EFFECTS OF HOUSEHOLD CREDITWORTHINESS ON MORTGAGE REFINANCINGS

S. Peristiani, P. Bennett, G. Monsen, R. Peach, and J. Raiff

Federal Reserve Bank of New York
Research Paper No. 9622

August 1996

EFFECTS OF HOUSEHOLD CREDITWORTHINESS ON MORTGAGE REFINANCINGS

August 7, 1996

by S. Peristiani, P. Bennett, G. Monsen, R. Peach, J. Raiff[1]

Abstract: Using a unique loan level data set that links individual household credit ratings with property and loan characteristics, we test the extent to which homeowners' equity and credit ratings affect the likelihood that mortgage loans will be refinanced as interest rates fall. The logit model estimates strongly support the importance of both the equity and credit variables. These results are interesting both from the viewpoint of investors in mortgage products (since prepayments are directly affected) and from the perspective of monetary policy (since refinancings are one channel by which lower interest rates normally help reliquify households).

1. Introduction

Homeowners typically have the option of prepaying all or part of the outstanding balance of their mortgage loans at any time, usually without penalty. However, unless they have sufficient wealth to pay off the balance, exercising this option requires obtaining a new loan.

---

[1]Stavros Peristiani, Paul Bennett, and Richard Peach are economists at the Federal Reserve Bank of New York. Gordon Monsen and Jonathan Raiff are principals of the Mortgage Research Group of Jersey City, New Jersey. The authors wish to thank Elizabeth Reynolds for outstanding technical support on this project.

The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

Evidence is accumulating that variation in homeowners' ability to qualify for new mortgage credit and in the cost of that credit accounts 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 focused almost exclusively on the difference between the interest rate on a homeowner's existing mortgage and rates available on new loans. This was due in large part to the fact that the data sets used to investigate this issue were 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 permit inclusion of individual property, loan, and borrower characteristics into the analysis. This paper represents a significant advance of 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's equity over time. Our findings 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 since they confirm that the responsiveness of mortgage cash flows 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. As shown in Chart 1, personal bankruptcies have risen quite sharply since the mid-1980's. While this partly reflects changes in laws and attitudes, it nonetheless suggests that credit histories for a growing segment of the population are deteriorating. Furthermore, as shown in Chart 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. In contrast, rates of home price appreciation in the East North Central and South Atlantic states 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 due to poor credit ratings or erosion of home equity. 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.

The findings in this paper also contribute to the understanding of how constraints on credit availability affect the transmission of monetary policy to the economy (e.g., see Bernanke (1993)). A number of studies have confirmed Fazzari, Hubbard, and Petersen's (1988) finding that investment expenditures by credit-constrained businesses are especially closely tied to those firms' cashflows and relatively insensitive to changes in interest rates, reflecting constraints on their ability to obtain credit. Analogously, credit- and/or equity-constrained homeowners may be less sensitive to changes in interest rates because of limited access to new credit, thereby short-circuiting an important channel by which lower interest rates improve household cashflows

and stimulate the economy.

2. Previous Loan Level Research on Mortgage Prepayments

Recognition that, in addition to changes in interest rates, individual loan, property, and borrower characteristics play a key role in determining the likelihood that a mortgage loan will prepay has spawned a relatively new branch of research on mortgage prepayments based on loan level data sets. This research has focused on the three major underwriting criteria mortgage lenders use in deciding whether to extend credit--equity, income, and credit history. Past studies have investigated the effect of changes in homeowners' equity and income on their ability to exercise the option 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 ratios (LTVs) and post-origination payment-to-income ratios based on changes in regional home prices and incomes. They concluded that post-origination equity was a key determinant of the termination experience of those loans (inverse relationship for defaults, positive relationship for prepayments) whereas post-origination income was insignificant. Caplin, Freeman, and Tracy (1993), using a sample of loans secured by properties in six states, also find evidence of the importance of home equity in influencing the likelihood of mortgage prepayment. They assess the effect of post-origination equity by dividing their sample into states with stable or weak property markets (based on transaction-based home price indices for specific SMSAs) and according to whether the loans had high or low original LTVs. They found that in states with weak property markets prepayment activity was less responsive to declines in mortgage interest

rates than was the case in states with stable property markets, consistent with the hypothesis that changes in home equity play an important role.

Archer, Ling, and McGill (1995) found that home equity had an important effect on the probability that a loan would be refinanced and provide evidence that changes in borrower income also play a significant role. The authors matched records from the 1985 and 1987 national samples of the American Housing Survey (AHS) to derive a subsample of non-moving 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. Their estimate of post-origination home equity was derived from the sum of the book value of all mortgage debt divided by the owner's assessment of the current value of his or her own property.[2] 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 hypothesized signs.

This paper advances this literature in several important respects. This is the first study to systematically investigate the effect of the third underwriting criteria-- homeowners' credit histories. In addition, we introduce an innovation in the estimation of post-origination equity by using county-level repeat sales home price indices.[3] We employ a unique loan level data set

---

[2] Homeowners assessments of the current market values of their properties may be biased, particularly around turning points. See for example, DiPasquale and Sommerville (1995) and Goodman and Ittner (1992).

[3]The authors would like to thank the firm of Case Shiller Weiss, Inc.(CSW) of Cambridge, Massachusetts for providing these home price indices.

that, in addition to providing the information on credit histories, allows large samples for major population centers as well as the nation as a whole and permits identification of the reason for prepayment--refinance, sale, or default. Finally, the richness of this data set allows us to look at borrower behavior over numerous time intervals, which should enhance the robustness of our results.

3. Our Data

The data was provided by the Mortgage Research Group (MRG) of Jersey City, New Jersey, which has entered into a strategic alliance with TRW to provide data for research on mortgage finance issues. MRG maintains a database covering roughly 42 million residential properties located in 396 counties in 36 states. The database is arranged into "tables". 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 for between 150 and 200 million transactions. For example, if the property is purchased, a purchase transaction code is entered along with key characteristics such as date of closing, purchase price, original mortgage loan balance, and maturity and type of mortgage (fixed rate, adjustable rate, balloon, etc). 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 offices, which are surveyed on a regular basis to keep the transaction data up-to-date.

Multiple other tables providing information such as the physical characteristics of the property, the demographic characteristics of the population that lives in the vicinity of the property, and periodic snapshots of the credit histories of the occupants of those properties can be linked to the transaction table on the basis of property identification numbers. The data on credit histories is derived from TRW Information Services, the consumer credit information side of the organization.

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. Selecting 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 identified the most recent purchase transaction for each property. The mortgages on some of these properties were subsequently refinanced, in some cases more than once, while the others had no further transactions recorded through the end of our sample period, December 1994. This established the zero-one, refinance-no refinance dependent variable we then try to explain. (For those 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.

An interesting feature of this sample is its varying time dimension. For example, the most recent purchase transaction can range from as recent as one year back from the sample cut-off date of December 1994 to as far back as 10 years (1984). Refinancings, the precise date of which are known, occur at varying intervals after the original purchase. Furthermore, the sample includes refinancings that occurred in the 1986-early 1987 "refi wave" as well as from the 1993-early 1994 wave, although most are from that latter period.

4. Our Model

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 his 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 either fail to exercise them, or exercise them only after interest rates have fallen quite far below the rate on their existing mortgage, 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 only qualify 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 borrowers' personal credit history has deteriorated.

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 is 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) the current loan-to-value ratio (as opposed the that prevailing at the time of purchase), typically referred to in the literature as 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 follows while Table 1 presents summary statistics.

