Credit, Equity, and Mortgage Refinancings

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Homeowners typically have the option to prepay all or part of the outstanding balance of their mortgage loan at any time, usually without penalty. However, unless homeowners have sufficient wealth to pay off the balance, they must obtain a new loan in order to exercise this option. Studies examining refinancing behavior are finding more and more evidence that differences in homeowners' ability to qualify for new mortgage credit, as well as differences in the cost of that credit, account for a significant part of the observed variation in that behavior. Therefore, 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.

Early research into the factors influencing prepayments focused almost exclusively on the difference between the interest rate on a homeowner's existing mortgage and the rates available on new loans. This approach arose in part because researchers most often had to rely on aggregate data on the pools of mortgages serving as the underlying collateral for mortgage-backed securities (for example, see Schorin [1992]). More recent research, however, has broadened the scope of this investigation through the utilization of loan-level data sets that include individual property, loan, and borrower characteristics.

This article significantly advances the literature on mortgage prepayments by introducing quantitative measures of individual homeowner credit histories to the loan-level analysis of the factors influencing the probability that a homeowner will refinance. In addition to credit histories, we include in the analysis changes in individual homeowner's equity and in the overall lending environment. Our findings strongly support the hypothesis that, other things being equal, the worse a homeowner's credit rating, the lower the probability that he or she will refinance. We also confirm the finding of other researchers that changes in home equity strongly influence the probability of refinancing. Finally, we provide evidence of a change in the lending environment that, all else being equal, has increased the probability that a homeowner will refinance.

These findings are important from an investment risk management perspective because they confirm that the responsiveness of mortgage cash flows to changes in interest rates will also be significantly influenced by the credit and equity conditions of individual borrowers. Moreover, evidence overwhelmingly indicates that these conditions are subject to dramatic changes. For example, although the sharp rise in personal bankruptcies since the mid-1980s (Chart 1) partly reflects changes in laws and attitudes, it nonetheless suggests that credit histories for a growing segment of the population are deteriorating. Furthermore, home price movements, the key determinant of changes in homeowners' equity, have differed considerably over time and in various regions of the country. Indeed, in the early to mid-1990s home price appreciation for the United States as a whole slowed dramatically while home prices actually fell for sustained periods in a few regions (Chart 2).

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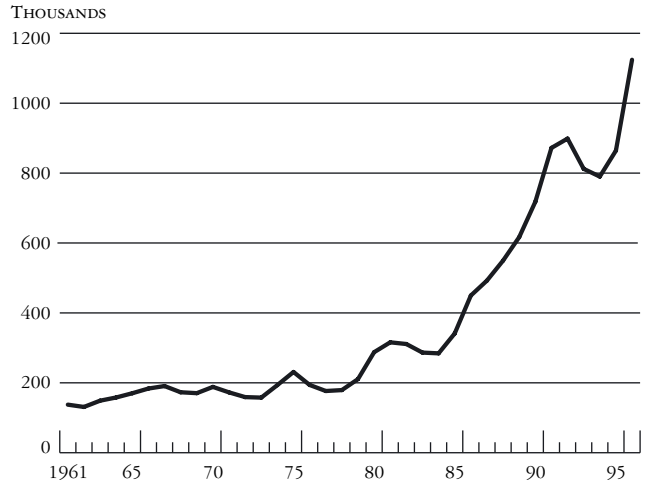
In short, as mortgage rates fell during the first half of the 1990s, many households likely found it difficult, if not impossible, to refinance existing mortgages because of poor credit ratings or erosion of home equity.[1] Consequently, the prepayment experience of otherwise similar pools of mortgage loans may vary greatly depending on the pools' proportions of credit- and/or equity-constrained borrowers.

Our findings also contribute to an understanding of how constraints on credit availability affect the transmission of monetary policy to the economy (for example, see Bernanke [1993]). Fazzari, Hubbard, and Petersen (1988) and others have found that investment expenditures by credit-constrained businesses are especially closely tied to those firms' cash flows and are relatively insensitive to changes in interest rates, reflecting constraints on their ability to obtain credit. Analogously, we find credit- and/or equity-constrained homeowners to be less sensitive to changes in interest rates because of their limited access to new credit, thereby short-circuiting one channel through which lower interest rates improve household cash flows and stimulate the economy.

Chart 1

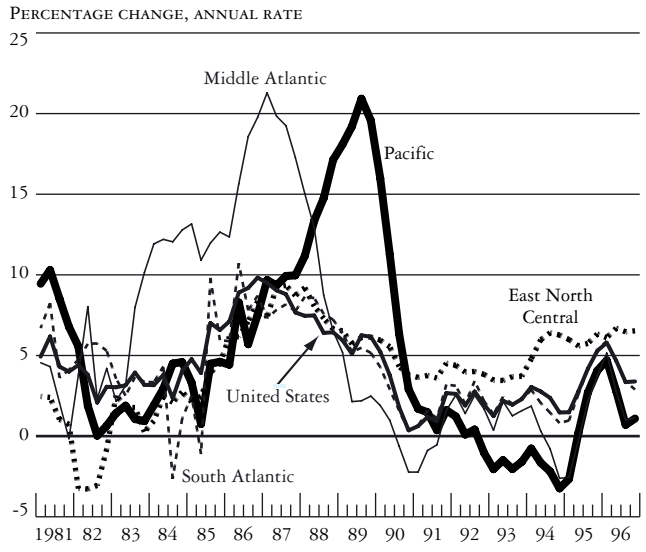
TOTAL PERSONAL BANKRUPTCIES



Source: Administrative office of the United States Courts.

Chart 2

RATE OF HOME PRICE CHANGE IN THE UNITED STATES AND SELECTED REGIONS, 1981-96



Source: Office of Federal Housing Enterprise Oversight.

Previous Loan-Level Research on Mortgage Prepayments

Recognition that individual loan, property, and borrower characteristics, in addition to changes in interest rates, play a key role in determining the likelihood of a mortgage prepayment has spawned a relatively new branch of research based on loan-level data sets. This research has generally focused on the three major underwriting criteria that mortgage lenders consider when deciding whether to extend credit: equity (collateral), income, and credit history.

