STRUCTURAL CHANGE IN THE MORTGAGE MARKET AND THE PROPENSITY TO REFINANCE

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Federal Reserve Bank of New York
Research Paper No. 9736

November 1997

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November 19, 1997

Abstract: We hypothesize that the intrinsic benefit required to trigger a refinancing has become smaller, due to a combination of technological, regulatory, and structural changes that have made mortgage origination more competitive and more efficient. To test this hypothesis, we estimate an empirical hazard model of loan survival for two subperiods, using a database that allows us to carefully control for homeowners' credit ratings, equity, loan size, and measurable transaction costs. Our findings strongly confirm that credit ratings and home equity have significant effects on refinancing probability. In addition, we provide evidence that homeowners postpone refinancing in the face of increased interest rate volatility, consistent with option value theory. Finally, our results clearly support the hypothesis that structural change in the mortgage market has increased homeowners' propensity to refinance.

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* The authors thank Fred Furlong for helpful comments, Dibora Amanuel and Reagan Murray for valuable research assistance. 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.

1. INTRODUCTION

A primary consideration in the pricing of residential mortgage loan assets is prepayment risk--the premature or unscheduled return of principal to investors when homeowners move, refinance, or default. Prepayment speeds have increased significantly in the 1990s relative to the 1980s, and this increase cannot be explained by changes in the independent variables normally used in modeling prepayment behavior. As seen in Figure 1, prepayments speeds for moderately seasoned and seasoned Fannie Mae mortgage backed securities (MBS) backed by 30 year fixed rate mortgages were substantially higher in the 1990s refinancing waves than was the case in the 1986-1987 wave, despite the fact that the decline in mortgage interest rates from 1983-1984 to early 1987 was somewhat greater than the decline that occurred from 1990 to late 1993. Rather, it appears that the quantitative relationships between prepayments--particularly refinancings--and those explanatory variables have changed in ways that make prepayment more likely, all else equal.

Significant changes on both the supply and demand sides of the mortgage market likely contributed to this rise of prepayment speeds by reducing transactions costs or "frictions" associated with obtaining a new loan. Indeed, over the past twenty-five years the U.S. housing finance system has undergone a fundamental restructuring. As seen in Figure 2, in the 1970s the provision of long-term financing to homeowners was dominated by portfolio lenders, primarily thrift institutions. Due to a complex combination of economic and regulatory changes as well as financial and technological innovations, today mortgage lending is dominated by mortgage bankers/brokers and the process of securitization.[1,2] An important distinction between these two systems is that the former, often referred to as the New Deal system, effectively limited competition among lenders.[3] In contrast, the modern system has eliminated most geographic and financial barriers to entry and so is extremely competitive (see Weicher (1994)).[4]

Increased competition in the primary mortgage market along with improvements in information processing technology have lowered the explicit, financial transactions costs associated with obtaining a mortgage, as reflected in the secular decline in points and fees (Figure 3). Nonfinancial transactions costs were also reduced in the form of shortened time periods from application to approval and approval to closing and lending programs with substantially reduced financial documentation in the application process. Furthermore, advances in computer technology have enabled lenders to quickly and cheaply identify and contact mortgagors with interest rates above prevailing market rates, thereby disseminating information about refinancing opportunities more quickly and broadly than occurred in the past. In addition,

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[1] Unlike thrifts, mortgage bankers are not depository institutions. They fund mortgages through assorted forms of short-term borrowing, often termed a warehouse line of credit, and then sell the loans (for cash or "swap" them for mortgage backed securities) in the secondary mortgage market. In most cases the loans are sold "servicing retained", where the originating mortgage banker then services the loan (collects monthly payments for principal, interest, property taxes, and property insurance (PITI) and distributes those funds, net of a servicing fee, to the appropriate parties). Mortgage brokers do much of the work of originating a loan but typically do not have a warehouse line and so must arrange for another lender to fund the mortgage at the closing table.

[2] Note, however, that many of the nation's largest mortgage bankers are owned by bank holding companies.

[3] Under the "New Deal system" Savings & Loan institutions accepted local time deposits and made long term mortgage loans on homes located within 50 miles of their home offices (100 miles after 1964). The Federal Home Loan Bank Board regulated and supervised the S&L's (established reserve requirements), the Federal Home Loan Banks served as a discount window, and deposits were insured by the Federal Savings and Loan Insurance Corporation (FSLIC). Regulation Q established maximum interest rates on deposits, giving thrifts a 25 basis point higher ceiling than commercial banks.

[4] Bradley, Gabriel, and Wohar (1995) examine the declining role of thrifts. They find that thrifts significantly influenced the interest rate spread between mortgages and treasuries during 1972 to 1982, but little after that.

the growth of the subprime mortgage market established a flow of credit to borrowers unable to meet the underwriting criteria of the government sponsored enterprises (GSEs). Reinforcing these developments on the supply side of the primary market, homeowners have likely become more financially savvy, increasing their propensity to refinance for a given set of measurable incentives.

This paper presents a formal test of the hypothesis that the propensity to refinance has increased over time. Conducting such a test represents a considerable challenge. Recent research has demonstrated quite convincingly that prepayment behavior, particularly refinancing behavior, is strongly influenced by individual borrower and property characteristics. For example, Peristiani *et al* (1997) find that in addition to changes in interest rates and transaction costs, individual homeowners' equity and credit histories play an important role in determining the probability that a mortgage will be refinanced. Accordingly, a convincing empirical test of this hypothesis must be based on loan level data that captures these individual borrower characteristics and which identifies the reason for loan prepayment. Furthermore, this loan level data must cover homeowner behavior over an extended time period. As is discussed more fully below, the analysis presented in this paper is based on a unique data set that meets all of these criteria.

The primary empirical findings of this analysis can be summarized as follows. First, the results reconfirm the importance of individual borrower and property characteristics in prepayment behavior. Second, controlling for interest rate levels and volatility, points and fees, and homeowners' equity and credit histories, the analysis strongly supports the hypothesis that changes on both the supply and demand sides of the primary mortgage market have made homeowners more inclined to refinance in the 1990s than was the case in the 1980s. Finally, the analysis also finds that homeowners delay refinancing as interest rate volatility increases, consistent with the conclusion of option valuation theory that the value of the call option imbedded in the standard mortgage contract rises with volatility.

The plan of the paper is as follows. Section 2 presents the theory of the optimal refinance decision rule. Section 3 describes the data set used in this analysis. Section 4 presents our model specification and defines the explanatory variables. Section 5 presents the empirical results of the model estimation. Finally, Section 6 concludes and presents policy implications of this research.