Interest Rates and Lending Environment

Fundamentally, the determination of the degree to which the call option is in the money, or alternatively the strength of the incentive to refinance, is made 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, the opportunity cost of the time spent shopping for and qualifying for a new loan,

and the borrower's marginal tax rate, since mortgage interest is an allowed itemized deduction. As will be discussed more fully below, there are numerous ways in which the strength of the incentive can be measured. The simplest, which we label as SPREAD, is the contract rate on the existing mortgage minus the interest rate that could be obtained on a new mortgage. For all loans in the sample, the contract rate on the existing mortgage is measured as the Freddie Mac national average commitment (contract) rate on fixed rate loans for the month the loan was closed. This is the so-called A paper rate or the rate available to the best credit risks. Likewise, the rate obtained on a new mortgage for those who did refinance was the same national average A paper contract rate in the month the new loan closed.[4] By basing SPREAD on the A paper rate, we explicitly exclude from this variable the influences that individual borrower equity and credit conditions may have on the actual spread faced by a particular borrower.

Assigning a spread to those homeowners that did not refinance is problematic and has been handled differently by different authors.[5] In tackling this problem, we noted that, as depicted in Chart 3, those who did refinance rarely did so at the highest spread (lowest market rate) that occurred over the period from their original purchase to the date they refinanced. If all the spreads observed over that period were ranked from highest to lowest, on average those who did refinance did so at about the 75th percentile. Accordingly, we assigned non-refinancers the

---

[4] Strictly speaking, there is typically a 30 to 60 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 found that in neither case were the results significantly different from using the average rate for the month the loan closed.

[5] For example, Archer, Ling, and McGill (1995) assign to those observations that did not refinance the lowest monthly average Freddie Mac commitment rate on 30-year FRMs over the two year time interval of their study.

75th percentile of spreads observed over the period from date of original purchase to the end of our sample period (December 1994).[6] In addition to SPREAD, we also include as an explanatory variable the historical standard deviation (HSD) of market rates during the relevant time interval, i.e. purchase to refinance or purchase to end of sample period. HSD is measured as the standard deviation of the 10-year Treasury bond rate. We expect this variable to be directly related to the probability that a loan is refinanced. That is, for a given value of SPREAD, if during the relevant time interval market rates were relatively volatile, a homeowner would have been more likely to observe an opportunity to refinance than if rates were relatively stable.[7]

A third, related explanatory variable is Lending Environment (LE), defined as the change in the average level of points and fees (expressed as a percent 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, over the period from the late 1980s into the 1990s the mortgage lending industry became much more competitive in general and much more aggressive with regard to soliciting refinancings. Over this period mortgage servicers began contacting customers with spreads greater than some threshold, often as low as 50 basis points, and encouraged them to refinance. Transactions costs declined as competition reduced points and

---

[6]As with those who did refinance, the spread assigned to non-refinancers was based on A paper interest rates. Any decline in incentive to refinance due to a homeowner's inability to qualify for the A paper rate, in which case actual spread would be less than that assigned, will be captured through the home equity and credit variables.

[7]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.

fees. (See Chart 4.) 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.

It is important to note that the particular combination of SPREAD, HSD, and LE that we employ to capture the effect of changes in interest rates and the lending environment, while quite reasonable, represents only one approach. For the current study, a key issue is whether the estimated effects of the credit history and/or home equity variables are significantly altered by how the interest rate variables are specified. Therefore, to test the robustness of the credit and equity variables, we experimented with several alternative specifications of the interest rate variables. As will be discussed below, the effects of our personal creditworthiness and home equity measures are insensitive to that specification.

Personal Creditworthiness

As mentioned above, for the purposes of this study complete TRW credit reports were matched to the individual records of the property transaction table that make up our sample of loans. This matching was based on record identification numbers; any information that would enable an individual or a property to be identified was 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 experimented with numerous alternative measures of creditworthiness, all of which strongly support it. However, we could find little empirical basis for concluding that one measure performed 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 so has elected to declare it as a bad debt loss for tax purposes. There are not any 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 judgements, both of which are labeled public derogatories because they are effected through the courts and are a matter of public record.

Somewhat more specific credit 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 individuals 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 30 days late), 60 (scheduled payment on one or more credit lines 60 days late),

90, 120, or 400 (a debt has been charged off, as described above).[8] Note that a worst ever of 400 constitutes a derogatory, whereas some lesser indicator of credit deterioration, such as a 90 or 120, for example, does not.

Chart 5 presents a hypothetical example of worst now and worst ever. An individual has three credit lines, a home mortgage, a credit card, and an auto loan, which at the beginning of this individuals credit history (t-11) are all current. At that point in time both worst now and worst ever have 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 reaches 120 days late, at which point that lender elects to charge off the debt and both worst now and worst ever take on the value of 400. Eventually, this individual is able to get all credit lines current again, bringing worst now back down to 1 by period t-1. But worst ever remains at 400 due to the charge off of the credit card debt in period t-6.[9]

Table 2 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 has 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 point in time nearly nine of every 10 individuals has a perfect credit rating (worst now = 1), at some point in their credit history roughly half the population experienced something less than a

---

[8] In fact, both variables can take on more values than those listed. For example, a value of 34 indicates that an individual is persistently 30 days late. For the purposes of this study, we have constrained worst now and worst ever to take on the values listed here.

[9] Legally, worst ever is supposed to look back just seven years. In practice, the worst ever reading might look back more than seven years unless disputed by the individual in question.

perfect credit rating (worst ever > 1). In fact, 8.0% have a worst now of 1 but a worst ever of 400. As is discussed more fully below, when entered individually into our model worst now and worst ever perform similarly; there is no statistical basis for choosing one over the other. On the other hand, improvement in one's credit rating appears to matter. We find some weak evidence that for those with a worst ever of 400, the probability that a homeowner will refinance is somewhat higher if worst now was better than 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, finance company loans, etc. On the theory that mortgage lenders give the performance on one type of credit line more weight than others, we also experimented 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.[10]

Post-Origination Home Equity

In addition to a poor credit history, another event that could prevent a homeowner from refinancing, regardless of how far current interest rates fall, is a decline in property value which significantly erodes that owner's equity in the property. For example, if the owner originally made a 20 percent downpayment (origination LTV=80 percent), a 15 percent decline in property

[10] 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, Bostic, Calem, and Canner (1996). 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 credit worthiness.

value following the date of purchase would push the post-origination LTV to nearly 95 percent, 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 so may be reluctant to approve a loan, an LTV in excess of 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 was greater than 80 percent, 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.[11] The denominator is the original purchase price indexed using the Case Shiller Weiss repeat sales

[11] The presence of second mortgages and home equity loans (HELs) introduces additional considerations into the issue of refinancings. 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.

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. For loans that did not refinance, the post-origination LTV 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 of 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, based on the Case Shiller Weiss repeat sales indices, home prices in the California counties included in our sample declined by roughly 30 percent from 1990 to 1995.

Age or "Burn-out"

The actual prepayment experience of pools of mortgages typically exhibits an increase in the conditional prepayment rate (CPR) during roughly the first 50 to 60 months, at which point loans are described as being "seasoned" and the prepayment rate then 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 "burn out". To capture this effect, most prepayment studies include the age of the loan or number of months since

origination as an explanatory variable.

One explanation of burn out is that homeowners who are not constrained in any way are relatively quick to refinance when their option goes in the money. In contrast, homeowners who are credit-, equity-, and/or income-constrained are prevented from exercising their option and 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 did 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. Since the effect of aging may not be a simple linear one, we also included age squared (AGESQ). Chart 6 compares the frequency distribution of AGE, broken out separately between homeowners that refinanced and those that 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.[12]

5. Empirical findings

Basic Model

The logit estimation results of our basic model, shown in Table 3, clearly demonstrate the significance of the creditworthiness and the home equity measures for refinancing activity. The results are presented for the four regions (California, Florida, Illinois, and New York/New Jersey) and for all regions combined. The basic model includes SPREAD as the measure of the

[12]As noted earlier, the sample excludes observations with AGE less than 12 months. The cells in Chart 6 refer to the lower value in each AGE range (i.e. "1 year" means between 1 and 2 years of age, and so forth).