However, past studies have only investigated the effects of changes in homeowners' equity and income on their ability to prepay. For example, Cunningham and Capone (1990)—using a sample of loans secured by properties in the Houston, Texas, area—estimated post-origination loan-to-value (LTV) ratios and post-origination payment-to-income ratios based on changes in regional home prices and incomes.[2] They concluded that post-origination equity was a key determinant of the termination experience of those loans (they found an inverse relationship for defaults and a positive relationship for refinancings and home sales), whereas post-origination income was insignificant. Caplin, Freeman, and Tracy (1993), using a sample of loans secured by properties in six states, also found evidence of the importance of home equity in influencing the likelihood of mortgage prepayment. They assessed the effect of post-origination equity by dividing their sample into states with stable or weak property markets (using transaction-based home price indexes for specific metropolitan statistical areas) and according to whether the loans had high or low original LTV ratios. Consistent with the hypothesis that changes in home equity play an important role in prepayments, the authors found that in states with weak property markets, prepayment activity was less responsive to declines in mortgage interest rates than in states with stable property markets.

In a related study, Archer, Ling, and McGill (1995) found that home equity had an important effect on the probability that a loan would be refinanced, and provided evidence that changes in borrower income are also a significant factor. The authors matched records from the 1985 and 1987 national samples of the American Housing Survey to derive a subsample of nonmoving owner-occupant households with fixed-rate primary mortgages, some of whom had refinanced, since the interest rate on their loan in 1987 was different from that reported in 1985. The authors' estimate of post-origination home equity was derived from the sum of the book value of a homeowner's entire mortgage debt, including second mortgages and home equity loans, divided by the owner's assessment of the current value of his or her property.[3] In addition, a post-origination mortgage payment-to-income ratio, derived from the homeowner's recollection of total household income, was included as an explanatory variable. The authors found that, along with changes in interest rates, post-origination home equity and income were significant and of the expected sign.

This article goes beyond the existing literature in several important respects. Ours is the first study to investigate systematically the effect of the third underwriting criterion: homeowners' credit histories. Ours is also the first study to estimate post-origination equity by using county-level repeat sales home price indexes.[4] These indexes are generally regarded as the best available indicator of movements in home prices over time. In addition, we employ a unique loan-level data set that not only provides information on credit history but also identifies the reason for prepayment: refinance, sale, or default (see box). The size of the data set allows very large samples to be drawn for major population centers as well as for the nation as a whole.

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The Data Set and Sample Construction

The data for this study were provided by the Mortgage Research Group (MRG) of Jersey City, New Jersey, which in the early 1990s entered into a strategic alliance with TRW—one of the country's three largest credit bureaus—to provide data for research on mortgage finance issues. Until late 1996, MRG maintained a data base, arranged into "tables," of roughly 42 million residential properties located in 396 counties in 36 states. The primary table is the transaction table, which is based on the TRW Redi Property Data 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 on 150 million to 200 million transactions. For example, if a property is purchased, a purchase code is entered along with key characteristics of the transaction, including date of closing, purchase price, original mortgage loan balance, and maturity and type of mortgage (such as fixed-rate, adjustable-rate, or balloon).

The characteristics of any subsequent transactions are also recorded, such as a refinancing of the original mortgage, another purchase of the same property, and, for some counties, a default. The primary sources of this information are the records of county recorders and tax assessors, which are surveyed on a regular basis to keep the transaction data current.

A separate table contains periodic snapshots of the credit histories of the occupants of the properties. The data on credit histories are derived from TRW Information Services, the consumer credit information group of TRW. The data include summary measures of individuals' credit status as well as detailed delinquency information on numerous categories of credit sources. Individual records in the credit table can be linked to records in the transaction table on the basis of property identification numbers.

For our study, a sample from the larger data set was constructed in several stages: First, we selected groups of counties representing the 4 major regions of the country. In the East, we chose 4 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 6 counties in central Florida (Citrus, Clay, Escambia, Hernando, Manatee, and Marion). In the Midwest, we chose Cook County and 5 surrounding counties in Illinois (Dekalb, DuPage, Kane, McHenry, and Ogle). In the West, we selected Los Angeles, Ventura, and Riverside Counties in California. Selecting these 4 diverse areas assured us that our statistical findings would be general rather than specific to a particular housing market. Furthermore, over the past decade, the behavior of home prices in the 4 regions has been quite different.

In the 19 counties examined, we identified for each property the most recent purchase transaction, going back as far as January 1984. The mortgages on some of these properties were subsequently refinanced, in some cases more than once, while other properties had no further transactions recorded through the end of our sample period, December 1994. (For multiple refinancings, we considered just the first one. In addition, we excluded from the sample loans that subsequently defaulted.) Thus, the sample consisted 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 refinanced loans, the new loan could be greater than, equal to, or less than the remaining balance on the old loan.) We limited our sample to fixed-rate mortgages outstanding for a year or more; the decision to refinance alternative mortgage types is more complex to model and is not treated in this study.

In the final step, MRG agreed to link credit records as of the second quarter of 1995 to a random sample of these properties. (Note that any information that would enable users of this data set to identify an individual or a property was masked by MRG.) The resulting sample consisted of 12,855 observations, of which slightly under one-third were refinanced.

Our sample is an extensive cross section, with each observation representing 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 36 months. This window represents one observation or experiment in our sample. Our approach differs from that of most other studies on this topic in that the starting date, ending date, and time interval between refinancings are unique for each observation. Starting dates (purchases) range from January 1984 to December 1993, while time intervals (loan ages) range from 12 to 120 months. Therefore, our sample includes refinancings that occurred in the "refi wave" from 1986 to early 1987 as well as in the wave from 1993 to early 1994, although most are from the latter period. This diverse sample allows us to investigate whether the propensity to refinance has changed over time.

Modeling the Decision to Refinance

When a homeowner refinances, he or she exercises the call option imbedded in the standard residential mortgage contract. In theory, a borrower will exercise this option when it is "in the money," that is, when refinancing would reduce the current market value of his or her liabilities by an amount equal to or greater than the costs of carrying out the transaction. In fact, however, many borrowers with apparently in-the-money options fail to exercise them while others exercise options that apparently are not in the money. This heterogeneity of behavior appears to be due partly to differences in homeowners' ability to secure replacement financing. If an 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.

While a decline in equity resulting from a drop in property value may rule out refinancing for some homeowners, refinancing may also not be possible or worthwhile because the homeowner's personal credit history is marginal or poor. This condition either prevents the borrower from obtaining replacement financing or raises the cost of that financing such that the present value of the benefits does not offset the transaction costs. Not only might the interest rate available exceed that offered to individuals with perfect credit ratings, but transaction costs might also be higher. In addition to paying higher out-of-pocket closing costs, the credit-impaired borrower may be asked to provide substantially more personal financial information and may face a substantially longer underwriting process.