2. THE THEORY OF OPTIMAL PREPAYMENT

Interest Rates and Refinancing

The starting point for modeling prepayment behavior is the option pricing model (see, for example, Follain, Scott, and Yang (1992)). The simplified premise is that prepayment is optimal if the present value of an existing mortgage liability exceeds the present value of a replacement loan by at least the total of all transaction costs associated with obtaining the new mortgage. Suppose that borrower (I) takes out a mortgage loan at time t_{0i} and that the expected terminal date of the mortgage is T_i, which is equal to or less than the maturity of the loan. Let $P(T_i,t,r_{ci})$ represent the present value at month t $(t=t_{0i},...,T_i)$ of the stream of payments based on the original contract interest rate (r_{ci}) of the I-th household's (callable) mortgage discounted at currently prevailing interest rates (r_{mti}). Similarly, $P(T_i,t,r_{mti})$ is the present value of the stream of payments on the same dollar amount of indebtedness based on prevailing market interest rates

(r_{mti}) and discounted at that same rate, i.e. the book value of the loan. A household seeking to minimize the present value of its mortgage financing cost will prepay if

$$P(T_i,t,r_{ci}) - P(T_i,t,r_{mti}) = P(T_i,t,r_{ci}) - Book\ Value > TC_{ti}, \tag{1}$$

where (TC_{ti}) equals the sum of points, fees and all other costs of making the transaction.

Volatility and the Option Replacement Cost

Expression (1) ignores the effect of uncertainty about future levels of interest rates on the refinancing decision. Of course, interest rates are volatile; the more volatile rates are expected to be in the future the less likely one is to exercise the embedded call option today since rates may decline further in the future. Put differently, higher expected future volatility increases the value of the call option. However, that volatility increases the value of an option "in-the-money"--the option in the existing mortgage--much more than an option well out of the money--the option in the replacement financing. Thus, the difference in value between these two options is another component of the costs of refinancing faced by the homeowner.

To capture this effect, the value of a callable mortgage asset can be expressed as the value of a noncallable bond less the value of the imbedded call option. Abstracting from the subscript I,

$$P(T,t,r_t) = B(T,t,r_t) - V(T,t,\sigma_t),$$

where $B(\bullet)$ is the annuity value of the stream of monthly mortgage prepayments and $V(T,t,\sigma_t)$

market conditions, transaction costs (TC_{it}) reflect a mix of market and individual factors. Conceptually, transaction costs can be divided into a number of distinct components: (1) direct, out-of-pocket expenses associated with prepaying the existing loan and obtaining replacement financing (e.g., points and fees, prepayment penalties, and legal expenses) (TC_{POINTS}); (2) additional out-of-pocket expenses, such as higher points and/or interest rate, and additional documentation required because of a poor credit rating or score (TC_{CREDIT}); (3) costs such as mortgage insurance that may result from low equity in the property (TC_{LTV}); and finally (4) frictional costs that may reflect the homeowner's time lost, the length of the application process, and the unsophistication of the borrower ($TC_{FRICTION}$). As shown in Figure 3, the first component of transaction costs--points and fees--have fallen over time, from 2.5 percent of the loan value in 1983 to around 1 percent at the end of 1995, likely reflecting both better technology and increased competition. Transactions costs associated with poor credit ratings may also have been reduced by innovations such as credit scoring and subprime lending, which provide lenders with a more efficient basis for pricing credit risk. Less well measured will be the cost of searching for and comparing different lenders or the burden of completing applications, most of which should have been moderated by more open competition and technological advances.

Our analysis assumes that transaction costs are reflected in the application fees, points, mortgage insurance premiums, and other charges levied at the time of loan application or origination or are amortized in the form of a higher interest rate charged on the loan itself. Either way, total transaction costs are likely higher for credit- and/or collateral-constrained borrowers. Note also that, to the extent transaction costs have important fixed components, they may not rise proportionally with loan size, causing refinancing behavior to differ accordingly.

denotes the value of the embedded call option at period t.[5] The value of this option, often referred to as the "time value" of the mortgage, depends on the expected holding period of the mortgage $(T-t)$ and the volatility of the noncallable asset (σ_t). As a result, we can replace (1) with

$$B(T_i,t,r_{ci}) \; - \; B(T_i,t,r_{mti}) > TC_{ti} \; + \; \upsilon(T_i,t,\sigma_t), \tag{3}$$

where

$$\upsilon(T_i,t,\sigma_t) = V_c(T_i,t,\sigma_t) - V_m(T_i,t,\sigma_t). \tag{4}$$

The left-hand-side of equation (3) represents the "intrinsic value" of refinancing or the financial gain from refinancing at the currently prevailing market interest rate. The variable $\upsilon(T_i,t,\sigma_t)$, which we label the *option replacement cost*, enters the analysis as the mechanism whereby interest rate volatility affects refinancing behavior. Gilberto and Thibodeau (1989) provide evidence that increased interest rate volatility reduces refinancings. This finding suggests that the effect of volatility on the value of the call option imbedded in the existing mortgage exceeds the effect on the value of the option imbedded in a replacement loan. This in turn is consistent with the prediction of option theory that the effect of volatility on the value of an option is greatest when it is in-the-money (see Hull (1993), Section 13.9).

Transaction Costs

While the intrinsic value of a loan and the option replacement cost are based on strictly

[5]The price of an option also depends on the value of the capitalization factor measured indirectly by the risk-free interest rate. For simplicity, however, we assume that this risk-free rate is constant over time.

3. DATA

The data for this study were obtained through the Mortgage Research Group (MRG) of Jersey City, New Jersey. Until late 1996, MRG maintained a data base on roughly 42 million residential properties located in thirty-six states. In addition to information pertaining to the original purchase of a property, such as date of closing, purchase price, original mortgage loan balance, and maturity and type of mortgage, data on subsequent refinancings, sales, and, is some cases, defaults, were also included.[6] In addition to the property and loan characteristics, the database also contains snapshots of the credit histories of the occupants of the properties, derived from TRW Information Services.

Aside from limiting the sample to complete observations, we further restricted it to a manageable size for computational purposes. Fist, we selected four clusters of counties in different regions of the country.[7] Next, we identified for each property the most recent purchase transaction, going in some cases back far as January 1984. The mortgages on many of these properties were subsequently refinanced, while the others had no further transactions recorded through the end of our sample period, December 1994, creating a zero-one, no-refinance/refinance observation. We also limited our sample to fixed-rate mortgages outstanding

[6]The primary sources of this information are the records of county recorders and tax assessors.

[7]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 County and five surrounding counties in Illinois (Dekalb, DuPage, Kane, McHenry, and Ogle). In the West, we selected Los Angeles, Ventura, and Riverside Counties in California. Selection of these diverse areas increases our confidence that our findings are general, particularly since the behavior of home prices in these four regions has been rather different.

for a year or more, leaving the more complex decision to refinance alternative mortgage types for further study. The resulting sample consists of 12,835 observations, of which slightly under one-third were refinanced.[8] The credit snapshots attached to these property/loan observations are as of the second quarter of 1995.

