information on individuals' credit histories, ranging from summary measures to detailed delinquency information on numerous categories of sources of credit.

Our hypothesis is that, other things equal, the worse the credit rating, the lower the probability that a loan will be refinanced, either because the homeowner is unable to qualify for a new loan or because the interest rate at which he or she is able to qualify is too high to make it worthwhile to exercise the option. To test this hypothesis, we experiment with numerous alternative measures of creditworthiness, all of which strongly support it. We could find little empirical basis for concluding that one measure performs substantially better than the others.

The most general summary measure of creditworthiness is the total number of derogatories, which we have labeled TDEROG. Four distinct events result in a derogatory. The first is a charge-off, meaning that after making a reasonable attempt to collect a debt a lender has deemed it to be uncollectible and elects to declare it as a bad debt loss for tax purposes. There are no hard and fast rules about when a lender can elect to charge off a debt or what represents a reasonable effort to collect. A charge-off may be the result of a bankruptcy but most often is not.

A second related event resulting in a derogatory is a collection, meaning a lender has enlisted the services of a collection agency in an effort to collect the debt. The remaining two events resulting in a derogatory are liens and judgments, both of which are labeled public derogatories because they are effected through the courts and are a matter of public record.

Somewhat more specific indicators of credit history are the summary measures of worst now (WRSTNOW) and worst ever (WRSTEVER) across all credit lines. As the names imply, these variables capture an individual's worst payment performance across all sources of credit as of some moment in time (now) and over the individual's entire credit history (ever). Both variables can take on values of 1 (all credit lines current), 30 (scheduled payment on one or more credit lines thirty days late), 60 (scheduled payment on one or more credit lines sixty days late), 90, 120, or 400 (a debt has been charged off, as described above). Note that a worst ever of 400 constitutes a derogatory, while some lower indicator of credit deterioration, such as a 90 or 120, does not.

We use in our logit analysis the values of the credit variables WRSTNOW and WRSTEVER exactly as they appear in the TRW credit report, except for some minor regrouping.[6] While it is true that the code for a charge-off (400) has no direct translation to number of days delinquent (thirty, sixty, ninety, etc.), we regard these values as representing a crude credit score. The variables WRSTNOW and WRSTEVER are thus continuous variables constrained to take on one of six values, and those values are cardinal, not ordinal. (The value 400 was constructed by TRW to convey the severity of the event (charge-off) for one's credit history.)[7]

Exhibit 4 presents a cross-tabulation of the worst now and worst ever readings for the individuals in our sample. For worst now, 85.5% of the sample have a value of 1 while 8.0% have a value of 400. Values from 30 to 120 represent just 6.5% of the total. In contrast, for worst ever, 18.4% of the sample have a value of 400, while just 52.9% have a value of 1.

Thus, while at any particular time nearly nine of every ten individuals have a perfect credit rating

EXHIBIT 4 ■ Cross-Tabulation of Worst Now and Worst Ever Credit Histories (%)

		Worst Now						
		1	30	60	90	120	400	Total
Worst Ever	1	52.9	0.0	0.0	0.0	0.0	0.0	52.9
	30	15.2	1.2	0.0	0.0	0.0	0.0	16.4
	60	5.9	0.7	0.5	0.0	0.0	0.0	7.1
	90	1.7	0.2	0.2	0.3	0.0	0.0	2.4
	120	1.8	0.1	0.2	0.1	0.6	0.0	2.9
	400	8.0	0.8	0.4	0.5	0.7	8.0	18.4
	Total	85.5	3.0	1.3	0.9	1.3	8.0	100.0

Source: Authors' calculations.

(WRSTNOW = 1), at some point in their credit history roughly half of our population had experienced something less than a perfect credit rating (WRSTEVER > 1). In fact, 8.0% have a worst now of 1 but a worst ever of 400.