Of course, other factors may explain this heterogeneity of refinancing behavior. For instance, 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 consumers can obtain, particularly on an after-tax basis. Conversely, some homeowners who are not equity-, credit-, or income-constrained choose not to exercise options that appear to be in the money. There are several possible reasons for such behavior. For instance, a homeowner who expected to move in the near future might not have enough time to recoup the transaction costs of refinancing.

In our model of refinancing, the dependent variable is a discrete binary indicator that assumes the value of 1 when the homeowner refinances and 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 nonfinancial, of carrying out a refinancing transaction, (2) the credit history of the homeowner, and (3) an estimate of the post-origination LTV ratio. 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. (See the appendix for further explanation of logit analysis and how it is applied in this case.) More details on the definition and specification of these variables follow; Table 1 presents summary statistics.

Table 1
Summary Statistics for Explanatory Variables

		Mean	
Explanatory Variable	Description	Refinancings	Nonrefinancings
WRSTNOW	Worst current credit status (1=good credit, 30, 60, 90, 120, 150, 180, 400=default)	26.5	42.5
WRSTEVER	Worst credit status ever (1=good credit, 30, 60, 90, 120, 150, 180, 400=default)	64.9	101.0
SPREAD	Coupon rate minus prevailing market rate (percentage points)	1.66	1.30
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
Memo:			
Related variables	Original purchase price of house (thousands of dollars)	150	129
	Original loan balance (thousands of dollars)	104	103

Source: Authors' calculations.

The Incentive to Refinance

Theory suggests that homeowners will refinance if the benefits of doing so—that is, the reduction in after-tax mortgage interest payments over the expected life of the loan—exceed the transaction costs of obtaining a new loan. Accordingly, measuring the strength of the incentive to refinance involves a comparison of the contract rate on the existing mortgage with the rate that could be obtained on a new mortgage. In addition, account should be taken of transaction costs (such as discount points and assorted closing costs), the opportunity cost of the time spent shopping for and qualifying for a new loan, and interest rate volatility, which influences the value of the call option.[5]

There are many ways to measure the strength of the incentive to refinance, none of which is perfect (see, for example, Richard and Roll [1989]). In this study, we employ the simplest of them—the spread between the contract rate on the existing loan (C) and the prevailing market rate (R), that is:

$$SPREAD_t = C - R_t,$$

where (t) represents the time period. For all observations in our sample, C is the Freddie Mac national average commitment (contract) rate on fixed-rate loans for the month in which the existing loan closed.[6] 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 in which the new loan closed.

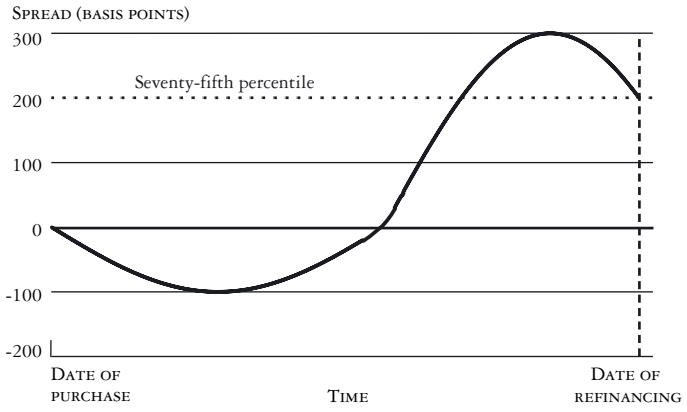
While SPREAD is a simple measure and tends to represent the way homeowners think about the refinancing decision, it has some drawbacks. First, it does not explicitly account for transaction costs, which are likely to vary across borrowers and over time. However, one could imagine that transaction costs create an implicit critical threshold of SPREAD, say 100 to 150 basis points, that must be exceeded to trigger a refinancing. 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. However, experimentation with alternative measures that do explicitly account for transaction costs and holding period revealed that the effects of creditworthiness and home equity on the probability that a loan will be refinanced are insensitive to the measure employed.[7]

An important issue that arises when using SPREAD in cross-sectional analysis is the assignment of the value of R to those individuals who did not refinance. Several possible approaches exist for assigning a value, and there is a certain amount of arbitrariness in selecting any particular one.[8] In tackling this problem, we noted that those who did refinance rarely did so at the largest spread (the lowest value of R) that occurred over the period from their original purchase to the date they refinanced (Chart 3). If all the values of SPREAD observed over that period were ranked from highest to lowest, on average those who refinanced did so at about the seventy-fifth percentile. Accordingly, we assigned nonrefinancers the value of R associated with the seventy-fifth percentile of spreads observed over the period from the date of original purchase to the end of our sample period (December 1994).

Note that by basing C and R on the A-paper rate, we explicitly excluded from SPREAD any influences that individual borrower characteristics might have on the actual values of particular individuals. The effects of those individual characteristics are captured by the credit and equity variables, as well as by the error term. In addition, we ignored the fact that the values of C and R for any one individual are

Chart 3

Spread at Which Refinancing Typically Occurs



Source: Authors' calculations.

likely to deviate somewhat from the national average because of regional differences in mortgage interest rates or differences in the shopping and bargaining skills of refinancers.

Volatility

As noted above, standard option theory suggests that there is value associated with *not* exercising the option to refinance that is increasing with the expected future volatility of interest rates. Assuming that one can correctly measure expected future volatility, theory also suggests that, when included in a model such as ours, volatility should have a negative sign. That is, higher volatility should reduce the probability that a loan will be refinanced. The expected effect of volatility has been found in some studies on this topic. For example, Giliberto and Thibodeau (1989), who measure volatility as the variance of monthly averages of mortgage interest rates over their sample period, find that greater volatility tends to increase the age of a mortgage (and decrease prepayments). In contrast, Caplan, Freeman, and Tracy (1993) find their measure of expected future volatility to be insignificant and drop it from their analysis.

Although the theoretical effect of expected future volatility on the probability that a loan will be refinanced is negative, actual volatility during a given time period should correlate positively with the probability of refinancing during that period. That is, if market interest rates during the relevant interval are relatively volatile, a homeowner will be more likely to observe an opportunity to refinance than if rates are 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 refinancing or from purchase to the end of the 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 will be refinanced.