4. MODEL SPECIFICATION AND VARIABLE DEFINITIONS

An Econometric Model of Prepayments

Several researchers have reported empirical models predicting prepayments from property-level observations. For example, using a hazard model of mortgage terminations, Caplin, Freeman, and Tracy (1997) provide evidence that homeowners with shrunken home equity are less likely to prepay. Using logit models, Cunningham and Capone (1990) and Archer, Ling, and McGill (1995) also find importance effects of home equity on the probability of refinancing.

Our study uses Cox's proportional hazard framework to estimate a model of monthly prepayments. The implied dependent variable in hazard analysis is the duration of time until the loan is prepaid (or, inversely, the conditional monthly probability of refinancing). The proportional hazard model is given by

$$h(\tau|x_{ti\bullet},\beta) = h_0(\tau)\exp(x_{ti\bullet}\beta), \tag{5}$$

where (τ) denotes duration of the mortgage loan and the vector $x_{ti\bullet}$ includes all explanatory

[8]For multiple refinancings, we considered just the first one. In addition, we excluded from the sample loans that subsequently defaulted.

variables. In the framework developed above, the duration of the i-th homeowner at month t is given by $\tau_{ti}=t-t_{0i}$. The function $h_0(\tau)$, the "baseline hazard function", equals the hazard for a household whose exogenous vector is zero.

The parameter vector β is estimated using *partial maximum likelihood* (PML), which allows us to estimate the β coefficients in the proportional hazard model without specifying a functional form for the baseline hazard. The PML estimator is consistent, has an asymptotically normal distribution, and has been found to have asymptotic relative efficiency (see Efron (1977)).

Variable Definitions

The endogenous variable in the proportional hazard model is the duration until the time of refinancing measured in months. The vector of explanatory variables $x_{ti\bullet}$ controls for the *intrinsic value* of refinancing, *the option replacement cost,* and *transaction costs.*

We measure the intrinsic value of refinancing by the present value annuity ratio proposed by Richard and Roll (1989):

$$PVALUE_{ti} = \left(\frac{r_{ci}}{r_{mti}}\right)\left(\frac{1-(1+r_{mti})^{t-T}}{1-(1+r_{ci})^{t-T}}\right), \qquad (6)$$

where r_{ci} again represents the coupon rate on the existing loan of the I-th borrower and r_{mti} is the current market rate or rate at which that borrower could refinance. In practice, borrowers may select from a menu of rate and point options, paying points in exchange for a lower coupon rate, as well as choosing from differing maturities. This creates a difficulty in comparing the coupon rate on the existing loan with the currently prevailing market rate. To deal with this, we standardized the rates by assigning r_{ci} as the average Freddie Mac commitment rate on a 30-year, fixed-rate mortgages for the month that loan was closed.[9] This rate is for so-called A credits, or borrowers who could meet the Fannie Mae and Freddie Mac underwriting criteria. Note that this original rate is fixed for the life of the loan while the prevailing market rate on newly issued loans, r_{mti}, varies monthly. In computing $PVALUE_{ti}$, we assume that the expected holding period of the loan is 30 years. We reestimated the model using 15- and 20-year horizons and found that the proportional hazard estimates are quite robust to the choice of assumption about maturity.

As noted, the option replacement cost will vary positively with expected volatility. However, in contrast to the intrinsic value of refinancing, which can be calculated directly, the option replacement cost is unobservable. But we can observe the standard deviation of the price of the noncallable asset. Thus, to estimate the effect of volatility on the decision to refinance, we used the implied volatility from options on 10-year U.S. Treasury note futures contracts (VOLATILITY).[10]

The model controls for three of the four types of transaction costs or frictions discussed above. Points and fees (TC_{POINTS}) comprise an important fixed cost which vary not only with mortgage market conditions but also reflect individual borrowers' menu choice. Accordingly, we included in the set of explanatory variables the average points and fees on mortgages issued expressed as a percent of the loan amount (POINTS).

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[9] The Freddie Mac mortgage interest rate series is published weekly. The interest rate is a contract rate with associated points and fees also published. By design, the points and fees are reasonably stable over time.

[10] The implied volatility data are from the rolling 3-month futures options contracts traded on the Chicago Board of Trade. We also experimented with several statistical variance computations or econometric projections of actual rate volatility. These alternative measures of volatility yielded qualitatively similar results. In this study we present our findings with respect to the implied volatility because this is conceptually preferable.

Borrowers also may face additional frictions because of poor credit history (TC_{CREDIT}). To capture this effect, we use the worst-ever credit rating from the borrower's credit snapshot (WRSTEVER). This credit rating represents the worst payment experience across all credit lines over the individuals entire credit history. It is expressed as the number of days late; for example, a worst-ever rating of 90 means that at one time the individual was reported ninety days late on a credit card, car loan, mortgage, or other debt. The best possible worst-ever rating is a 1, meaning no late payments ever. On the other end of the scale, a worst-ever score of 400 means that a lender has charged off a debt of that borrower (see Peristiani *et al* (1997) for additional details on the credit snapshot).[11]

Another potential transaction friction stems from the amount of equity a borrower has in the property (TC_{LTV}). Borrowers applying for a mortgage loan that has a loan-to-value ratio greater than 80 percent are usually required to take out private mortgage insurance, which typically involves some payment at closing as well as a higher interest rate on the loan. If the value of a property has fallen, in which case the loan-to-value ratio may exceed 100 percent, the borrower would most likely be unable to refinance. We measure the effect of home equity by the ratio of the outstanding mortgage loan balance to the current value of the property (LTV). The current value of the property is the original purchase price adjusted for local home price movements.[12]

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[11] An alternative credit measure would have been the worst *now* credit rating or the worst payment experience as of the date of the credit snapshot. Earlier experimentation found that the effect of a bad worst ever rating on refinancing probabilities lingers even after the worst now has improved relative to worst ever. For this reason, we chose the worst ever rating.

[12] Current home prices were estimated by adjusting the purchase price for movements in county-level home price indexes from Case, Shiller, Weiss Inc. Outstanding loan balance was inferred from the original loan amount, the contract interest rate, and the original maturity.

While our analysis controls for many of the frictions associated with refinancing, it is impossible to fully account for all such frictions since they may depend on the efficiency of mortgage lenders and the level of sophistication of borrowers. A homeowner's decision about whether or not to refinance a loan may also depend on the loan size involved. To the extent certain costs of refinancings are fixed rather than proportional to the loan size, larger loans may be refinanced more readily. Thus we include a variable measuring the size of the monthly payment (SIZE), with the expectation that it should be positively correlated with refinancings, other factors equal.

Table 1 summarizes the explanatory variables used in the estimation, with separate means shown depending on whether or not the loan was refinanced.