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. As noted, 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 with 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 lessens 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. Chart 7 demonstrates the estimated effect of changes in house price by graphing simulated values of the probability of prepayment for different levels of the post-origination house price as a percent of the original purchase price. 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.

Sensitivity Analysis -- Alternative Measures of Incentive to Refinance

As noted earlier, a test of 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. Table 4 presents the estimation results for our model for all four regions combined using four alternative measures of the strength of the incentive to refinance. In the first column are the

estimated coefficients when using SPREAD, as defined above. The next three columns introduce the measures PROBIN, INMONEY, and PVALUE, respectively, all of which are explained in detail in the appendix. 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.

Sensitivity Analysis -- Alternative Measures of Credit History

As a further test of the finding that credit history is an important determinant of the probability of refinancing, Table 5 presents logit estimations of the basic model for all regions combined after having replaced the credit history variable WRSTNOW with three alternatives--WRSTEVER, WRSTCRD, and TDEROG, all of which are described in Section 4 above. All four alternatives give similar results, so there is no basis for preferring one over the others. (The coefficient value on TDEROG differs due to 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.

Interactions Between Credit and Interest Rate Effects

As argued above, for an individual (or firm) without access to external financing, variations in market interest rates may have little effect on his decision making. In this case, the argument would be that variations in market interest rates relative to the contract rate on a

homeowners' existing mortgage would have greater effect on the refinancing probability of a borrower with a perfect credit history than for a homeowner with serious credit difficulties, such as a 400 for either WRSTNOW or WRSTEVER. To test this hypothesis, we created two subsamples, one of individuals with values of WRSTNOW equal to 1 ("good credits") and the other with values equal to 400 ("bad credits"). We then estimated our basic model for each of these subsamples while dropping the credit history variable.

The results of this exercise, shown in Table 6, confirm the presence of key interactions between credit history and SPREAD. The size of the coefficient of SPREAD among "good credits" is approximately twice as high as it is among "bad credits", with a corresponding sizable drop in statistical significance in the latter case. This result further emphasizes 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 rates, all else equal. Therefore, 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*.

Improvement in Credit Report

As noted in the discussion in Section 4 above, there are cases in our sample where an individual's credit history has improved in the sense that WRSTNOW has a lower value than WRSTEVER. In fact, as shown in Table 2, 8.0 percent of the sample had a WRSTEVER of 400 (the worst credit classification) and a WRSTNOW of 1 (the best credit classification). We investigated the extent to which improvement in a homeowner's credit history may increase his

or her access to credit. To do this, we estimated the model over a subsample that had a value of 400 for WRSTEVER. We then added a variable labeled IMPROVE defined as the difference between WRSTEVER and WRSTNOW. If WRSTEVER was 400 and WRSTNOW was 1, for example, IMPROVE would equal 399. In contrast, if WRSTEVER was 400 and WRSTNOW was 400, improve would equal zero. Thus, a positive sign on the estimated coefficient of this variable indicates that the improvement in credit rating does help an individual gain access to credit for refinancing, other factors equal. As seen in the results, presented in Table 7, the sign of the estimated coefficient of IMPROVE is indeed positive, providing some support for the idea that improvement in credit history helps. Simulations based on this equation suggest that a value of 399 for IMPROVE raises the likelihood of refinancing by about 5 percent. However, that coefficient is not statistically significant at the 95 percent level of confidence.

Effect of Lending Environment

As a final sensitivity test, we investigated the effect of the variable intended to capture changes in the lending environment (LE). Table 8 presents estimation results for our model for all four regions combined using the four alternative measures of the strength of the incentive to refinance (the same as Table 4) but excluding the variable LE. Without LE, the overall explanatory power of the model is diminished somewhat. While they remain highly significant, the magnitudes of the coefficients on the alternative measures of incentive to refinance, on AGE, and on HSD are changed. Of particular interest, the variables WRSTNOW and LTV remain highly significant and the estimated coefficients are relatively stable. These results suggest that LE is capturing an important influence on the probability that a loan is refinanced. Also, the

results confirm that inclusion of LE in the model is not influencing the finding of the significance of the credit and equity variables.

6. Effect of Credit History and Home Equity on the Probability of Refinancing

Using the separately estimated equations for the WRSTNOW=1 and WRSTNOW=400 subsamples presented in Table 6, it is possible to simulate values for the probability of refinancing for hypothetical individuals with different credit histories and different values of the post-origination LTV. Table 9 summarizes these results. The four columns of this table 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, suggesting that refinancings motivated by the desire to extract equity from the property is fairly high among this group. As SPREAD rises to 300 basis points, the probability of refinancing essentially doubles to nearly 60 percent. Moving to the second column, where LTV=100%, the probabilities drop quite sharply; at SPREAD=0 the probability is just .1 while at SPREAD=300 the probability is 0.32, about half that when LTV=60%.

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 a poor credit history. With LTV=60%, probabilities of refinancing are essentially the same at SPREAD =0 and 100 as in the WRSTNOW = 1 case.

However, without substantial equity (LTV=100%) the probability of refinancing is not only low but also unresponsive to increases in SPREAD.

CONCLUSIONS

The foregoing analysis provides compelling evidence that poor credit histories significantly reduce the probability that a homeowner will refinance a mortgage, even when the financial incentive from doing 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 his or her property. Poor credit histories and low equity positions make it very difficult for homeowners to meet lenders' underwriting criteria, and so they are blocked from obtaining the replacement financing necessary for them to exercise the option to prepay their existing mortgage.

On one level, this research contributes to the evidence that households' financial conditions can have significant consequences on the channels through which declines in interest rates affect 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 financing costs by locking in a lower interest rate on their mortgage, it is likely that there would 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 due to deteriorated credit histories and/or erosion of equity, the stimulative effect on consumption would likely be less than otherwise would be the case.

The other side of the coin is the effect on the investors in the various cash flows generated by a pool of mortgages. When homeowners refinance, those investors lose above-market-rate income streams and so are keenly interested in any factors which may have a significant bearing on the probability that a homeowner will refinance. This analysis demonstrates quite clearly that in addition to changes in interest rates and home prices, those investors should also be concerned with both the credit histories of the homeowners represented in a particular pool of mortgages as well as trends in those credit histories over time. Notwithstanding guarantees against credit risk, 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.

Appendix

Alternative Measures of the Incentive 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. There are numerous alternative measures that can be used to capture the strength of the incentive to refinance, four of which were employed in this study. Those alternatives, described below, fall into the general categories of discrete and cumulative.

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,

$$SPREAD_t = C - R_t, \qquad (1)$$

where (t) represents the time period. While 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. That threshold would likely vary across borrowers and over time.[13]

Another drawback of this simple measure 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

[13] See Follain, Scott, and Yang (1992) and Follain and Tzang (1988).

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

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

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

The variables PV(R) and PV(C) represent the per dollar annuity of monthly payments at interest rates R and C over the remainder of the original 30 year maturity. The ratio of PV(R) and PV(C) offers a simple criterion for refinancing:

$$PVALUE_t = (\frac{C}{R})(\frac{1-(1+R)^{t-360}}{1-(1+C)^{t-360}}) = (\frac{C}{R})\times\gamma. \quad (4)$$

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

An important issue that arises when using discrete measures such as SPREAD and PVALUE in cross-sectional analysis is the fact that they take on unique value for different time periods or intervals and it is not clear what value should be used. For example, in a study such as this one homeowners can be thought of a purchasing their home at period t=0. From that point in time elapses a window of T periods, where T is either the time period in which the loan

is refinanced or, in the case of nonrefinancers, the end of the time period of the sample. For individuals that refinance it seems clear that the appropriate value of SPREAD or PVALUE to use in the cross sectional analysis is the value at or near the time of refinancing. For individuals that do not refinance, however, it is unclear what value is appropriate. An infinite number of possibilities exist and there is a certain amount of arbitrariness in selecting any particular one. In our analysis of the data we noted that, on average, those homeowners who did refinance did so not at the maximum values of SPREAD or PVALUE but rather at around the 75-th percentile of the values that occur between the date of purchase and date of refinancing. Therefore, we assigned individuals that did not refinanced the 75-th percentile of the values of SPREAD and PVALUE that existed from their date of purchase to the end of the sample period (December 1994).