Lending Environment

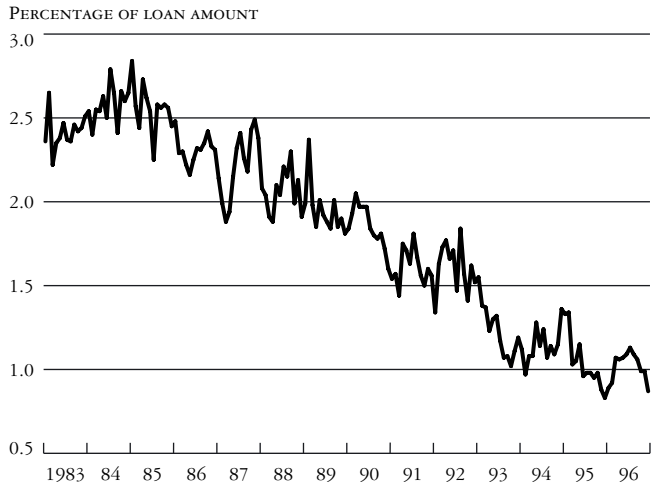
As noted by many industry experts, between the late 1980s and the early 1990s, the mortgage lending industry became more aggressive in soliciting refinancings. To encourage refinancing, mortgage servicers began contacting customers with spreads above some threshold, often as low as 50 basis points, and informing them of the opportunity and benefits of refinancing. Transaction costs declined as competing lenders reduced points and fees (Chart 4). Indeed, many lenders began offering loans with no out-of-pocket costs to borrowers. "Psychic" transaction costs were also reduced as lenders introduced mortgage programs that minimized the financial documentation required of borrowers ("no doc" or "low doc" programs) and drastically shortened the periods from application to approval and from approval to closing. This change in the lending environment likely increased the probability of a loan being refinanced, all else being equal.

Between the late 1980s and the early 1990s, the mortgage lending industry became more aggressive in soliciting refinancings.

To capture this effect, we introduce an explanatory variable termed lending environment (LE). LE is defined as the change in the average level of points and fees (expressed as a percentage of the loan amount) on conventional fixed-

Chart 4

Initial Fees and Charges on Conventional Loans Closed



Source: Federal Housing Finance Board.

rate loans closed between the time of the original purchase and either refinancing or the end of the sample period.

Personal Creditworthiness

Since credit history is a key determinant of mortgage loan approval, it clearly should have some bearing on the likelihood that a loan will be refinanced. However, because of a lack of data, this effect has never before been quantified. Our study is able to overcome this obstacle. The Mortgage Research Group (MRG)—the source of most of our data—has matched complete TRW credit reports to the individual property records that make up our sample of loans (see box). Using this matched data, we are able to test our hypothesis that, other things being equal, the worse an individual's credit rating, the lower the probability that he or she will refinance a mortgage, either because the homeowner cannot qualify for a new loan or because the interest rate and transaction costs at which he or she can qualify are too high to make it financially worthwhile.

The most general measure of an individual's credit history presented in the TRW reports is the total number of "derogatories."[9] A derogatory results from one of four events:

- a charge off: when a lender, after making a reasonable attempt to collect a debt, has deemed it uncollectible and has elected to declare it a bad debt loss for tax purposes. There are no hard and fast rules specifying when a lender can elect to charge off a debt or what represents a reasonable effort to collect. A charge off may result from a bankruptcy, but most often it is simply the result of persistent delinquency.
- a collection: when a lender has enlisted the services of a collection agency in an effort to collect the debt.
- a lien: a claim on property securing payment of a debt. A lien (for example, a tax lien or mechanics lien) is a public derogatory because it is effected through the courts and is a matter of public record.
- a judgment: a claim on the income and assets of an individual stemming from a civil law suit. Like a lien, a judgment is a public derogatory.

Somewhat more specific indicators of an individual's credit history are the worst now (WRSTNOW) and worst ever (WRSTEVER) summary measures 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). At the extremes, either variable can take on a value of 1 (all credit lines are current) or a value of 400 (a debt has been charged off). Intermediate values capture the number of days a scheduled payment has been late: 30 (a scheduled payment on one or more credit lines is thirty days late), 60, 90, or 120.[10] Note that a 400 constitutes a derogatory, whereas some lesser indicator of credit deterioration, such as a 90 or 120, does not.

To clarify how the WRSTNOW and WRSTEVER measures are used to assess an individual's credit status, we offer the example of a homeowner who has three credit lines—a home mortgage, a credit card, and an auto loan (Table 2). At the beginning of the homeowner's credit history (t-11), all three credit lines are current, giving the

Table 2
SAMPLE CREDIT HISTORY OF INDIVIDUAL HOMEOWNER

HOMEOWNER'S CREDIT LINES												
Mortgage	1	1	1	30	1	30	30	30	30	1	1	1
Credit card	1	30	60	90	120	400	-	-	-	-	-	-
Auto loan	1	1	30	60	30	60	90	60	30	30	1	1
SUMMARY MEASURE OF HOMEOWNER'S CREDIT HISTORY												
Worst ever	1	30	60	90	120	400	400	400	400	400	400	400
Worst now	1	30	60	90	120	400	90	60	30	30	1	1
	t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1	t
	TIME											

Source: Authors' calculations.

homeowner WRSTNOW and WRSTEVER values of 1. For some reason—perhaps loss of employment, illness, or divorce—this individual begins to experience some difficulty meeting scheduled payments on a timely basis. The credit card payment due becomes 120 days late in period t-7, prompting the lender to charge off that debt in period t-6, at which point both WRSTNOW and WRSTEVER take on a value of 400. Eventually, this individual gets all credit lines current again, bringing WRSTNOW down to 1 by period t-1. However, WRSTEVER remains at 400 because of the charge off of the credit card debt in period t-6. Indeed, once someone experiences credit difficulties, his or her credit history is likely to be affected for a long time.