Finally, in addition to the summary measures of worst now and worst ever, identical measures for separate categories of credit lines are available, such as for loans secured by real estate, bank credit cards, retail charge accounts, or finance company loans. On the theory that mortgage lenders give performance on one type of credit line more weight than others, we also experiment with worst ever for bank credit cards (WRSTCRD). As before, this credit measure turns out to be highly significant, but the explanatory power of the model is essentially the same as when the alternative measures are used.[8]

Post-Origination Home Equity

Another event that could prevent a homeowner from refinancing, regardless of how far current interest rates fall, is a decline in property value that significantly erodes that owner's equity in the property. In a recent study, Abrahams [1997] has shown that the conditional prepayment rate on a large sample of fixed-rate mortgages drops significantly at higher levels of LTV. To illustrate why the relationship is negative, consider a homeowner with an original 20% downpayment (origination loan-to-value ratio (LTV) = 80%). In this case, a 15% decline in property value following the date of purchase would push the post-origination LTV to nearly 95%, typically the maximum possible with conventional financing. In addition to the fact that loan underwriters would likely be leery of the recent trend in property values and thus reluctant to approve a loan, an LTV in excess of 80% would typically require some form of mortgage insurance, which would increase transaction costs and reduce the effective interest rate spread by as much as 25 to 50 basis points. If the original LTV were greater than 80%, much smaller declines in property values would have similar effects.

In contrast, increases in property values would likely increase the probability of refinancing. Greater equity simply makes it easier to qualify for a loan, while it may also increase the incentive to refinance in order to take equity out of the property (cash-out refinancing). Furthermore, if price appreciation substantially lowers the post-origination LTV, through refinancing a borrower may be able to lower or eliminate the cost of mortgage insurance, thereby increasing the effective interest rate spread.

To capture the effect of changes in home equity on the probability of refinancing, we enter an estimate of post-origination LTV as an explanatory variable. The numerator is the amortized balance of the original first mortgage on the property using standard amortization formulas for fixed-rate mortgages and the interest rate assigned to that loan, as discussed above.[9] The denominator is the original purchase price indexed using the Case Shiller Weiss repeat sales home price index for the county in which the property is located. While they are not completely free of bias, repeat sales home price indexes are generally regarded as the best indicator, of the options currently available, of movements in home prices over time. This approach allows the computation of a post-origination LTV for each month from date of purchase to either the date of refinance or the end of the sample period.

For loans that did refinance, the post-origination LTV used is the estimate for the month in which the refinance loan was closed. As in the case of the interest rate (R), however, a value of the post-origination LTV must be assigned to those observations that did not refinance. As in that case, we observed that, on average, homeowners who did refinance did so at the forty-fifth percentile of values of LTV observed from the date of purchase to the date of refinance. Given this observa-

tion, the LTV we assign to those who did not refinance is the average over the entire period from date of purchase to the end of the sample period.

It should be noted that virtually all the movement in LTV is the result of changes in the denominator. The amount of amortization of the original balance of a mortgage is relatively modest over the typical life of the mortgages in our sample. In contrast, over the time period represented by this sample, home price movements have been quite dramatic in some regions. For example, according to the Case Shiller Weiss repeat sales indexes, home prices in the California counties included in our sample declined by roughly 30% from 1990 to 1995.