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 what values to assign to those who did not refinance is much more clear cut.

We employed two cumulative measures, the first of which we 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 the following condition holds:

$$PV_t(R) - PV_t(C) > TC_t, \tag{5}$$

where the present value terms are defined by equations (2) and (3) above and TC is a measure of transaction costs.[14] For simplicity, let y_t be a binary 0-1 variable measuring when the homeowner is in the money,

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

INMONEY is then defined as,

$$INMONEY = \frac{1}{T} \sum^{T} y_t. \tag{7}$$

The variable INMONEY requires that the present value difference (PV(R)-PV(C)) exceed the transaction costs (TC) limit in order to be in the money (get a 1). In some instances, however, we observe refinancings when the present value difference is less than our measure of transactions costs. At the same time, INMONEY does not gauge by how much the present value difference exceeds transactions costs. To overcome these deficiencies, a second, more complicated cumulative measure was constructed which assigns a probability to the likelihood of refinancing at each time period since the date of purchase. In particular,

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

$$PROBIN = \frac{1}{T}\sum^{T} P[PV_t(R) - PV_t(C) > TC_t] = \tag{8}$$

$$= \frac{1}{T}\sum^{T} P[d_t > 0],$$

where d_t=PV(R)-PV(C)-TC_t. PROBIN measures the average probability that a homeowner is in the money. To estimate PROBIN, we simply use the empirical moments of d_t and assume that the probability distribution P[.] is normal.

REFERENCES

Wayne Archer, David Ling, and Gary McGill, "The Effect of Income and Collateral Constraints on Residential Mortgage Terminations", NBER Working Paper No. 5180, July 1995.

Robert V. Avery, Raphael W. Bostic, Paul S. Calem, and Glenn B. Canner, "Credit Risk, Credit Scoring, and the Performance of Home Mortgages", Federal Reserve Bulletin, July 1996, pp. 621-648.

Ben Bernanke, "Credit in the Macroeconomy," Federal Reserve Bank of New York *Quarterly Review*, Spring 1993, pp 50-70.

Andrew Caplin, Charles Freeman, and Joseph Tracy, "Collateral Damage: How Refinancing Constraints Exacerbate Regional Recessions," NBER Working Paper No. 4531, November 1993.

Sewin Chan, "Spatial Lock-in: Do Falling House Prices Constrain Residential Mobility?" mimeo, Rutgers University, November 1995.

Donald F. Cunningham and Charles A. Capone, Jr., "The Relative Termination Experience of Adjustable to Fixed-Rate Mortgages", Journal of Finance, Vol. XLV, No. 5, December 1990.

Denise DiPasquale and C. Tsuriel Somerville, "Do Housing Price Indexes Based on Tranacting Units Represent the Entire Stock? Evidence from the American Housing Survey," Journal of Housing Economics 4(3), 1995, pp 195-229.

Arturo Estrella, "Measures of Fit with Dichotomous Dependent Variables: Critical Review and a New Proposal," Unpublished paper, Federal Reserve Bank of New York, 1996.

Steven M. Fazzari, R. Glenn Hubbard, and Bruce C. Peterson, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1988, No.1, pp 141-195.

James R. Follain, James O. Scott, TL Tyler Yang, "Microfoundations of a Mortgage Prepayment Function," Journal of Real Estate and Economics, vol. 5, 1992, pp. 197-217.

James R. Follain and Dah-Nein Tzang, "Interest Rate Differential and Refinancing a Home Mortgage," The Appraisal Journal, vol. LVI, no. 2, April 1988.

John L. Goodman and John B. Ittner, "The Accuracy of Home Owners' Estimates of Value," *Journal of Housing Economics* 2(4), 1992, pp 339-357.

Lynn Paquette, "Estimating Household Debt Service Payments," Federal Reserve Bank of New York *Quarterly Review*, Summer 1986, pp 12-23.

Scott F. Richard and Richard Roll, "Prepayments on Fixed-Rate Mortgage-backed Securities," *The Journal of Portfolio Management*, Spring 1989, pp 73-82.

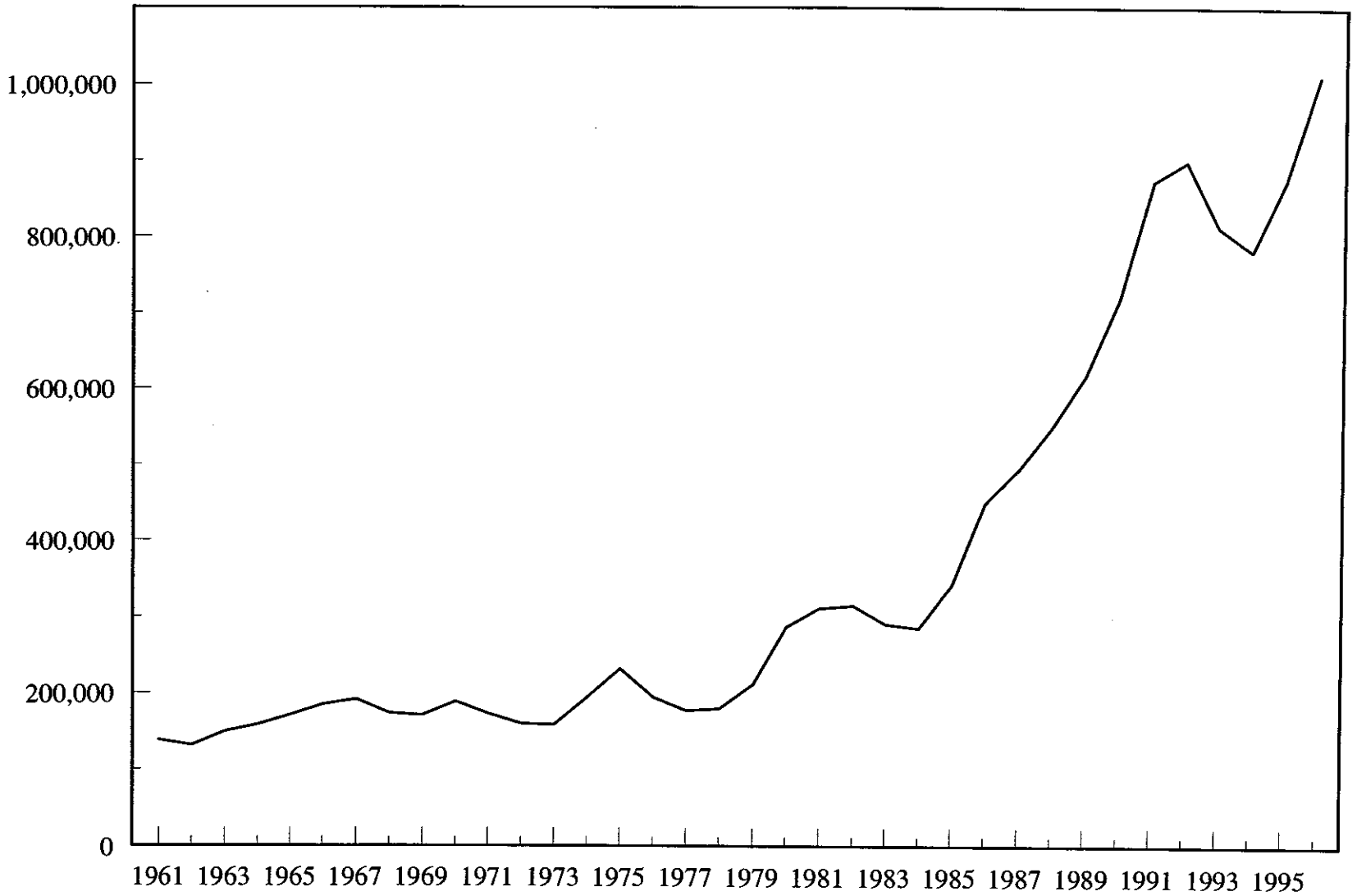
Ronald W. Spahr and Mark A Sunderman, "The Effect of Prepayment Modeling in Pricing Mortgage-Backed Securities," *Journal of Housing Research*, Volume 3, Issue 2, pp 381-400,

1992.