We now examine a cross tabulation of the WRSTNOW and WRSTEVER values for all individuals in our sample (Table 3). For WRSTNOW, 85.5 percent of the sample have a value of 1 while 8.0 percent have a value of 400. Values from 30 to 120 represent just 6.5 percent of the total. In contrast, for WRSTEVER, 18.4 percent of the sample have a value of 400 while just 52.9 percent have a value of 1. Thus, although at any point in time nearly nine of every ten individuals have a perfect credit rating (WRSTNOW=1), at some time in their credit history roughly half the population experienced something less than a perfect credit rating (WRSTEVER>1). In fact, 8.0 percent have a WRSTNOW of 1 but a WRSTEVER of 400.[11]

The ideal data set for determining the effect of credit history on the probability that a loan will be refinanced would include a credit snapshot as of the date the home was originally purchased and periodic updates, perhaps once per quarter, as the loan ages. With this information, the researcher could determine whether the homeowner's credit history had deteriorated since the purchase of the home. Unfortunately, data sets that link property transaction data with credit histories are a relatively new phenomenon, so these periodic updates of the credit history are not yet available. As a second-best alternative, we use one credit snapshot—as of the second quarter of 1995—that includes both a current (WRSTNOW) and a backward-looking (WRSTEVER) credit measure. We included these measures of creditworthiness in numerous specifications of our logit model and, regardless of specification, found that they were both statistically and economically significant in determining refinancing probability. Moreover, by comparing WRSTNOW with WRSTEVER, we were able to identify cases where a mortgagor's credit history had improved over time, and found some evidence that improvement reduced, but did not completely overcome, the negative impact of a WRSTEVER value of 400.[12]

Table 3
CROSS TABULATION OF WORST NOW AND WORST EVER CREDIT HISTORIES FOR HOMEOWNERS IN THE SAMPLE

	Worst Now						
Worst Ever	1	30	60	90	120	400	Total
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.

Note: Figures in table represent the percentage of the sample that has the indicated combination of worst now and worst ever measures.

POST-ORIGINATION HOME EQUITY

In addition to a poor credit history, another factor that could prevent a homeowner from refinancing, regardless of how far interest rates have fallen, is a decline in property value that significantly erodes that owner's equity. For example, if a homeowner originally made a 20 percent down payment (origination LTV ratio=80 percent), a 15 percent decline in property value following the date of purchase would push the post-origination LTV ratio to nearly 95 percent, typically the maximum allowable with conventional financing. Loan underwriters would likely be concerned that the recent downward trend in property values would continue and therefore would be reluctant to approve such a loan.

In addition, an LTV ratio exceeding 80 percent 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 ratio was greater than 80 percent, correspondingly smaller declines in property value would have similar effects. In contrast, increases in prop-

erty value would likely raise the probability of refinancing. Greater equity simply makes it easier for homeowners to qualify for a loan since the lender is exposed to less risk. It may also increase the incentive to refinance for homeowners who wish to take equity out of their property (known as a cash-out refinancing). Furthermore, if price appreciation substantially lowers the post-origination LTV ratio, a borrower may be able to use refinancing to reduce 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 the post-origination LTV ratio as an explanatory variable. The LTV ratio's numerator is the amortized balance of the original first mortgage on the property, calculated by using standard amortization formulas for fixed-rate mortgages and the interest rate assigned to that loan, as discussed above.[13] 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 repeat sales home price indexes are not completely free of bias, they are superior to other indicators in tracking the movements in home prices over time. This approach allows us to calculate a post-origination LTV ratio for each month from the date of purchase to either the date of refinance or the end of the sample period.

In addition to a poor credit history, another factor that could prevent a homeowner from refinancing, regardless of how far interest rates have fallen, is a decline in property value that significantly erodes that owner's equity.

For loans that were refinanced, the post-origination LTV ratio used is the estimate for the month in which the refinance loan closed. However, as in the case of interest rate R, a value of the post-origination LTV ratio must be assigned to those observations that did not refinance. We noted that, on average, homeowners who refinanced did so at the forty-fifth percentile of values of the LTV ratio observed from the date of purchase to the date of refinance. On the basis of this observation, the LTV ratio assigned to those who did not refinance is the average over the entire period from the date of purchase to the end of the sample period.

We should note that virtually all of the movement in the LTV ratio is the result of changes in the value of the home. 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, the Case Shiller Weiss repeat sales indexes suggest that home prices in the California counties included in our sample declined by roughly 30 percent from 1990 to 1995.

Age or "Burnout"

The actual prepayment performance of mortgage pools typically shows an increase in the conditional prepayment rate during roughly the first fifty to sixty months, at which point loans are described as being "seasoned." As the aging process continues, the remaining loans in a pool become quite resistant to prepayment, 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 for burnout is that homeowners prevented from refinancing by credit, equity, and/or income constraints come to dominate mortgage pools over time as homeowners who are not similarly constrained refinance or sell their homes. To the extent that our equity and credit variables capture this effect, the age of the loan per se should be less important than it would be in a model that does not include those variables. However, recognizing that credit and equity may not capture all age-correlated effects, we also include AGE as an explanatory variable. Because the effect of aging may not be a simple linear one, we also include age squared (AGESQ). In comparing the frequency distribution of AGE for homeowners who refinanced with the corresponding distribution for homeown-

ers who did not, we see that the general shape of these distributions is similar—although, as one would expect, the proportion of higher AGE values is greater for nonrefinancers than for refinancers (Chart 5).[14]

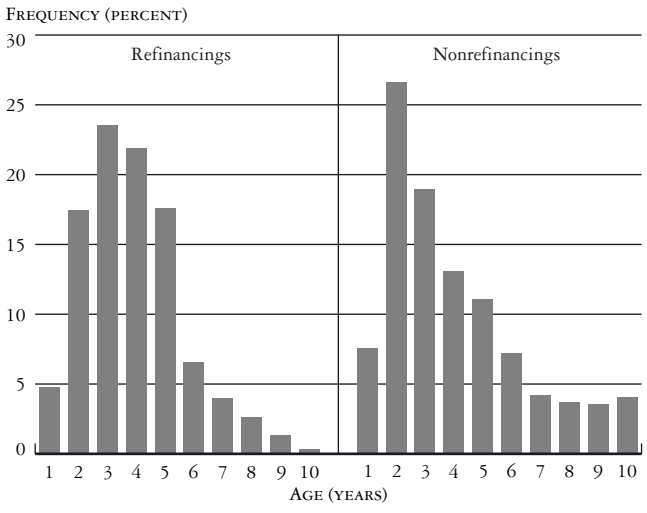
Empirical Findings

Logit estimations of our model for the entire sample—that is, all regions combined—appear in Table 4. We account for the effect of credit on the probability of refinancing by dividing the sample into three subsamples: individuals with values of WRSTNOW equal to 1 (good credits), individuals with WRSTNOW between 30 and 120 (marginal credits), and individuals with WRSTNOW equal to 400 (bad credits). We then estimate our model for each of the subsamples while dropping the credit history variable. We eliminate this variable because variations in market interest rates relative to the contract rate on a homeowner's existing mortgage would have a greater effect on the refinancing probability of a borrower with a perfect credit history than on one with serious credit difficulties. This variability in responsiveness suggests that there should be significant interactions between credit history and the other explanatory variables, particularly SPREAD. In addition, it is not clear whether the credit variables WRSTNOW and WRSTEVER should be viewed as continuous, such as crude credit scores, or as categorical.[15]

Our results confirm that credit history has a marked effect on the probability of refinancing. The coefficient on

Chart 5

Distribution of Sample of Mortgage Loans by Age



Source: Authors' calculations.