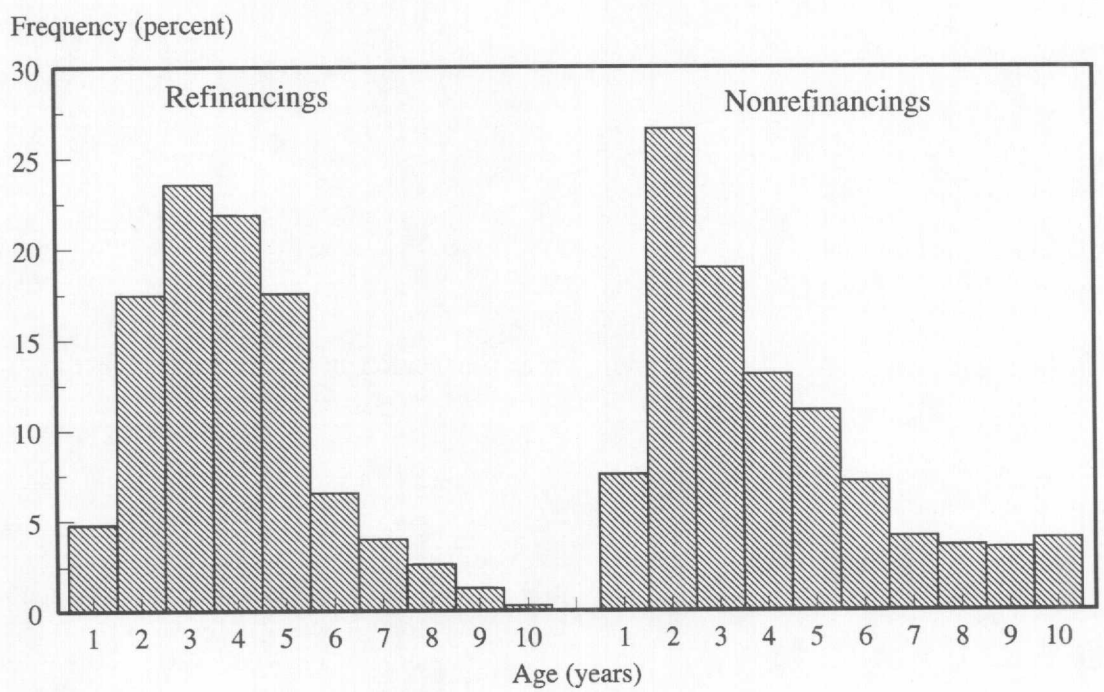
Age or "Burnout"

The actual prepayment experience of pools of mortgages typically exhibits an increase in the conditional prepayment rate (CPR) during roughly the first fifty to sixty months, at which point loans are described as "seasoned" and the prepayment rate begins to decline. As the aging process continues, the remaining loans in a pool become quite resistant to further prepayments even with strong incentives, a phenomenon known as "burnout." To capture this effect, most prepayment studies include the age of the loan or the number of months since origination as an explanatory variable.

One explanation of burnout is that homeowners who are not constrained in any way are relatively quick to refinance when their option goes in the money. Homeowners who are credit-, equity-, or income-constrained are prevented from exercising their option, and thus become a greater proportion of the remaining loans in a pool over time. To the extent that our equity and credit variables capture this effect, the age of the loan per se should be less important than would be the case in a model that does not include these variables. Recognizing that credit and equity may not capture all age-correlated effects, however, we also include age as an explanatory variable (AGE). Since the effect of aging may not be a simple linear one, we also included age squared (AGESQ).

Exhibit 5 compares the frequency distribution of AGE, broken out separately between homeowners who

EXHIBIT 5 ■ Distribution of Sample of Mortgage Loans by Age



Source: Authors' calculations

Note: The bars refer to the lower value in each age range (for example, one year is between one and two years of age).