Charles N. Schorin, "Modeling and Projecting MBS Prepayments," in Frank J. Fabbozi, ed., *Handbook of Mortgage Backed Securities*, Probus Publishing Company, 1992, U.S.A., pp 221-262.

Chart 1

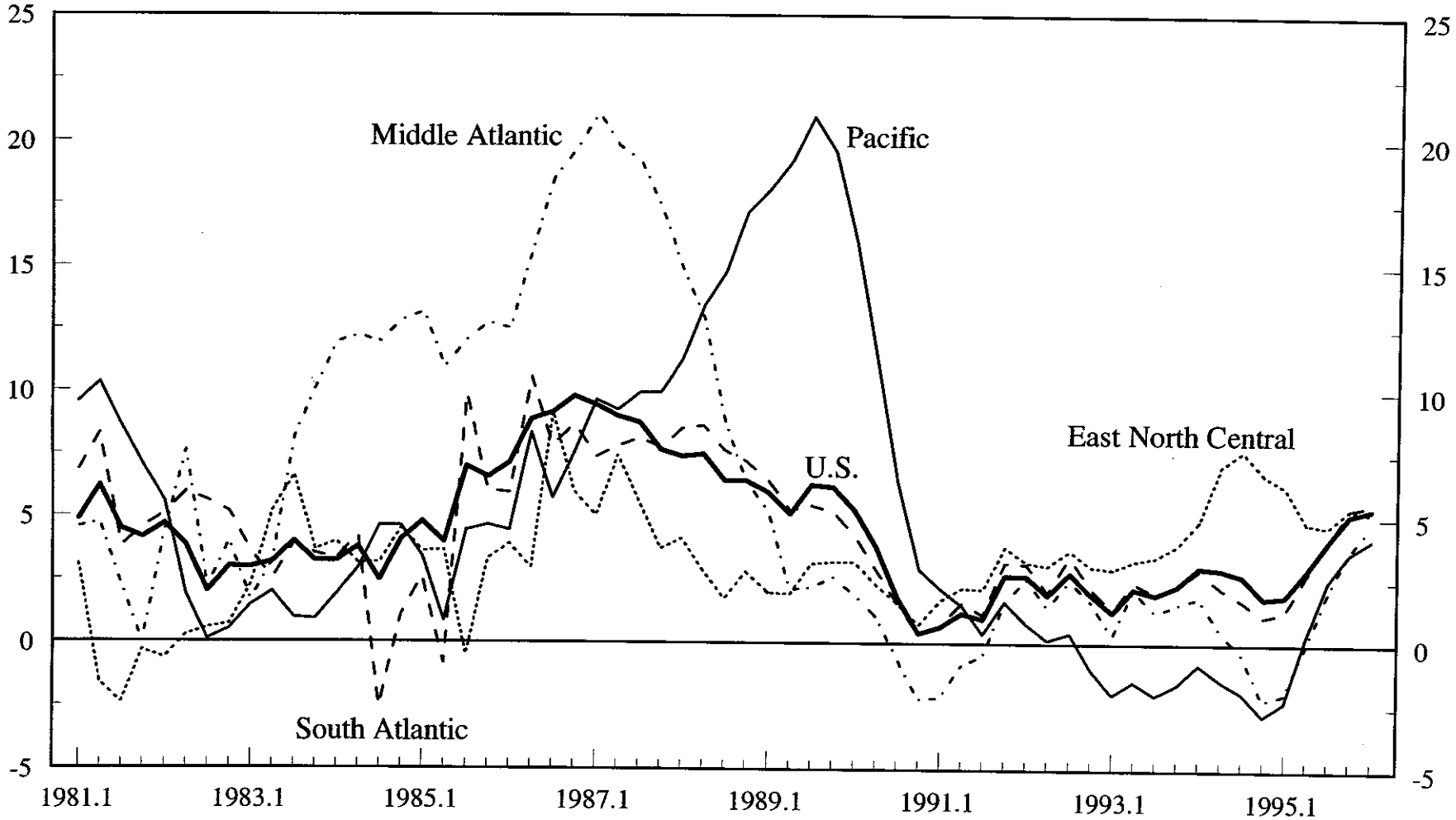
Total Personal Bankruptcies



Sources: U.S. courts and Federal Reserve Board of Governors

Chart 2

Fannie Mae - Freddie Mac Repeat Sales Housing Price Index
U.S. and Selected Regions