Note: Each number on the horizontal axis represents a one-year range. That is, "1" represents one to two years of age; "2," two to three years of age; and so on.

Table 4

Logit Analysis of Factors Influencing the Decision to Refinance, by Credit Category: All Regions

Dependent variable: refinance=1, nonrefinance=0

Explanatory Variable	WRSTNOW=1	30 ≤ WRSTNOW <400	WRSTNOW=400
CONSTANT	1.187***	3.292***	2.245***
	(56.29)	(20.51)	(12.99)
SPREAD	0.585***	0.521***	0.266*
	(233.60)	(9.55)	(3.30)
LTV	-0.032***	-0.055***	-0.044***
	(470.89)	(64.29)	(58.26)
AGE	-0.172***	-0.548**	-0.273
	(10.18)	(5.94)	(1.77)
AGESQ	-0.059***	-0.022	-0.053***
	(140.52)	(1.12)	(7.76)
HSD	4.273***	4.872***	3.983**
	(94.51)	(8.27)	(5.28)
LE	4.445***	3.418***	4.798***
	(472.25)	(15.07)	(38.39)
DUM_IL	-0.387***	-0.971**	-1.039***
	(19.65)	(5.43)	(7.04)
DUM_FL	0.147**	0.836***	0.496**
	(5.99)	(9.65)	(4.11)
DUM_CA	0.417***	1.237***	0.694**
	(33.49)	(12.35)	(5.67)
Number of refinancings	3,522	177	218
Number of nonrefinancings	7,488	648	802
Pseudo R-squared[a]	0.248	0.259	0.244
Chi-square of model	2805.72	214.56	250.31
Concordant ratio (percent)	79.2	81.0	80.5

Source: Authors' calculations.

Note: Figures in parentheses are chi-square statistics.
[a]Pseudo R-squared is defined in Estrella (1997).
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

SPREAD for good credits is approximately twice as large as it is for bad credits, with a corresponding sizable drop in statistical significance in the latter case. Similarly, we find that the coefficients on HSD are positive and highly significant, although slightly smaller and somewhat less significant for the WRSTNOW=400 subsample. While high values of HSD indicate more opportunities for a mortgagor's option to be in the money, such values have less impact on the refinancing probability of credit-constrained borrowers. As expected, we find that the coefficients of the variable SPREAD are uniformly significant and positive across the subsamples.

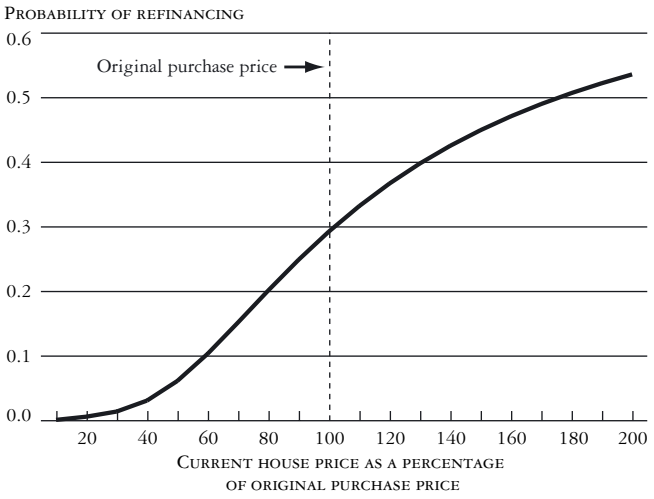
Changes in home equity also have an important influence on the probability of refinancing, as evidenced by the negative sign and high level of significance of the LTV ratio. We demonstrate the estimated effect of changes in house price by plotting simulated values of the probability of refinancing for different levels of the post-origination house price as a percentage of the original purchase price (Chart 6). Note that in Table 4, the coefficient on the LTV ratio is somewhat larger for the bad credit group, suggesting that to some extent there is a trade-off between equity and credit rating.

Lending environment is also significant and bears the predicted sign, suggesting that increased lender aggressiveness and consumer financial savvy have boosted the probability that a loan will be refinanced. Again note that the coefficient of LE is somewhat greater for bad credits than for good credits, suggesting that an important element of increased lender aggressiveness has been the increase in subprime credit quality lending, or lending to borrowers with credit histories worse than that required in the A-paper market. Finally, 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.

These results emphasize the dependence of estimates of interest rate sensitivities on credit factors. Pools of mortgages with relatively high proportions of borrowers with poor credit histories will experience significantly slower prepayment speeds, all else being equal. Investors in mortgage-backed securities are affected by the credit conditions of the households represented in the underlying pools of mortgages even though they may be insulated against homeowner default per se. Moreover, our results suggest that a change in the overall lending environment has occurred over the past decade, probably because lenders have become more aggressive and borrowers more sophisticated. All else being equal, this change has increased the probability that a homeowner will refinance.

Chart 6

EFFECT OF CHANGE IN HOUSE PRICE ON PROBABILITY OF REFINANCING



Source: Authors' calculations.

EFFECTS OF AN IMPROVEMENT IN CREDIT RATING

The summary measures of credit history used in this study suggest that the credit performance of many individuals in our sample has improved: for these individuals, WRSTNOW has a lower value than WRSTEVER. As Table 3 shows, 8.0 percent of the sample have a WRSTEVER of 400 (the worst credit classification) and a WRSTNOW of 1 (the best credit classification).

To investigate the extent to which improvement in a homeowner's credit history affects the probability of refinancing, we first select all those cases in which WRSTEVER is 400 (18.4 percent of the total sample). We then divide that group into three subsamples based on the extent of improvement: WRSTEVER=400, WRSTNOW=1; WRSTEVER=400, 1<WRSTNOW<400; and WRSTEVER=400, WRSTNOW=400. Next we estimate our model, absent

the credit history variable, over these three subsamples. We find that the coefficients on SPREAD and HSD are larger for the subsample with the greatest improvement than for the subsample with no improvement. These results provide some support for the hypothesis that improvement in one's credit rating increases the probability of refinancing (Table 5).