EXHIBIT 6 ■ Logit Estimation of Basic Model

Explanatory Variable	California	Florida	Illinois	NY & NJ	All Regions
CONSTANT	2.605***	1.715***	9.746***	–0.804	1.420***
	(52.85)	(40.40)	(192.16)	(2.12)	(90.87)
SPREAD	0.272***	0.752***	0.907***	0.629***	0.573***
	(11.42)	(136.72)	(39.61)	(77.59)	(251.79)
WRSTNOW	–0.00069	–0.00068**	–0.00204**	–0.00169***	0.00115***
	(2.01)	(4.28)	(4.76)	(11.38)	(26.05)
LTV	–0.0346***	–0.0227***	–0.119***	–0.0359***	–0.0339***
	(123.49)	(94.34)	(254.70)	(223.10)	(601.55)
AGE	–0.317***	–1.00***	–0.858***	1.156***	–0.214***
	(9.43)	(102.69)	(23.26)	(13.31)	(17.80)
AGESQ	–0.0617***	0.0738***	–0.0713***	–0.214***	–0.0561***
	(45.27)	(42.09)	(21.47)	(24.13)	(143.01)
HSD	4.350***	3.608***	6.444***	2.744***	4.355***
	(27.80)	(29.14)	(19.89)	(7.28)	(112.23)
LE	5.718***	4.171***	3.887***	3.125***	4.428***
	(180.57)	(192.12)	(29.78)	(53.74)	(530.82)
DUM IL					–0.474***
					(33.18)
DUM FL					0.201***
					(12.59)
DUM CA					0.479***
					(49.09)
Number of Refinancings	879	1510	362	1166	3917
Number of Non-refinancings	1543	3396	1686	2313	8938
Pseudo R^2	0.280	0.224	0.462	0.278	0.249
Chi-Square of Model	703.08	1126.04	926.55	1000.65	3279.10
Concordant Ratio	80.5%	78.1%	92.4%	80.0%	79.3%

Note: Explanatory variables are defined in Exhibit 3. Numbers in parentheses are chi-square statistics. Pseudo R^2 is defined in Estrella [1998]. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels.

refinanced and those who did not. The general shape of these distributions is similar, although, as one would expect, the proportion of higher AGE values is greater for non-refinancers than for refinancers.

III. EMPIRICAL FINDINGS

The logit estimation results of our basic model shown in Exhibit 6 clearly demonstrate the significance of the creditworthiness and the home equity measures for refinancing activity. The results are presented for the four separate regions (California, Florida, Illinois, and New York/New Jersey) and for all regions combined. The basic model includes SPREAD as the measure of the strength of the incentive to refinance and WRSTNOW as the measure of credit history.

As expected, the coefficients of the variable SPREAD are uniformly significant and positive. In addition, the coefficients on HSD are positive as expected, also consistent with the importance of interest rate effects. High values of HSD indicate more opportunities during the measurement interval for the homeowner to have observed and locked in a lower rate. Lending environment (LE) is also significant and of the predicted sign, suggesting that increased lender aggressiveness has boosted the probability that a loan will be refinanced. The estimated coefficients of WRSTNOW are negative and significant, providing strong support for the hypothesis that a poor credit history diminishes a homeowner's ability to refinance.

Changes in home equity also have an important influence on the probability of refinancing, as evidenced by the negative sign and high level of significance of LTV. Finally, while it is not true for each region, for all regions combined AGE and AGESQ are significant with negative signs, indicating that credit and equity do not explain all of the decline in probability of refinancing as a mortgage ages.

As noted earlier, one way to test the robustness of the significance of the credit and equity variables is to see how they perform under alternative specifications of the incentive to refinance. Exhibit 7 presents the estimation results for our model for all four regions combined using our four alternative measures of the strength of the incentive to refinance: SPREAD, PROBIN, INMONEY, and PVALUE.

All four measures are highly significant, while the overall explanatory power of the model is essentially the same in all cases. Most important for the central hypothesis of this study, however, is the fact that, irrespective of the measure of incentive to refinance, the estimated effects of WRSTNOW and LTV are qualitatively similar. Moreover, the values of HSD and LE are also significant and of the expected sign in all cases.

As a further test of the finding that credit history is an important determinant of the probability of refinancing, Exhibit 8 presents logit estimations of the basic model for all regions combined after replacing the credit history variable WRSTNOW with the three alternatives: WRSTEVER, WRSTCRD, and TDEROG. All four variables give similar results, so there is no basis for preferring one over another. (The coefficient value on TDEROG differs because of the difference in measurement scales.) On the other hand, regardless of the credit history measure used, credit history is highly significant, and the overall model retains its explanatory power.