Source: Office of Federal Housing Enterprise Oversight

Chart 3

Spread Assigned to Those Who Did Not Refinance

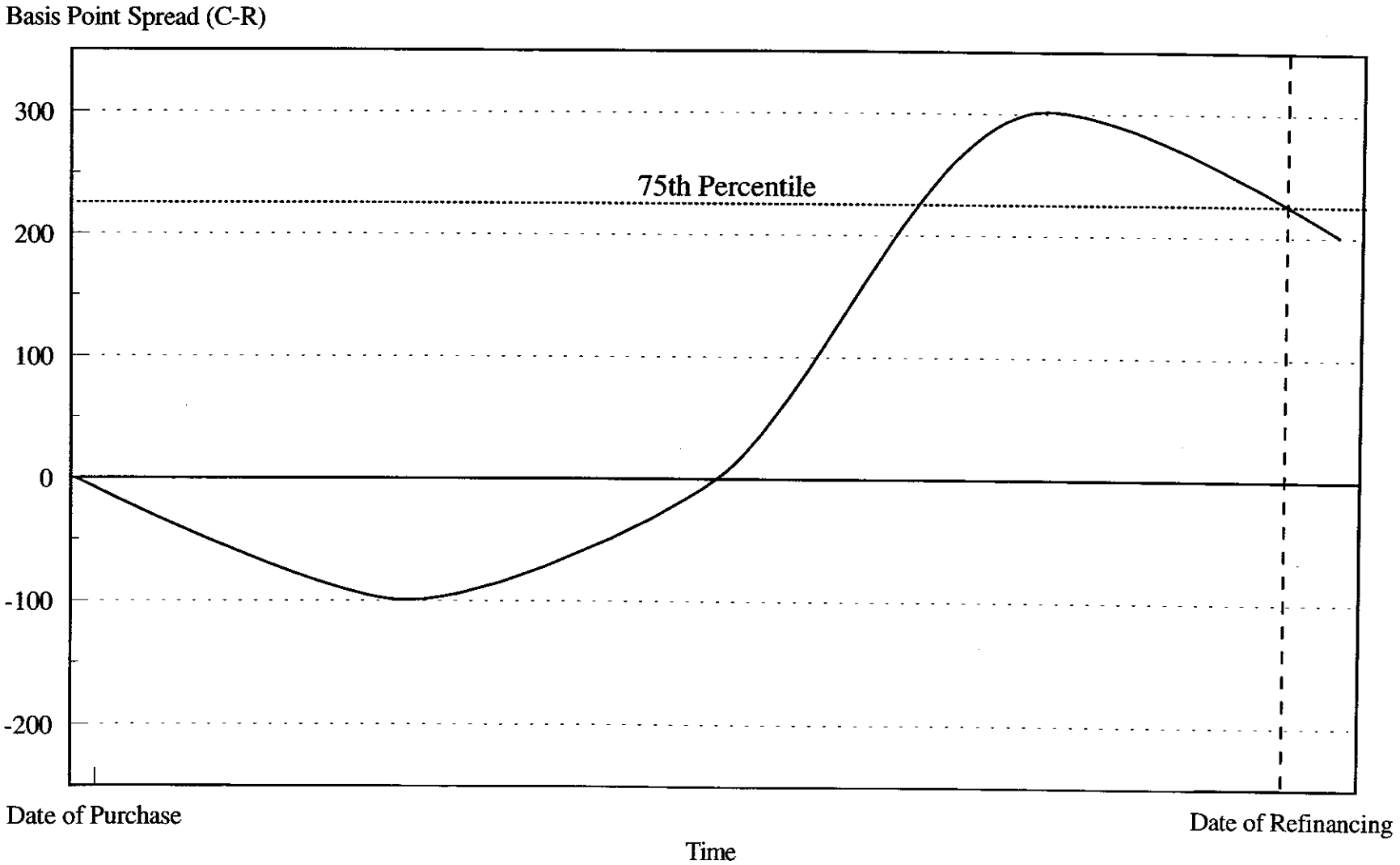
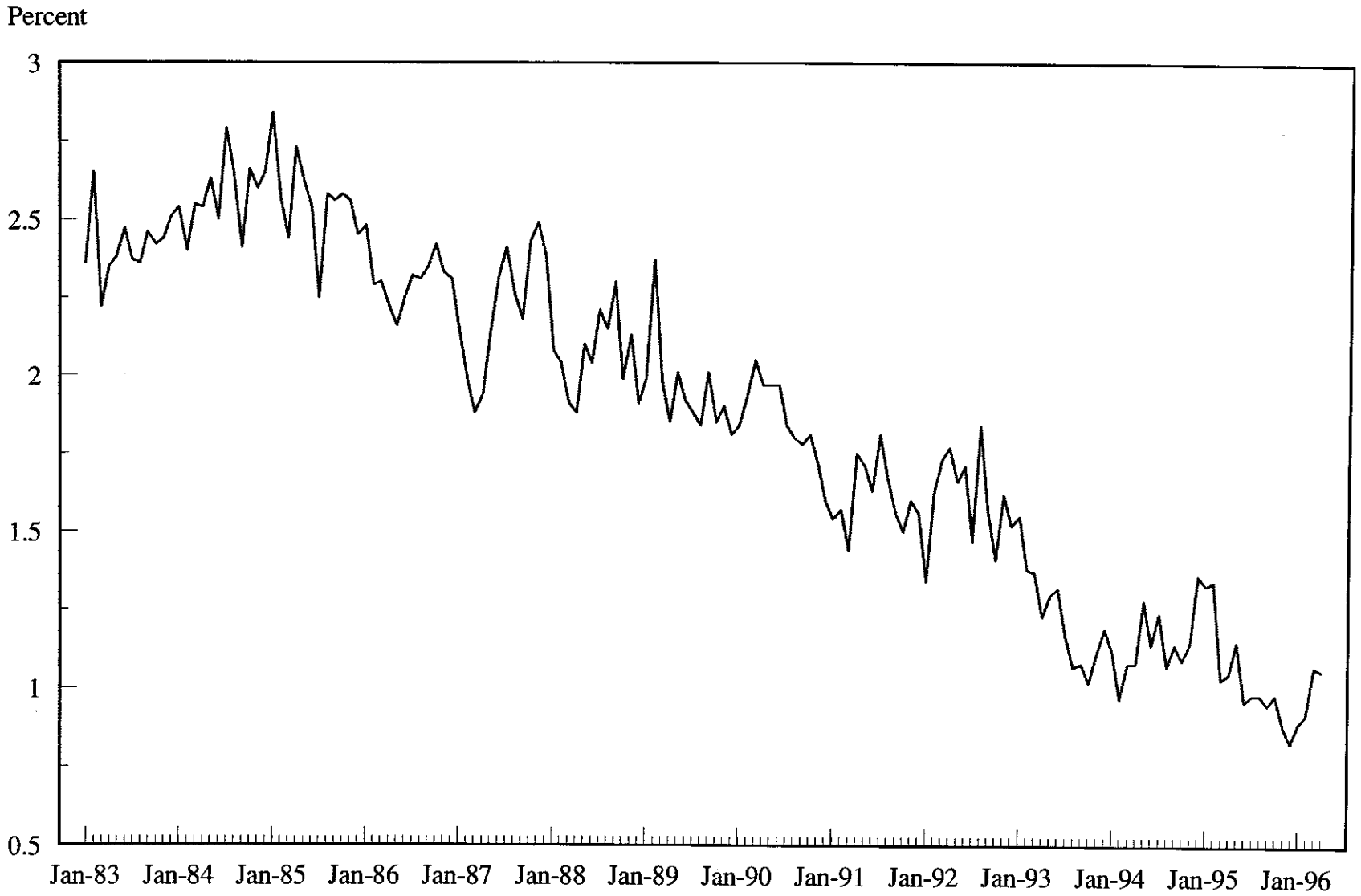


Chart 4

Initial fees and charges



Source: Federal Housing Finance Board

Chart 5

Example of Worst Now/Worst Ever Credit Histories

	t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1	t
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
Credit Lines												
A (mortgage)	1	1	1	30	1	30	30	30	30	1	1	1
B (credit card)	1	30	60	90	120	400	--	--	--	--	--	--
C (auto loan)	1	1	30	60	30	60	90	60	30	30	1	1