Table 5
THE EFFECT OF CREDIT HISTORY IMPROVEMENT

Explanatory Variable	WRSTEVER=400 WRSTNOW=1	WRSTEVER=400 1<WRSTNOW<400	WRSTEVER=400 WRSTNOW=400
CONSTANT	2.860***	3.455***	2.245***
	(18.43)	(5.76)	(12.99)
SPREAD	0.540***	0.721***	0.266
	(12.77)	(4.579)	(3.30)
LTV	-0.050***	-0.063***	-0.044***
	(65.80)	(23.19)	(58.26)
HSD	6.252***	2.357	3.983***
	(13.45)	(0.26)	(5.28)
AGE	-0.536***	-0.404	-0.273
	(6.64)	(0.65)	(1.77)
AGESQ	-0.040***	-0.073	-0.053***
	(4.652)	(1.97)	(7.76)
LE	4.981***	3.970***	4.798***
	(38.64)	(5.10)	(38.39)
DUM_IL	-0.703***	-0.846	-1.039***
	(4.24)	(0.86)	(7.04)
DUM_FL	0.579***	1.311***	0.496***
	(5.36)	(5.29)	(4.11)
DUM_CA	1.183***	2.626***	0.694***
	(14.35)	(11.94)	(5.67)
Number of refinancings	221	55	218
Number of nonrefinancings	788	249	802
Pseudo R-squared[a]	0.260	0.339	0.244
Chi-square of model	264.74	101.96	250.31
Concordant ratio (percent)	81.3	86.3	80.5

Source: Authors' calculations.

Note: Figures in parentheses are chi-square statistics.
[a]Pseudo R-squared is defined in Estrella (1997).
* Significant at the 1 percent level.
** Significant at the 5 percent level.
*** Significant at the 10 percent level.

SIMULATING THE EFFECTS OF CREDIT AND EQUITY ON THE PROBABILITY OF REFINANCING

Using the separately estimated equations for the WRSTNOW=1 and WRSTNOW= 400 subsamples, we simulate values for the probability of refinancing for hypothetical individuals with different credit histories and different values of the post-origination LTV ratio (Table 6). The four columns of this table represent alternative combinations of the variables WRSTNOW and the LTV ratio. Moving down each column, we see that the variable SPREAD rises from 0 to 300 basis points, an increase that should normally motivate refinancing. The first column, with WRSTNOW=1 and the post-origination LTV ratio=60 percent, 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, suggesting that refinancings motivated by the desire to extract equity from the property are fairly high among this group. As SPREAD rises to 300 basis points, the probability of refinancing essentially doubles, reaching nearly 60 percent. In the second column, where the LTV ratio=100 percent, the probabilities drop sharply; at SPREAD=0, the probability is just 0.1, while at SPREAD=300, the probability is 0.32, about half of that when the LTV ratio=60 percent.

In contrast, the third and fourth columns depict an individual who is severely credit-constrained (WRSTNOW=400). As suggested above, having substantial equity can overcome many of the problems associated with

Table 6
PROBABILITY OF REFINANCING UNDER ALTERNATIVE COMBINATIONS OF SPREAD, CREDIT HISTORY, AND LOAN-TO-VALUE RATIO

	WRSTNOW=1		WRSTNOW=400	
SPREAD	LTV Ratio=60	LTV Ratio=100	LTV Ratio=60	LTV Ratio=100
0	0.29	0.11	0.34	0.11
100	0.38	0.16	0.36	0.12
200	0.48	0.23	0.37	0.13
300	0.58	0.32	0.39	0.14

Source: Authors' calculations.

Note: The simulated probabilities were obtained using models summarized in Table 4.

a poor credit history, particularly because more lenders have moved into subprime lending programs. With the LTV ratio=60 percent, probabilities of refinancing are essentially the same at SPREAD=0 and SPREAD=100 as in the WRSTNOW=1 case. However, without substantial equity (an LTV ratio=100 percent), the probability of refinancing is not only low but also unresponsive to increases in SPREAD.

Additional simulations test the marginal effect on the probability of refinancing of relevant changes in the model's other explanatory variables (Table 7). We saw in Table 1 that the mean value for LE for refinancers is 24 basis points. The results reported in Table 7 indicate that, all else being equal, this mean value of LE results in a 0.2 increase in the probability of refinancing. Comparing Table 7 with Table 6, we conclude that the change in the lending environment over the past decade has had an effect on the probability of refinancing equivalent to moving from an LTV ratio of 100 percent to an LTV ratio of 60 percent—a very powerful effect. Similarly, each year in which a loan ages reduces the probability of refinancing by 0.1, all else being equal.

Table 7
MARGINAL EFFECT OF OTHER EXPLANATORY VARIABLES ON THE PROBABILITY OF REFINANCING

Variable	Change in Variable	Change in Probability
LE	+25 basis points	+0.20
HSD	+5 basis points	+0.04
AGE	+1 year	-0.10

Source: Authors' calculations.

Note: Changes for LE and HSD are roughly equal to a change of one standard deviation.

CONCLUSION

Our analysis provides compelling evidence that a poor credit history significantly reduces the probability that a homeowner will refinance a mortgage, even when the financial incentive for doing so appears strong. Moreover, consistent with previous studies, we find that refinancing probabilities are quite sensitive to the amount of equity a homeowner has in his or her property. Homeowners with poor credit histories and low equity positions cannot easily meet lenders' underwriting criteria, so they are often blocked from obtaining the replacement financing necessary to prepay their existing mortgage.

On another level, this research contributes to the evidence that households' financial conditions can have significant effects on the channels through which declines in interest rates influence the overall economy. From the broadest viewpoint, mortgage refinancings can be viewed as redistributions of cash flows among households or investment intermediaries. For those households able to reduce costs by locking in a lower interest rate on their mortgage, refinancing is likely to have 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 deteriorated credit histories or erosion of equity, the stimulative effect on consumption would likely be less.

Of course, refinancing decisions also affect the investors in the various cash flows generated by pools of mortgages. When homeowners refinance, those investors lose above-market-rate income streams and so are keenly interested in any factors that may have a significant bearing on the probability of refinancing. This analysis demonstrates that, in addition to monitoring changes in interest rates and home prices, those investors should be concerned with the credit histories of the homeowners represented in a particular pool of mortgages as well as trends in those credit histories over time. Despite guarantees against credit risk, the relative proportions of credit-constrained households represented in pools of mortgages will have a significant impact on the prepayment behavior of those pools under various interest rate and home price scenarios.