5. STATISTICAL RESULTS

Table 2 shows the partial maximum likelihood estimates of the parameter vector β. The Wald chi-square statistics presented at the bottom of the table reject the null hypothesis that $H_0{:}\beta=0$. The first column in the table presents the coefficient estimates for the entire panel. We find that the coefficient on PVALUE is positive and significant, as predicted. VOLATILITY has a significant negative effect on the refinancing decision, consistent with the hypothesized effect of interest rate uncertainty on the option replacement cost. Also as expected, POINTS have a significant negative effect. The negative and significant coefficient on LTV confirms that equity-constrained borrowers are less likely to refinance. Similarly, a high WRSTEVER score reduces the refinancing probability, although this effect is quantitatively less pronounced than that of LTV. The small effect of credit quality may reflect measurement problems with the worst-ever credit snapshot; if available, a continuously evolving credit measures might produce a stronger estimated effect on refinancing.[13] Finally, the size of the monthly payment (SIZE) has the predicted sign and is statistically significant, suggesting that the size of the loan may provide some incentive to refinance beyond that reflected in PVALUE and that there may be important fixed costs associated with refinancing.

Credit and Collateral Subgroups

Since earlier research has found that credit and collateral variables can interact with the other explanatory variables, we estimated the model separately for different credit and collateral subgroups. The findings, shown in Table 2, Columns 2 through 5, are again consistent with the notion that credit and equity affect refinancing probability, but a channel of effect is clarified: The estimated sensitivity of refinancing probability to PVALUE is appreciably lower for credit- and equity-constrained borrowers. This is consistent with the separate findings of interaction effects between refinancing incentives and home equity (Caplin, Freeman, and Tracy (1997)) and between refinancing incentives and credit ratings (Peristiani *et al* (1997)).

The impact of a poor credit rating can be illustrated by estimating the survival function of loans, that is, the cumulative likelihood of a loan "surviving" (i.e., not being refinanced) over time, for borrowers in different WRSTEVER categories. In the partial likelihood framework, the survival function can be estimated from

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[13] For example, the delinquency may have occurred some time ago, been on a less significant credit line (for instance, a store card rather than a mortgage), or the borrower may have been able to provide a reasonable explanation for the delinquency. Also, Peristiani et al (1997) report evidence that an improvement in credit history (worst now better than worst ever) increases refinancing probabilities, but not enough to completely erase the effect of a poor worst-ever score.

$$S(\tau,x_{ti\bullet}) = (S_0(\tau))^{\exp(x_{ti\bullet}\beta)}. \tag{7}$$

The variable $S_0(\tau)$ represents the baseline survival function. An estimate of the baseline function is obtained using a nonparametric maximum likelihood method. Figure 4 presents survival functions for two WRSTEVER categories, good credits (WRSTEVER=1; the bottom line) and poor credits (WRSTEVER=400; the top line). These estimated survival functions indicate that--under the market conditions faced by the borrowers in our sample--nearly 13 percent of the good credits had refinanced after 100 months (eight years and 4 months) versus just about 3 percent of the poor credits.[14] This underlines the need to properly control for these factors, which enter the equations in nonlinear ways, in comparing refinancing propensities over time.

Comparing Refinancing Propensities in the 1980s and 1990s

To explore the possibility that refinancing behavior has changed, we divided the sample between mortgagors that purchased their homes during 1984-90 and those who purchased during 1991-94. Because the sample includes just one credit snapshot (1995Q2), we were hesitant to assign that credit information to refinancing behavior over the period of a decade. Nevertheless, based on the Table 2 results, credit is demonstrably important and should not be ignored in intertemporal comparisons. Therefore, in this sample splitting exercise we controlled for credit rating by limiting our sample to good credits (WRSTEVER=1). By taking this approach, we arguably reduce the generality of our results somewhat, since an increase in the incidence of weak credit ratings in the 1990s would be at least a partial offset to any increased propensity to

[14] It is important to remember that refinancing probabilities are considerably smaller than overall prepayment probabilities, which include sales and defaults. Thus, the survival rates in this sample (which excludes sales and defaults) will appear correspondingly higher.

refinance among good credits. On the other hand, limiting the sample to good credits makes ours a purer test of the hypothesis that structural changes have increased refinancing probabilities.

The proportional hazard model, excluding the credit rating variable, is estimated for the two subsamples to test the null hypothesis H_0: $\beta_{84-90}=\beta_{91-94}$, where the subscripts identify the date range of home purchases in the respective subsamples. The coefficient estimates for β_{91-94} are shown in column 3 of Table 3. Estimating the model for borrowers that took out a loan during 1984-90 is not completely straightforward because in this case the sample "spills over" into the 1990s (that is, purchasers in the 1980s are still at risk of refinancing their purchased mortgages in the latter decade). To address this potential problem, the proportional hazard coefficients presented in the column 1 of Table 3 represent early period purchases (1984-90) but with the data truncated after 1990 -- focusing the estimation more closely on refinancing behavior during 1984-90. For comparison, column 2 shows the coefficient estimates for borrowers in 1984-90, but continuing the sample into the 1990s.

The differences in the estimated coefficients for the subperiods are striking. Households that purchased during 1991-94 (column 3) are much more responsive to the intrinsic value of refinancing (PVALUE). At the same time, the estimated coefficient of POINTS has the predicted sign and is highly statistically significant in both subperiods. The coefficient on VOLATILITY is not statistically significant in the earlier subperiod while it is highly significant with predicted sign in the latter period. The coefficient on LTV does not have the predicted sign in the earlier period, perhaps because home prices were generally rising quite rapidly over that period.

The difference in sensitivity to PVALUE in the two subperiods is quite surprising given that, on average, the values of PVALUE that mortgagors were exposed to over the two subperiods were roughly comparable.[15] This is quite strong support for our hypothesis of a structural change and is consistent with the anecdotal conclusion that the interest rate differential needed to induce a mortgagor to refinance has declined. Also supportive of this hypothesis is the fact that the size of the coefficient on the variable SIZE declines very sharply in the latter period, consistent with the idea that fixed-cost transaction frictions which have declined over time. In short, the results are quite consistent with the idea that lower transactions costs (measurable and otherwise), and perhaps increased sophistication of borrowers, have increased the propensity to refinance. As the Wald test shows (bottom of Table 3), borrowers in the 1990s continue to exhibit a much greater willingness to refinance.

Figure 5 contrasts the mortgage loan survival experience of the 1990s with that of the 1980s. For the 1980s we simulate the survival function two ways. The top curve represents 1984 to 1990 parameter values (column 1 of Table 3) with values of the explanatory variables for the same period.[16] The middle curve represents 1984-90 parameter values but with values for the explanatory variables from the 1991-94 period. The distance between the top and middle survival functions reflects the effects of the differing exogenous variables (including, importantly, about a 50 basis point difference in average points and fees) between the two periods.[17]

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[15]In fact, mortgage holders enjoyed more favorable interest rate spreads during 1984-1990. The average interest spread during the period 1991-94 was around 60 basis points compared to 125 basis points during 1984-90.