TIME

Chart 6

Age Distribution of Mortgage Loans

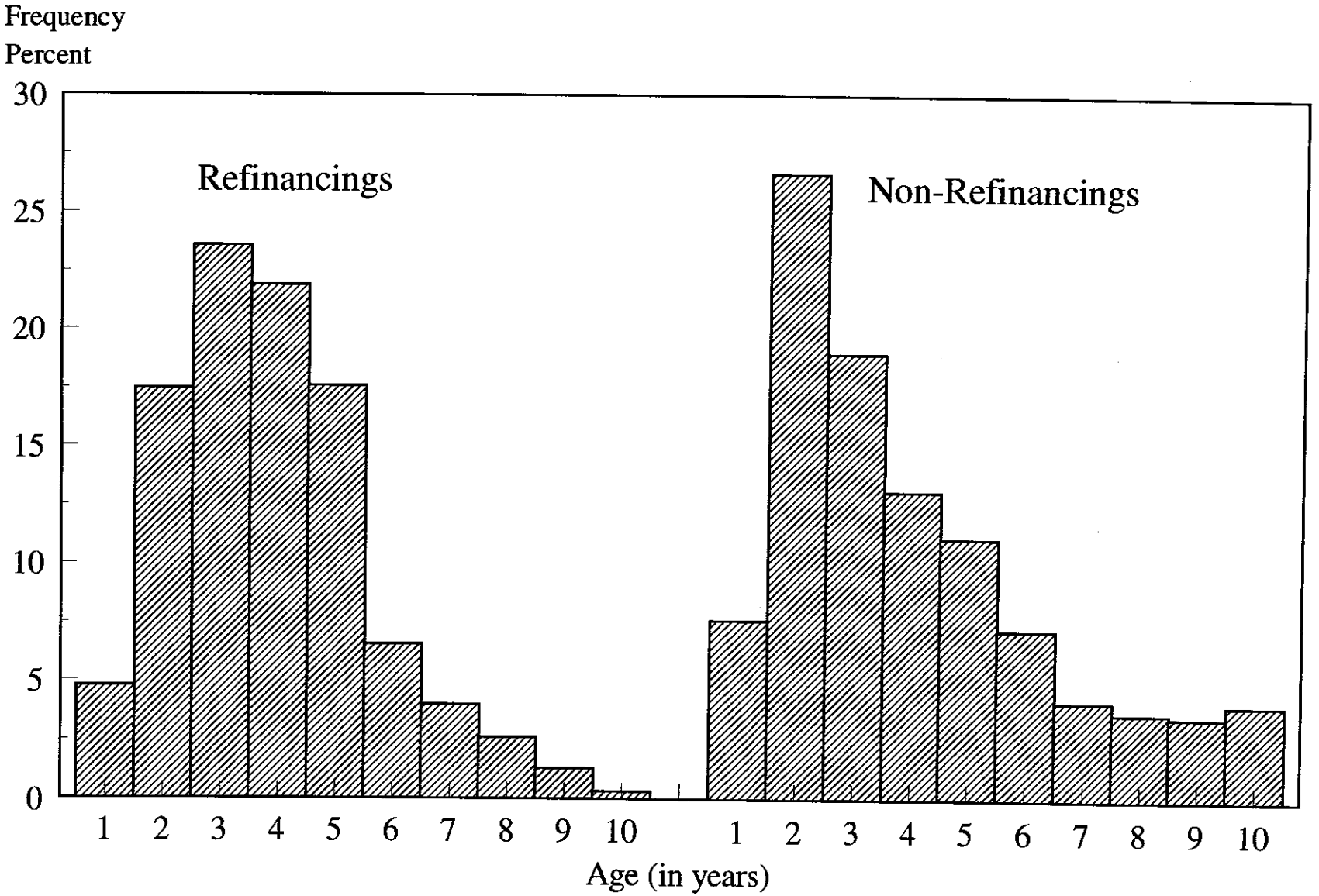


Chart 7

Effect of change in house price on probability of refinancing

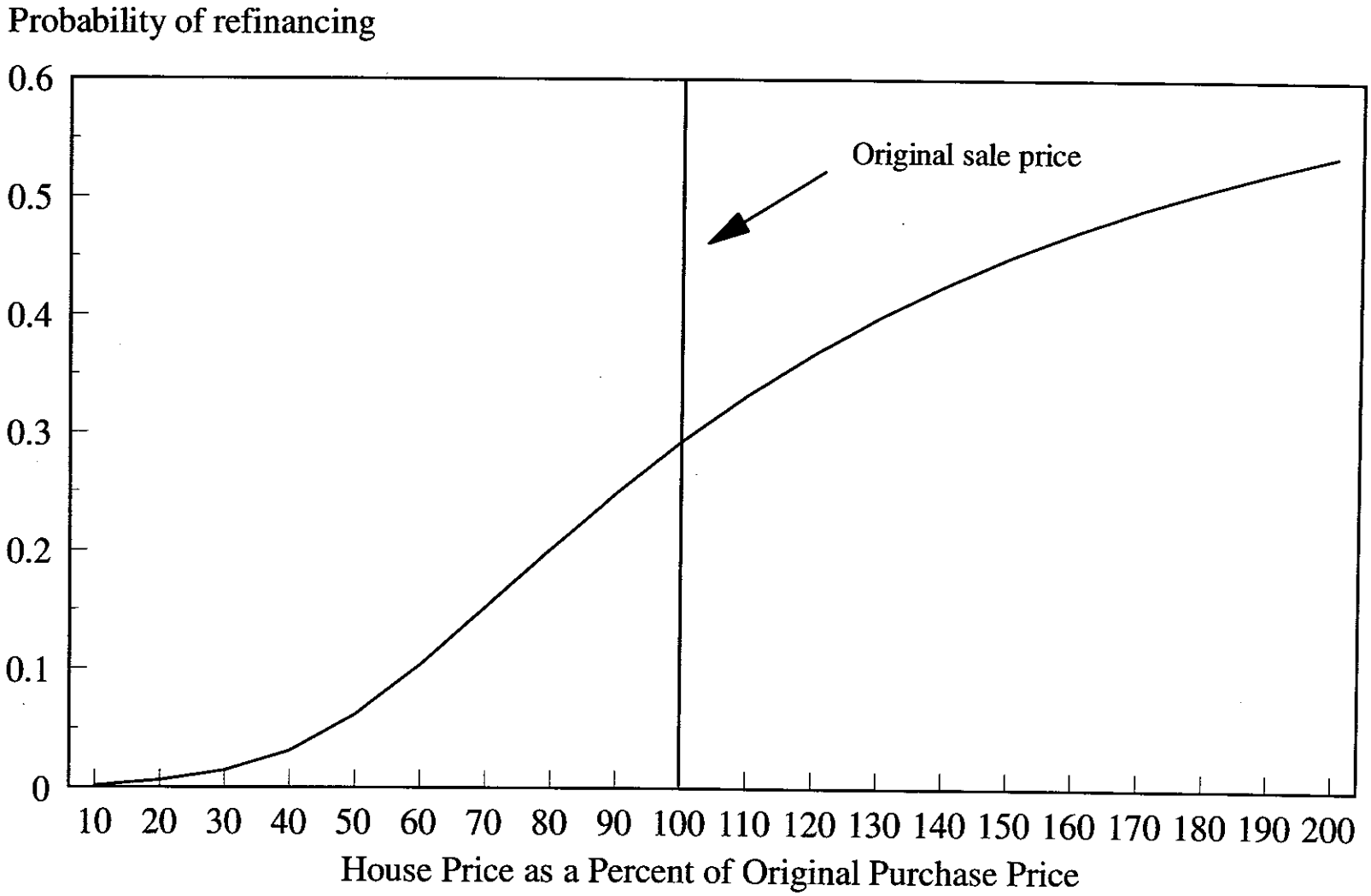


Table 1

Summary Statistics for Variables

Explanatory Variable	Description	Mean	
		Refinancing	No Refinancing
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 (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 transactions costs (percent)	0.24	0.13

Other Related Variables

	Sale 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

Notes: The interest rate measures SPREAD, PROBIN, INMONEY, and PVALUE are described more extensively in the Appendix.

Table 2

Crosstab of Worst Now by Worst Ever

		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%

Table 3

Logit Estimation of Basic Model

Explanatory Variable	California	Florida	Illinois	NY & NJ	All regions
CONSTANT	2.605*** (52.85)	1.715*** (40.40)	9.746*** (192.16)	-0.804 (2.12)	1.420*** (90.87)
SPREAD	0.272*** (11.42)	0.752*** (136.72)	0.907*** (39.61)	0.629*** (77.59)	0.573*** (251.79)
WRSTNOW	-0.00069 (2.01)	-0.00068** (4.28)	-0.00204** (4.76)	-0.00169*** (11.38)	-0.00115*** (26.05)
LTV	-0.0346*** (123.49)	-0.0227*** (94.34)	-0.119*** (254.70)	-0.0359*** (223.10)	-0.0339*** (601.55)
AGE	-0.317*** (9.43)	-1.100*** (102.69)	-0.858*** (23.26)	1.156*** (13.31)	-0.214*** (17.80)
AGESQ	-0.0617*** (45.27)	0.0738*** (42.09)	-0.0713*** (21.47)	-0.214*** (24.13)	-0.0561*** (143.01)
HSD	4.530*** (27.80)	3.608*** (29.14)	6.444*** (19.89)	2.744*** (7.28)	4.355*** (112.23)
LE	5.718*** (180.57)	4.171*** (192.12)	3.887*** (29.78)	3.125*** (53.74)	4.428*** (530.82)
DUM_IL					-0.474*** (33.18)
DUM_FL					0.201*** (12.59)
DUM_CA					0.479*** (49.09)
# of Refinancings	879	1510	362	1166	3917
# 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%

Notes: Explanatory variables are defined more extensively in Table 2. Pseudo R^2 is defined in Estrella (1996). The symbols (***, **, *) indicate statistical significance at the 1, 5, and 10 percent levels.