IV. EFFECT OF CREDIT HISTORY ON HOME EQUITY AND THE PROBABILITY OF REFINANCING

Using separately estimated equations for the WRSTNOW = 1 and WRSTNOW = 400 subsamples, Exhibit 9 presents simulated values for the probability of refinancing for hypothetical individuals with different credit histories and different values of the post-origination LTV. In addition to the actual probability of refinancing, which is computed over the entire life of the loan, the table presents in brackets annualized measures of prepayment. The annualized probability of refinancing is comparable to a constant prepayment rate (CPR), which is used extensively in the mortgage industry.

The four columns of Exhibit 9 represent alternative combinations of the variables WRSTNOW and LTV. Moving down each column, the variable SPREAD increases from 0 to 300 basis points, which should normally motivate refinancing.

The first column, with WRSTNOW= 1 and post-origination LTV= 60%, shows how an individual who is neither equity- nor credit-constrained would react to an increase in SPREAD. Note that with SPREAD = 0, the probability of refinancing is 0.29 (0.073 in CPR), suggesting that refinancings motivated by the desire to extract equity from the property are fairly frequent among this group. As SPREAD rises to 300 basis points, the probability of refinancing essentially doubles to nearly 60% (0.147 in CPR). In the second column, where LTV = 100%, the probabilities drop quite sharply; at SPREAD = 0, the probability is just 0.11 while at SPREAD = 300 the probability is 0.32, about half that when LTV = 60%.

The third and fourth columns of Exhibit 9 depict by contrast mortgagees who are severely credit-constrained (WRSTNOW = 400). As suggested above, having substantial equity can overcome many of the problems associated with a poor credit history, particularly as more lenders have moved into B and C lending programs. With LTV = 60%, probabilities of refinancing are essentially the same at SPREAD = 0 and 100 as in the WRSTNOW = 1 case. Without substantial equity (LTV = 100%), however, the probability of refinancing is not only low but also unresponsive to increases in SPREAD. Note in the last column that the conditional prepayment rate is very small (between 2%

EXHIBIT 7 ■ Logit Estimation Using Alternative Measures of Incentive to Refinance (all regions)

Variable	SPREAD	PROBIN	INMONEY	PVALUE
CONSTANT	1.420***	0.845***	1.365***	–8.651***
	(90.87)	(32.42)	(84.16)	(671.88)
Alternative Incentive Measure	0.573***	3.200***	1.564***	11.292***
	(251.79)	(337.53)	(70.68)	(1066.78)
WRSTNOW	–0.00115***	–0.00130***	–0.00125***	–0.00105***
	(26.05)	(33.26)	(31.48)	(20.43)
LTV	–0.0339***	–0.03550***	–0.0338***	–0.0354***
	(601.55)	(630.38)	(608.04)	(578.99)
LE	4.428***	4.421***	5.460***	2.803***
	(530.82)	(555.62)	(927.54)	(213.32)
AGE	–0.214***	–0.280***	–0.0218	–0.566***
	(17.80)	(30.69)	(0.197)	(121.78)
AGESQ	–0.0561***	–0.0451***	–0.0707***	–0.0232***
	(143.01)	(90.35)	(229.05)	(24.25)
HSD	4.355***	5.022***	4.249***	5.105***
	(112.23)	(151.06)	(108.16)	(144.72)
DUM IL	–0.474***	–0.495***	–0.485***	–1.390***
	(33.18)	(36.05)	(35.12)	(224.94)
DUM FL	0.201***	0.254***	0.139**	–0.644***
	(12.59)	(19.46)	(6.12)	(92.10)
DUM CA	0.479***	0.564***	0.391***	–0.263***
	(49.09)	(66.05)	(32.63)	(12.59)
Number of Refinancings	3917	3917	3917	3917
Number of Non-refinancings	8938	8938	8938	8938
Pseudo R^2	0.249	0.255	0.235	0.323
Chi-Square of Model	3279.10	3365.69	3088.80	4302.84
Concordant Ratio	79.3%	80.0%	78.6%	82.2%

Numbers in parentheses are chi-square statistics. ***, ***, * indicate statistical significance at the 1%, 5%, and 10% levels.

and 3%), irrespective of the level of the coupon rate differential.