[16] The survival function for the untruncated 1980s sample (column 2 of Table 3) is very similar.

[17]The average coupon rate spread $(r_{mti}-r_{ci})$ in the period 1984-90 was about 150 basis points. By contrast, the mean coupon spread during 1991-94 was roughly 60 basis points, hence not contributing to higher refinancing rates in the 1990s subperiod.

The bottom survival curve represents 1991-94 parameter estimates and 1991-94 values of the explanatory variables. Hence the middle and bottom survival curves compare individuals exposed to the same explanatory variables, but with different responses to those conditions as represented by the differences in the estimated coefficients. The distance between these two curves represents the difference in refinancing behavior that can be attributed to structural change in the mortgage market, above and beyond the changes in measurable transaction frictions such as points and fees. For example, after four years in the 1990's, nearly 14 percent of the purchase mortgages loans had been refinanced. In contrast, under 1980s behavioral response, cumulative refinancings over the first four years would have totaled only 9 percent.

6. DISCUSSION AND CONCLUSIONS

We developed an empirical model to test whether structural changes in the U.S. mortgage market have affected mortgagors' refinancing behavior. We hypothesized that the intrinsic benefit required to trigger a refinancing has become smaller, due to a combination of technological, regulatory, and structural changes that have made mortgage origination more competitive and more efficient. To test this hypothesis, we estimated an empirical hazard model of loan survival for two time subperiods, using a database that allowed us to carefully control for homeowners' credit ratings, equity, loan size, and measurable transaction costs. Overall, we are confident that our hypothesis has been tested on the basis of a reasonably comprehensive model of individual and market determinants of refinancings.

Our findings strongly confirm earlier findings that credit ratings and home equity have significant effects on refinancing probability. In addition, we provide evidence that homeowners postpone refinancing in the face of increased interest rate volatility, consistent with option value theory. Finally, our results clearly support the hypothesis that structural change in the mortgage market has increased homeowners' propensity to refinancing. This conclusion emerges from two findings. One is that measurable transaction costs, such as points and fees and other fixed costs, are quite important in the refinancing decision and that those costs have declined significantly in the 1990s relative to 1980s--a development we attribute to increased efficiency and competition in mortgage origination. Secondly, even after controlling for points and fees, loan size, and other important variables, refinancing probabilities were considerably higher in the latter period. This we attribute to declines in nonmeasurable frictions, which likely takes the form of aggressive solicitations of refinancings by lenders, which have the effect of disseminating information faster and more broadly, as well as increased financial sophistication among homeowners.

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TABLE 1
SUMMARY STATISTICS

Explanatory Variable	Description	Mean: Refinancing	Mean: No Refinancing
WRSTEVER	Worst delinquency ever (1 = good credit, 30, 60, 90, 120, 150, 180, 400=default)	64.79	99.71
PVALUE	Present value ratio as defined by equation (9) (percent)	117	111
LTV	Current loan-to-value (percent).	54.94	66.49
VOLATILITY	Implied volatility on options on the 10-year treasury note futures (basis points).	6.63	7.06
POINTS	Initial fees and point changes on conventional home mortgages. National average for all major lenders (percent).	1.99	2.03
AGE	Age of loan (measured in months).	48.17	53.59
SIZE	Logarithm of original loan balance (balance measured in thousands of dollars).	11.65	11.39
Number of monthly observations		4226	497243

TABLE 2
FACTORS INFLUENCING THE DECISION TO REFINANCE: PROPORTIONAL HAZARD MODEL

Explanatory Variable	All Borrowers	Good Credit (WRSTEVER=1)		Poor Credit (WRSTEVER=400)	
		LTV≤80	LTV>80	LTV≤80	LTV>80
DUM-NY	0.688***	0.966***	0.511***	0.747***	0.112
	(157.97)	(130.41)	(7.85)	(12.49)	(0.12)
DUM-IL	-0.947***	-0.435***	0.258	-1.81***	-1.862***
	(194.96)	(21.52)	(1.23)	(56.97)	(12.67)
DUM-FL	0.959***	1.076***	1.307***	1.175***	1.003***
	(292.70)	(152.97)	(45.10)	(37.55)	(8.05)
WRSTEVER	-0.001***				
	(65.39)				
PVALUE	1.210***	1.403***	1.463***	-2.388***	-1.957**
	(40.07)	(22.70)	(6.84)	(13.18)	(4.32)
VOLATILITY	-0.454***	-0.455***	-0.532***	-0.317***	-0.651***
	(371.26)	(161.53)	(75.50)	(13.53)	(35.65)
LTV	-0.019***	-0.021***	0.010*	-0.037***	0.015
	(763.55)	(327.45)	(2.65)	(163.16)	(2.00)
POINTS	-5.350***	-5.836***	-3.915***	-4.91***	-3.166***
	(2462)	(1261)	(165.25)	(179.49)	(37.61)
SIZE	0.326***	0.271***	0.740***	0.146	0.788***
	(130.66)	(43.27)	(71.07)	(2.01)	(20.30)
Wald chi-square	6284.80	2987.14	379.55	730.45	155.43
Censored obs.	497243	166484	83552	54369	50339
Refinancing obs.	4226	1864	637	332	205

NOTES: The symbols (***), (**), and (*) indicate statistical significance at the 1-, 5-, and 10-percent level, respectively. Table 1 describes in more detail the explanatory variables.