Table 4

Logit Estimation using Alternative Measures of Incentive to Refinance (All regions)

Variable	SPREAD	PROBIN	INMONEY	PVALUE
CONSTANT	1.420*** (90.87)	0.845*** (32.42)	1.365*** (84.16)	-8.651*** (671.88)
Alternative Incentive Measure	0.573*** (251.79)	3.200*** (337.53)	1.564*** (70.68)	11.292*** (1066.78)
WRSTNOW	-0.00115*** (26.05)	-0.00130*** (33.26)	-0.00125*** (31.48)	-0.00105*** (20.43)
LTV	-0.0339*** (601.55)	-0.0350*** (630.38)	-0.0338*** (608.04)	-0.0354*** (578.99)
LE	4.428*** (530.82)	4.421*** (555.62)	5.460*** (927.54)	2.803*** (213.32)
AGE	-0.214*** (17.80)	-0.280*** (30.69)	-0.0218 (0.197)	-0.566*** (121.78)
AGESQ	-0.0561*** (143.01)	-0.0451*** (90.35)	-0.0707*** (229.05)	-0.0232*** (24.25)
HSD	4.355*** (112.23)	5.022*** (151.06)	4.249*** (108.16)	5.105*** (144.72)
DUM_IL	-0.474*** (33.18)	-0.495*** (36.05)	-0.485*** (35.12)	-1.390*** (224.94)
DUM_FL	0.201*** (12.59)	0.254*** (19.46)	0.139** (6.12)	-0.644*** (92.10)
DUM_CA	0.479*** (49.09)	0.564*** (66.05)	0.391*** (32.63)	-0.263*** (12.59)
# of Refinancings	3917	3917	3917	3917
# 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%

Table 5

Logit Estimation using Alternative Measures of Credit (All regions)

Variable	WRSTNOW	WRSTEVER	WRSTCRD	TDEROG
CONSTANT	1.420*** (90.87)	1.404*** (88.79)	1.431*** (92.40)	1.407*** (89.06)
SPREAD	0.573*** (251.79)	0.566*** (245.42)	0.574*** (252.81)	0.571*** (249.92)
Alternative Credit Measure	-0.00115*** (26.05)	-0.00102*** (40.17)	-0.00100*** (13.24)	-0.0663*** (18.31)
LTV	-0.0339*** (601.55)	-0.0333*** (579.40)	-0.0340*** (607.25)	-0.0339*** (599.62)
AGE	-0.214*** (17.80)	-0.205*** (16.32)	-0.217*** (18.40)	-0.213*** (17.68)
AGESQ	-0.0561*** (143.01)	-0.0564*** (144.34)	-0.0558*** (141.98)	-0.0561*** (143.64)
HSD	4.355*** (112.23)	4.347*** (111.83)	4.358*** (112.74)	4.362*** (112.83)
LE	4.428*** (530.82)	4.427*** (530.01)	4.426*** (530.89)	4.438*** (533.09)
DUM_IL	-0.474*** (33.18)	-0.451*** (29.85)	-0.479*** (33.98)	-0.472*** (32.88)
DUM_FL	0.201*** (12.59)	0.208*** (13.46)	0.199*** (12.27)	0.204*** (12.96)
DUM_CA	0.479*** (49.09)	0.467*** (46.64)	0.470*** (47.26)	0.478*** (48.81)
# of Refinancings	3917	3917	3917	3917
# 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%

Table 6

Logit Estimation by Credit Category (All regions)

Explanatory Variable	WRSTNOW=1	WRSTNOW=400
CONSTANT	1.187***	2.245***
	(56.29)	(12.99)
SPREAD	0.585***	0.266*
	(233.60)	(3.30)
LTV	-0.0317***	-0.0439***
	(470.89)	(58.26)
AGE	-0.172***	-0.273
	(10.18)	(1.77)
AGESQ	-0.0593***	-0.0533***
	(140.52)	(7.76)
HSD	4.273***	3.983**
	(94.51)	(5.28)
LE	4.445***	4.798***
	(472.25)	(38.39)
DUM_IL	-0.387***	-1.039***
	(19.65)	(7.04)
DUM_FL	0.147**	0.496**
	(5.99)	(4.11)
DUM_CA	0.417***	0.694**
	(33.49)	(5.67)
# of Refinancings	3522	218
# of Non-refinancings	7488	802
Pseudo R^2	0.248	0.244
Chi-Square of Model	2805.72	250.31
Concordant Ratio	79.2%	80.5%

Table 7

Evaluating the effect of credit rating improvements

Explanatory Variable	WRSTEVER=400
CONSTANT	2.572***
	(35.13)
IMPROVE	0.00047†
	(2.24)
SPREAD	0.431***
	(18.70)
LTV	-0.0487***
	(148.43)
HSD	4.823***
	(17.29)
AGE	-0.420***
	(9.14)
AGESQ	-0.0470***
	(13.53)
LE	4.824***
	(84.00)
DUM_IL	-0.839***
	(12.02)
DUM_FL	0.616***
	(13.84)
DUM_CA	1.057***
	(26.79)
# of Refinancings	494
# of Non-refinancings	1839
Pseudo R^2	0.257
Chi-Square of Model	603.18
Concordant Ratio	81.3%

IMPROVE = WRSTEVER - WRSTNOW.

† P-value for coefficient is 0.13.

Table 8

Logit Estimation using Alternative Measures of Incentive to Refinance: Without Lending Environment (All regions)

Variable	SPREAD	PROBIN	INMONEY	PVALUE
CONSTANT	0.851*** (34.97)	-0.144 (1.06)	0.543*** (14.89)	-11.195*** (1460.73)
Alternative Incentive Measure	1.018*** (1047.10)	5.225*** (1130.42)	3.820*** (499.92)	13.655*** (1873.37)
WRSTNOW	-0.00103*** (22.14)	-0.00129*** (34.21)	-0.00119*** (30.70)	-0.00099*** (18.67)
LTV	-0.0355*** (682.88)	-0.0368*** (723.05)	-0.0361*** (751.58)	-0.0363*** (616.40)
AGE	-0.0687 (1.88)	-0.123** (6.06)	0.337*** (50.13)	-0.446*** (77.04)
AGESQ	-0.0454*** (96.67)	-0.0305*** (42.91)	-0.0660*** (204.46)	-0.0167*** (12.61)
HSD	3.972*** (100.42)	5.119*** (171.43)	4.055*** (112.16)	4.891*** (137.79)
DUM_IL	-0.323*** (16.13)	-0.352*** (19.26)	-0.259*** (10.82)	-1.509*** (265.85)
DUM_FL	0.390*** (50.27)	0.461*** (68.43)	0.377*** (49.42)	-0.745*** (121.69)
DUM_CA	0.769*** (138.55)	0.885*** (178.35)	0.755*** (137.96)	-0.302*** (16.60)
# of Refinancings	3917	3917	3917	3917
# of Non-refinancings	8938	8938	8938	8938
Pseudo R^2	0.206	0.211	0.155	0.307
Chi-Square of Model	2703.57	2767.28	2027.51	4081.45
Concordant Ratio	77.0%	77.6%	73.7%	81.3%

Table 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
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

Notes: The simulated probabilities were obtained using models summarized in Table 6.