V. CONCLUSIONS

Our analysis provides compelling evidence that poor credit histories significantly reduce the probability that a homeowner will refinance a mortgage, even when the financial incentive to do so appears to be quite strong. Moreover, consistent with previous work, we have found that refinancing probabilities are quite sensitive to the amount of equity a homeowner has in the property. Poor credit histories and low equity positions make it very difficult for homeowners to meet lenders' underwriting criteria, so they are blocked from obtaining the replacement financing necessary for them to exercise the option to prepay their existing mortgage.

EXHIBIT 8 ■ Logit Estimation using Alternative Measures of Credit (all regions)

Variable	SPREAD	PROBIN	INMONEY	PVALUE
CONSTANT	1.420***	1.404***	1.431***	1.407***
	(90.87)	(88.79)	(92.40)	(89.06)
SPREAD	0.573***	0.566***	0.574***	0.571***
	(251.79)	(245.42)	(252.81)	(249.92)
Alternative Credit Measure	–0.00115***	–0.00102***	–0.00100***	–0.0663***
	(26.05)	(40.17)	(13.24)	(18.31)
LTV	–0.0339***	–0.0333***	–0.0340***	–0.0339***
	(601.55)	(579.40)	(607.25)	(599.62)
AGE	–0.214***	–0.205***	–0.217***	–0.213***
	(17.80)	(16.32)	(18.40)	(17.68)
AGESQ	–0.0561***	–0.0564***	–0.0558	–0.0561***
	(143.01)	(144.34)	(141.98)	(143.64)
HSD	4.355***	4.347***	4.358***	4.362***
	(112.23)	(111.83)	(112.74)	(112.83)
LE	4.428***	4.427***	4.426***	4.438***
	(530.82)	(530.01)	(530.89)	(533.09)
DUM IL	–0.474***	–0.451***	–0.479***	–0.472***
	(33.18)	(29.85)	(33.98)	(32.88)
DUM FL	0.201***	0.208***	0.199**	–0.204***
	(12.59)	(13.46)	(12.27)	(12.96)
DUM CA	0.479***	0.467***	0.470***	0.478***
	(49.09)	(46.64)	(47.26)	(48.81)
Number of Refinancings	3917	3917	3917	3917
Number of Non-refinancings	8938	8938	8938	8938
Pseudo R^2	0.249	0.250	0.248	0.248
Chi-Square of Model	3279.10	3293.12	3265.53	3271.48
Concordant Ratio	79.3%	79.4%	79.3%	79.3%

Numbers in parentheses are chi-square statistics. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels.

On one level, this research contributes to the evidence that households' financial conditions can have significant consequences on the ways declines in interest rates affect the overall economy. From the broadest perspective, mortgage refinancings can be viewed as redistributions of cash flows among households or investment intermediaries. For households able to reduce financing costs by locking in a lower interest rate on their mortgage, there is likely to be a wealth or permanent income effect that might boost overall consumption spending. Conversely, to the extent that households are unable to obtain replacement financing at lower interest rates because of poor credit histories or erosion of equity, there is likely to be a dampening effect on consumption.

The other side of the coin is the effect on investors in pools of mortgages. When homeowners refinance, these investors lose above-market rate

EXHIBIT 9 ■ Probability of Refinancing: Simulated Values

SPREAD	WRSTNOW = 1		WRSTNOW = 400	
	LTV = 60	LTV = 100	LTV = 60	LTV = 100
0	0.29	0.11	0.34	0.11
	[0.073]	[0.072]	[0.074]	[0.023]
100	0.38	0.16	0.36	0.12
	[0.096]	[0.041]	[0.078]	[0.026]
200	0.48	0.23	0.37	0.13
	[0.123]	[0.058]	[0.081]	[0.028]
300	0.58	0.32	0.39	0.14
	[0.147]	[0.081]	[0.089]	[0.030]

Note: Values in brackets express the probability of refinancing as a constant prepayment rate (CPR).

income streams; they should be keenly interested in any factors that may have a significant bearing on the probability that a homeowner will refinance.