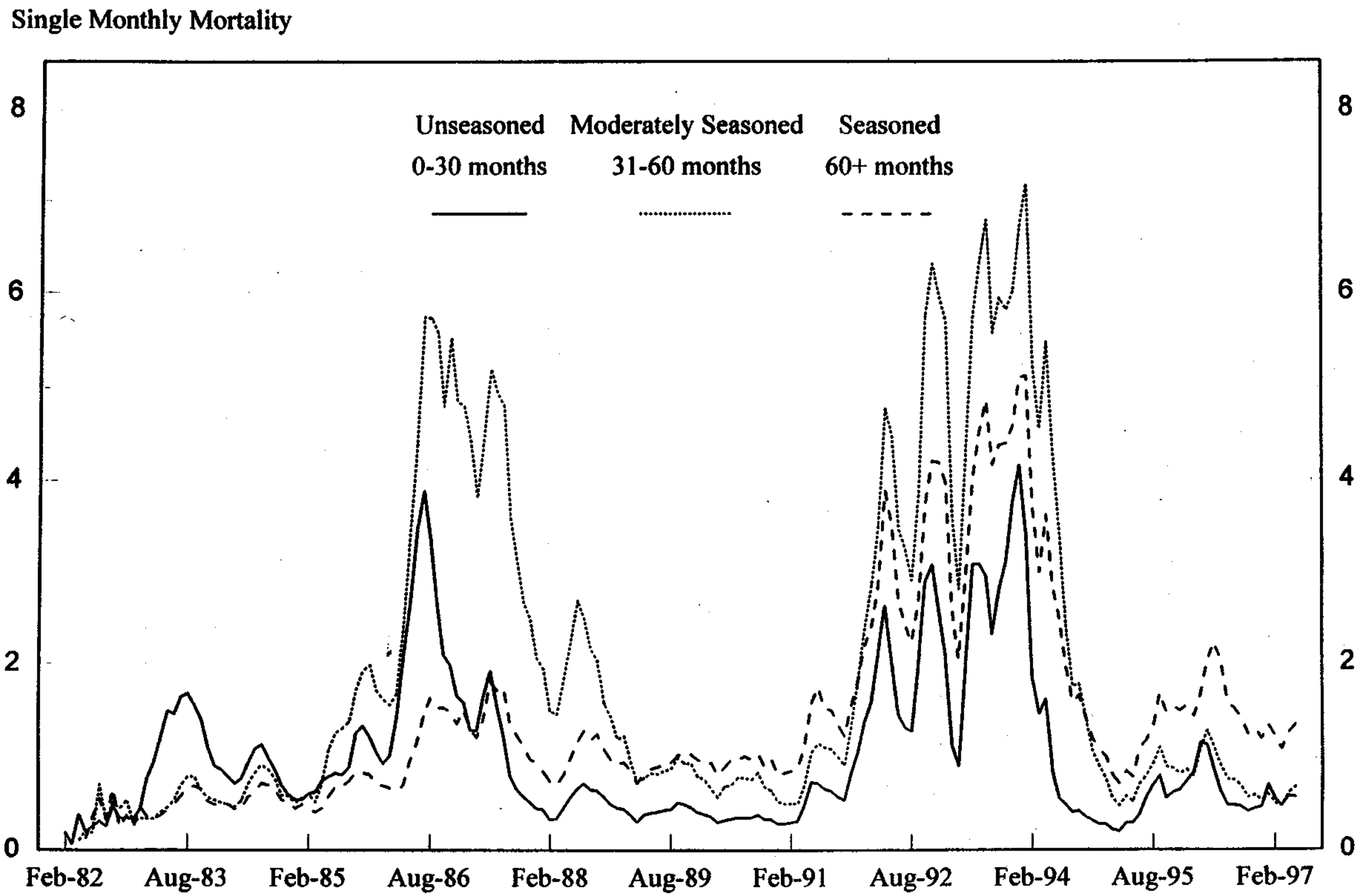
TABLE 3
THE WILLINGNESS TO REFINANCE DURING THE 1980s AND 1990s
(Numbers in parentheses represent Wald chi-square statistics).

Variable	Purchases in 1984 -1990: 1984-1990[a]	Purchases in 1984 -1990: 1984-1994[b]	Purchases in 1991-1994
DUM-NY	-17.91 (0.00)	1.448*** (261.38)	-0.849*** (47.12)
DUM-IL	-2.129*** (56.06)	-0.777*** (51.17)	0.060 (0.18)
DUM-FL	-0.436** (5.02)	1.388*** (252.50)	-0.441*** (10.05)
PVALUE	-1.79* (2.34)	0.832*** (6.86)	3.76*** (44.23)
LTV	0.033*** (41.88)	-0.008*** (43.38)	-0.031*** (544.91)
VOLATILITY	0.087 (1.23)	-0.391*** (101.29)	-0.623*** (141.43)
POINTS	-3.430*** (48.87)	-3.89*** (405.78)	-5.118*** (305.05)
SIZE	0.536*** (24.03)	0.413*** (76.81)	0.052*** (0.75)
χ^2 test H_0:β=0	235.80***	1686.68***	1317.95***
χ^2 test H_0:β_{91-94}=β_{84-90}	297.85***	319.74***	
Refinancing obs.	277	1486	1015
Censored obs.	97520	160095	89941

[a]Sample of homeowners is truncated after 1990.
[b]Proportional hazard estimates for the complete spell (e.g., last observation of panel ends in December 1994 or at the month of refinancing, which ever comes first).

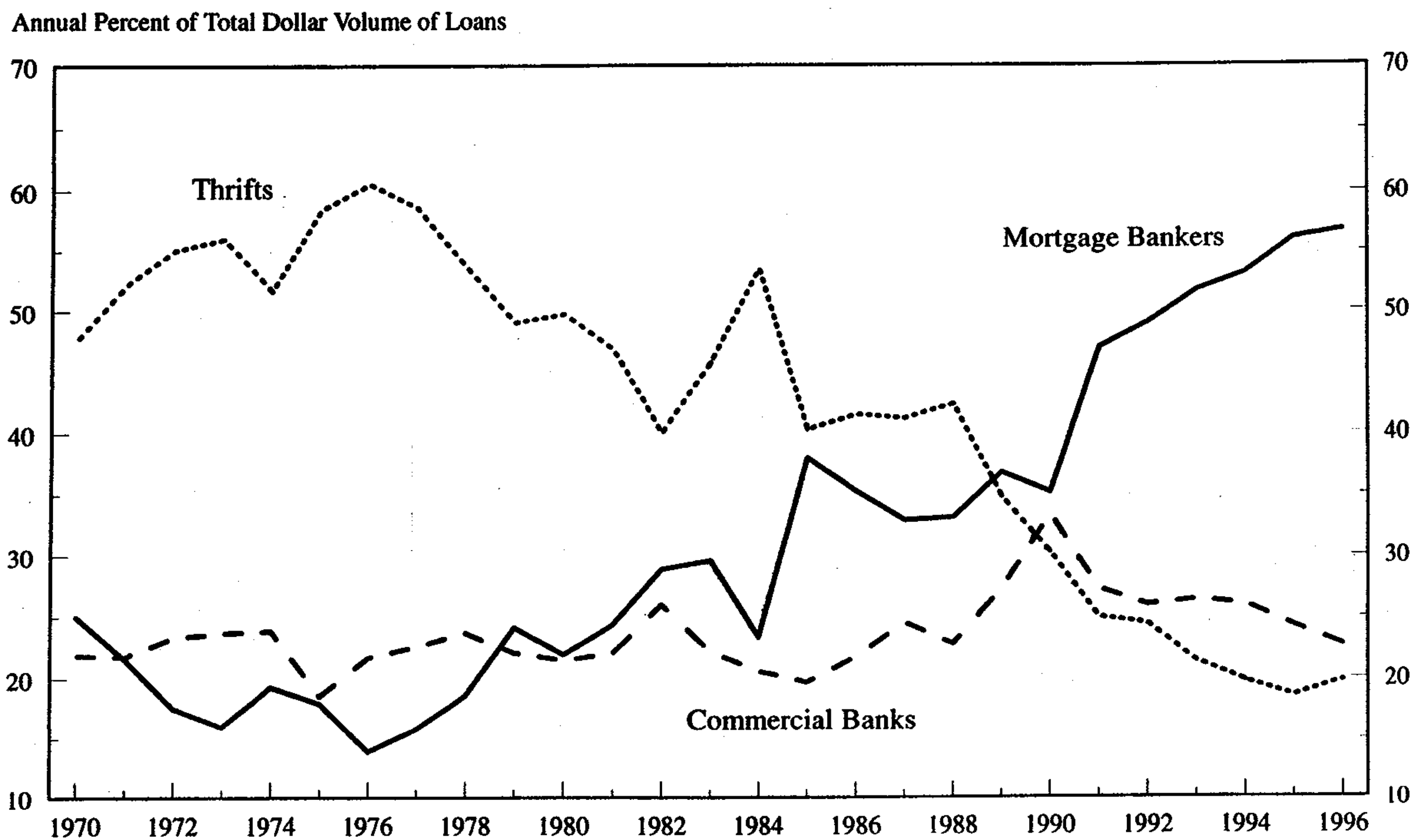
NOTES: The symbols (***), (**), and (*) indicate statistical significance at the 1-, 5-, and 10-percent level, respectively. Table 1 describes in more detail the explanatory variables. χ^2 values are Wald statistics.