APPENDIX: MODELING THE DECISION TO REFINANCE

A homeowner decides to refinance by comparing the costs of continuing to hold the current mortgage with the costs of obtaining a new mortgage, both evaluated over some expected holding period. For simplicity, let B* represent the difference between the cost of continuing to hold the mortgage at the original rate and the cost of refinancing at the current rate, discounted over the expected duration of the loan. The variable B* represents the net benefit from refinancing; if B* is positive, the homeowner would want to refinance.

Although this notional desire to refinance, measured by B*, is not observable, we can observe some of the key factors that determine it. Such factors include the difference between the homeowner's current mortgage interest rate and the prevailing market interest rate at the time this decision is being evaluated (SPREAD), the homeowner's credit history (WRSTNOW), the amount of equity in the property (LTV), the number of months since the origination of the existing mortgage (AGE), the volatility of mortgage interest rates since origination (HSD), and any changes in the lending environment since origination that may have reduced the financial, psychic, or opportunity costs of obtaining a loan (LE). Thus, we can express B* as a function of these explanatory variables:

$$(A1)\quad B_i^* = \alpha_0 + \alpha_1 SPREAD_i + \alpha_2 WRSTNOW_i + \alpha_3 LTV_i + \alpha_4 AGE_i + \alpha_5 HSD_i + \alpha_6 LE_i + u_i ,$$

where the subscript (i) represents the i-th mortgage holder and u_i represents the error term. We assume for simplicity that the relationship between B* and the factors that determine it is linear.

The decision to refinance can be expressed as a simple binary choice that assumes:

$$(A2)\quad r_i = 1 \quad if \quad B_i^* > 0 \quad \textit{(refinancing)}$$
$$r_i = 0 \quad if \quad B_i^* \leq 0 \quad \textit{(no refinancing).}$$

Equations A1 and A2 jointly represent an econometric model of binary choice. If the net benefit from refinancing is positive, we would expect on average that the i-th homeowner would refinance (represented by binary outcome $r_i = 1$); otherwise the individual would not (outcome $r_i = 0$). We estimate the parameters of the binary choice model (that is, $[\alpha_0, \alpha_1, \ldots, \alpha_6]$) using maximum likelihood logit analysis (for more details, see Maddala [1983] and Green [1993]).

Noting the significant interaction effects between the creditworthiness measure and the other explanatory variables, and the uncertainty over whether WRSTNOW is a continuous or categorical variable, we develop an alternative to an estimation of equation A1 by dividing the sample into subsamples based on the various values of WRSTNOW, dropping WRSTNOW as an explanatory variable, and estimating the resulting equation, A3, over those subsamples:

$$(A3)\quad B_i^* = \alpha_0 + \alpha_1 SPREAD_i + \alpha_2 LTV_i + \alpha_3 AGE_i + \alpha_4 HSD_i + \alpha_5 LE_i + u_i .$$

ENDNOTES

Stavros Peristiani, Paul Bennett, and Richard Peach are economists at the Federal Reserve Bank of New York. Gordon Monsen is a managing director in Asset Trading and Finance and Jonathan Raiff is a first vice president in Mortgage Strategy at PaineWebber Incorporated. *The authors wish to thank Elizabeth Reynolds for outstanding technical support on this paper.*

1. Another factor that may have impeded a borrower's ability to refinance is a decline in household income. Unfortunately, the data set used in this study does not include information on an individual borrower's income at the time of the initial purchase of the home or afterward.

2. In the literature on this topic, a distinction is made between the values of LTV ratios, income, and credit history at the time the mortgage loan is originated (the origination values) and the values of those variables at some point in time after the origination (the post-origination values). The post-origination values are the most relevant for the decision to prepay a mortgage, but they also tend to be the most difficult on which to obtain data.

3. Homeowners' assessments of the current market values of their properties may be biased, particularly during periods when there are significant changes in those values. See, for example, DiPasquale and Sommerville (1995) and Goodman and Ittner (1992).

4. Case Shiller Weiss, Inc., of Cambridge, Massachusetts, provided these home price indexes.

5. See Follain, Scott, and Yang (1992) and Follain and Tzang (1988).

6. The interest rate on existing loans C is not directly observed in the data base. An estimate of that interest rate can be derived from information on the original loan balance, original maturity, and periodic readings of the amortized balance, which is reported in the TRW credit reports discussed below.

Strictly speaking, an interval of thirty to sixty days usually separates the date of application for a mortgage from the date of closing, although borrowers typically have the option of locking in the interest rate at the time of application or letting the rate float, in some cases up to the date of closing. We experimented with lagging the national average mortgage interest rate by one and then two months and found that in neither case were the results significantly different from those we obtained using the average rate for the month in which the loan closed.

7. In a more technical version of this study, we tested four alternative, increasingly complex measures of the incentive to refinance. Details on the definitions and specifications of these measures, as well as the estimation results, are presented in Peristiani et al. (1996).

8. For example, Archer, Ling, and McGill (1995) assign to those 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.

9. In the technical version of this study (Peristiani et al. 1996), we use total derogatories as an explanatory variable in determining the probability of refinancing and find it to be highly significant with the predicted sign, although somewhat less significant than WRSTNOW or WRSTEVER.

10. In fact, each variable 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 WRSTNOW and WRSTEVER to take on only those values cited in the text.

11. To an increasing extent, mortgage lenders are relying on a single credit score summarizing the vast amount of information on an individual's credit report. For an overview of this issue, see Avery, Bostic, Calem, and Canner (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.

12. For additional information on these alternative specifications, see Peristiani et al. (1996).

13. The presence of second mortgages and home equity loans introduces additional considerations into the issue of refinancing. On the one hand, second mortgages and home equity loans would tend to reduce a homeowner's equity. On the other hand, since second mortgages and home equity loans typically have interest rates well above the rates on first mortgage loans, the spread based on the homeowner's weighted-average cost of credit would likely be higher. Although the MRG data base indicates the presence and amount of second mortgages and home equity loans taken out since the original purchase, we do not investigate their effect on refinancing probabilities. This is an area for future research.

14. As noted earlier, the sample excludes observations with AGE of less than twelve months.

15. Dividing the sample into three subsamples based on credit rating is equivalent to estimating the model over the entire sample with dummy variables for the three credit classifications and fully interacting those dummy variables with the other explanatory variables of the model.

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