Our analysis demonstrates quite clearly that investors should be concerned with (in addition to changes in interest rates and home prices) both the credit histories of the homeowners represented in a particular pool of mortgages and the trends in those credit histories over time. Notwithstanding credit risk guarantees, the relative proportions of credit-constrained households represented in pools of mortgages will have a significant impact on the prepayment experiences of those pools under various interest rate and home price scenarios.

ENDNOTES

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[1]The interest rate on existing loans (C) is not directly observed in the data base. An estimate of this interest rate can be derived from information on the original loan balance, original maturity, and periodic readings of the amortized balance, which are reported in the credit snapshots. Strictly speaking, there is typically a thirty- to sixty-day lag between the date of application for a mortgage and the date of closing, although borrowers typically have the option of locking in the rate at the time of application or letting the rate float, in some cases all the way up to the date of closing. We experimented with lagging the national average rate by one and then two months, and find that in neither case are the results significantly different from using the average rate for the month the loan closed.

[2]For example, Archer, Ling, and McGill [1995] assign to the observations that did not refinance the lowest monthly average Freddie Mac commitment rate on thirty-year fixed-rate mortgages over the two-year time interval of their study.

[3]As a measure of transaction costs we use the average initial fees and charges for fixed-rate loans closed as published by the Federal Housing Finance Board.

[4]We assume that homeowners purchase their home at time (t = 1) and refinance at time (t = T). For individuals who did not refinance, T represents the last period, which is December 1994.

[5]In contrast to HSD, which is a backward-looking measure of rate variability, theory predicts that rational debtors expecting higher *future* volatility would, ceteris paribus, delay refinancing due to the increased value of their repayment option. HSD is premised on a distinction between *expected* forward-looking and *historical* backward-looking volatility.

[6]In fact, both variables can take on more values than those listed. For example, a value of 34 indicates that an individual is persistently thirty days late. For the purposes of this study, we have constrained worst now and worst ever to take on the values listed here.

[7]Nonetheless, we are sensitive to the possibility that the scale we have used for the credit variables may strongly influence the results. To test the possibility, we reconfigure the credit valuables in two ways. First, we reorder WRSTNOW and WRSTEVER from 1, 30, 60, 90, 120, and 400 to 1, 2, 3, 4, 5, and 6. Second, we group 1 and 30 as "good credits" with a value of 1; 60, 90, and 120 as "marginal credits" with a value of 2; and anything above 120 (including 400s) as "bad credits" with a value of 3. Finally, we subdivide our sample into three subsamples: WRSTNOW = 1, WORSTNOW = 30 to 120, and WORSTNOW = 400, and run the model for each subsample. All three alternative approaches yield the same result; the credit variables are significant and of the hypothesized sign.

[8]To an increasing extent, mortgage lenders are relying on credit scores as a single measure summarizing the vast amount of information on the credit report. For an overview of this issue see Avery et al. [1996]. As an extension of the research on the effect of credit histories on mortgage refinancings, credit scores could also be tested as an alternative measure of creditworthiness.

[9]The presence of second mortgages and home equity loans (HELs) introduces additional considerations. On the one hand, they would tend to reduce a homeowner's equity. On the other hand, since they typically have interest rates well above the rates on first mortgage loans, the spread based on the homeowners' weighted-average cost of credit would likely be higher. While the MRG data base indicates the

presence and amount of second mortgages and HELs taken out since the original purchase, we did not investigate their effect on refinance probabilities. This is an area for future research.

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