Figure 1: Prepayment Speeds on FNMA MBS Backed by 30-year Fixed Rate Mortgages



Source: Global Advanced Technology Corporation

Figure 2: Primary Mortgage Market: Market Shares by Type of Lender
(Percent of 1-4 Family Originations)



Source: U.S. Department of Housing and Urban Development, *Survey of Mortgage Lending Activity*

Figure 3: Initial Fees and Charges on Conventional Loans Closed

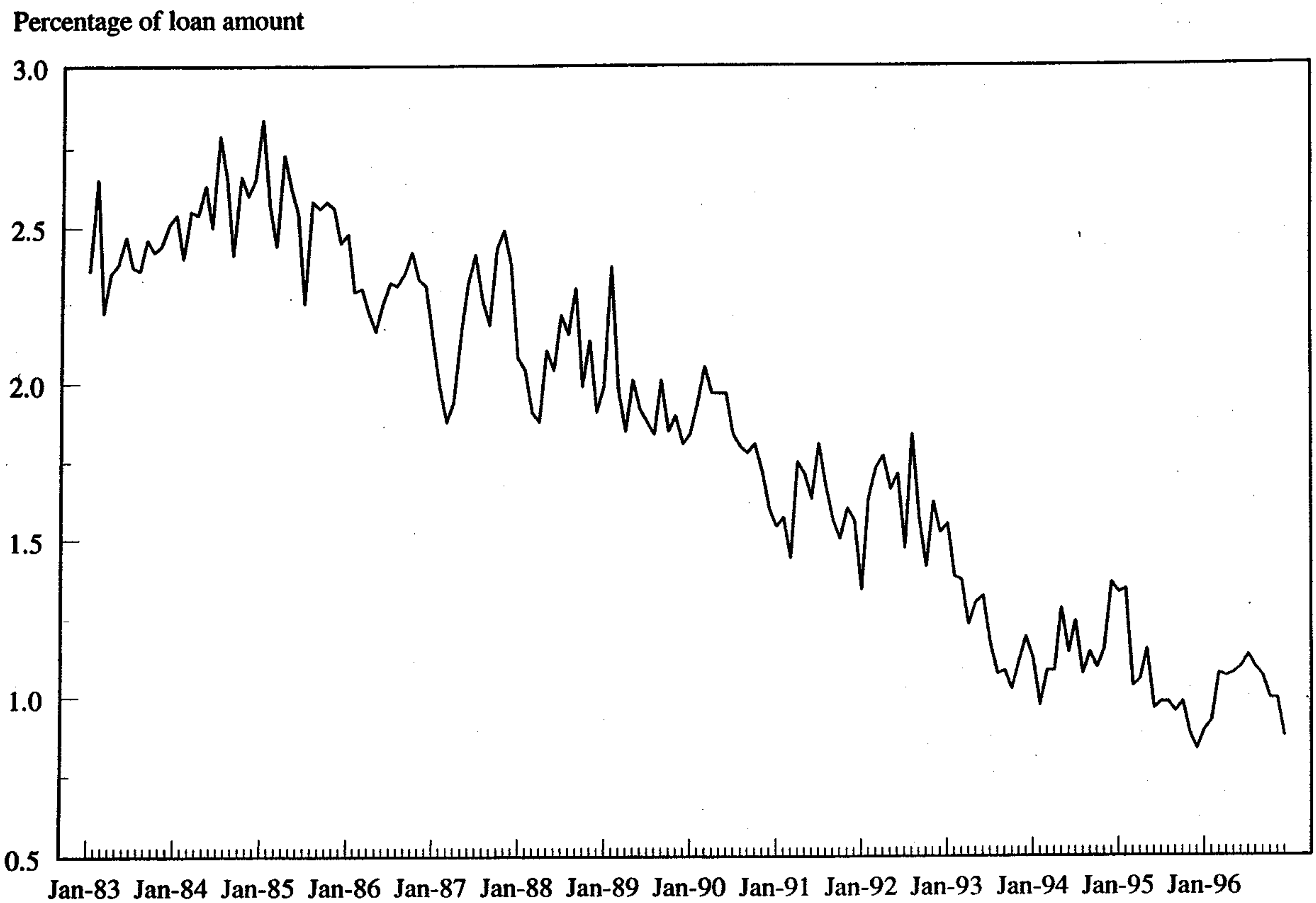


Figure 4. Survival Function by Credit Level

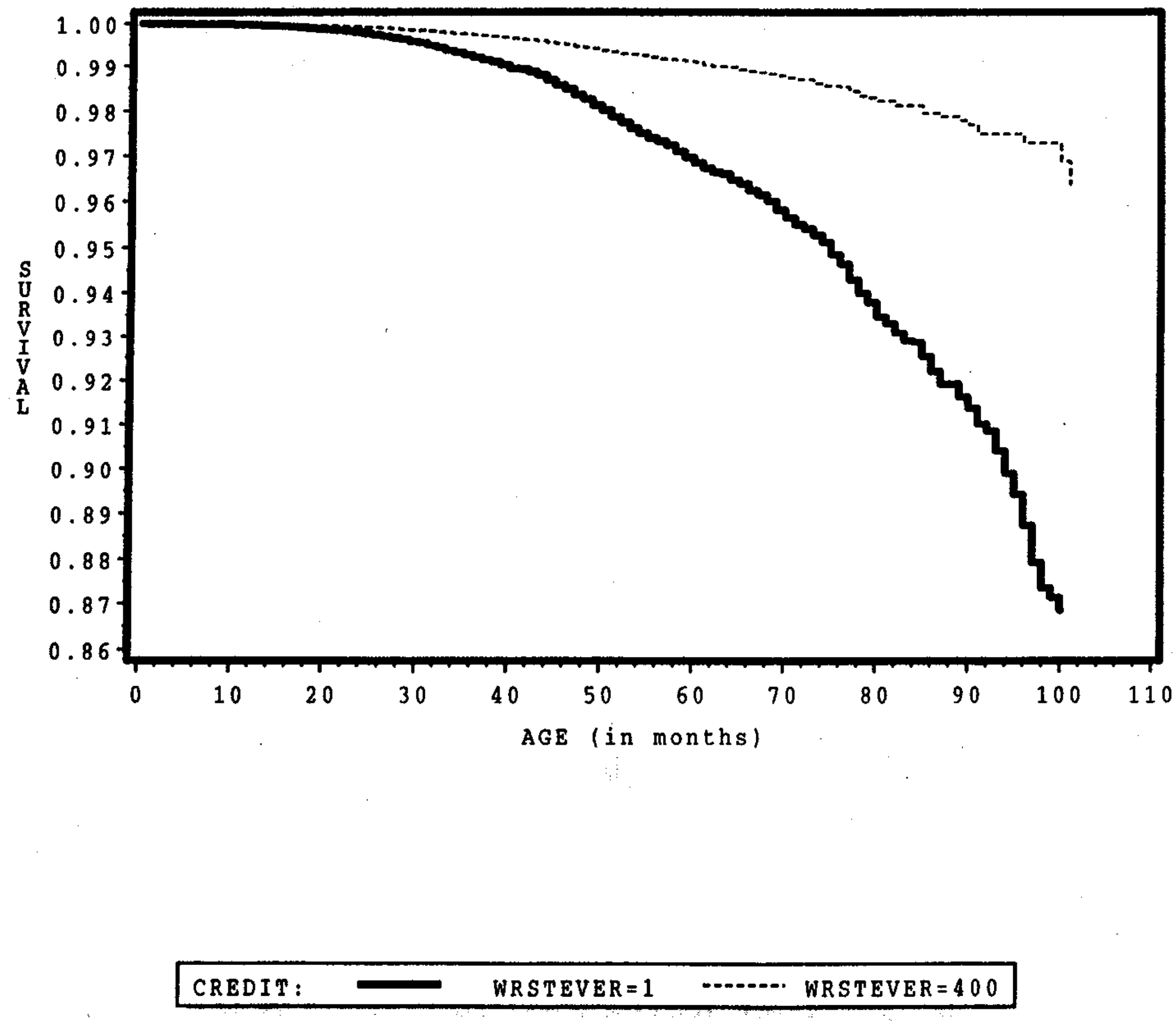
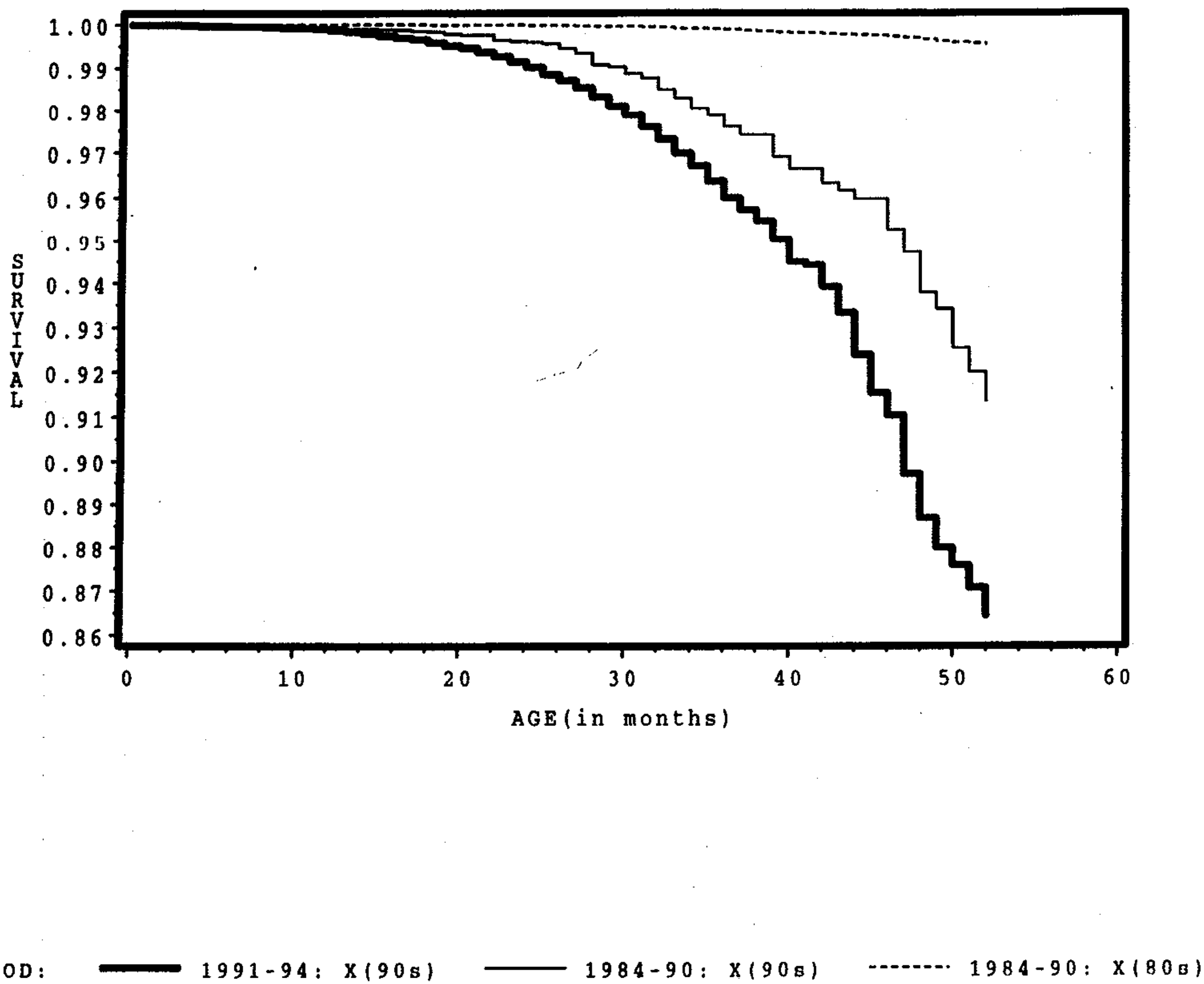


Figure 5. Survival Function Before and After 1990



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