

Credit Spreads: Evidence from the Mortgage Market

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Abstract

Using micro-level data from the mortgage market, we examine yield spreads as a function of both credit risk and prepayment risk using a two-stage instrumental variable approach. Our results are consistent with findings in the finance literature that leverage-induced financial risk reflected in capital structure results in higher yield spreads on debt. In particular, borrowers with loan-to-value ratios less than 80 percent have credit spreads 14, 21, and 22 basis points lower than borrowers with LTV ratios between 80 and 85 percent, between 86 and 90 percent, and greater than 90 percent, respectively. We also find evidence that securitization reduces credit spreads by between 5-10%.

Keywords: credit spreads, leverage, mortgage, and securitization

Introduction

A variety of developments have increased the interest in credit risk measurement over recent years. In the global financial market, these include a worldwide trend upward in the number of bankruptcies, increased disintermediation by the highest quality borrowers, increased competitive pressure driving down margins on loans, declines in collateral values in many markets, and an increase in the use of credit risk derivatives (Altman and Saunders [1998]). In the U.S. capital markets, securitized mortgage debt is now the largest component of the fixed income market, with a total value as of the second Quarter 2001 of \$3.7 trillion, now greater than both the treasury bond market total of \$2.8 trillion and the corporate bond market value of \$3.5 trillion (Source: Bond Market Association web site).

Many of the same trends are evident in the U.S. mortgage market as in the broader global financial markets. For example, a long-term secular trend upward in default and foreclosures has been documented (Elmer and Seelig [1998]). Moreover, during the 1990s lenders increasingly ventured into below-investment grade, or sub-prime, lending, just as the high yield or “junk-bond” industry developed during the 1980s. Similarly, disintermediation away from portfolio lenders is evident with more than half of the \$5.6 trillion residential mortgage market is now securitized, though some of this trend may result from risk-based capital rules. In contrast to the corporate market where firms can directly place debt in the capital markets, lenders remain involved to service loans even when credit risk is borne by the government-sponsored enterprises (GSEs), Fannie Mae and Freddie Mac. The GSEs, while private shareholder owned

corporations, enjoy certain benefits as a result of their congressional charters, including a funding advantage generally thought attributable to an implicit federal guaranty of their obligations.

In this paper, we develop an *ex-ante* model of mortgage spreads that controls for the credit risk of the borrower. The model features a variety of borrower and loan risk characteristics including credit score, borrower age and income, loan-to-value ratio, and debt burden. We also control for differential liquidity, i.e. whether the loan was sold into the secondary mortgage market either as an agency or private label mortgage-backed security, or retained in portfolio by the originating lender.

Credit Risk and Mortgage Spreads

Like corporate bonds, yields on residential mortgages can be measured as a spread to the risk free rate, as a proxy, to the comparable maturity Treasury. Comparable maturity for mortgages is not easy to define, however, given the prepayment option embedded in most residential mortgage contracts. Conceptually, the yield spread on residential mortgages should reflect credit, prepayment, and liquidity risk premiums. In the corporate case, a large body of literature emphasizes that credit risk is related to firm capital structure. For the individual household, loan-to-value ratio is the analog to the capital structure of the firm, reflecting the degree of borrower leverage. While not a perfect analog, since households may have other assets and liabilities not tied to home equity, it is generally recognized that for most households the home is the largest single asset and mortgage debt its largest liability. Accordingly, the mortgage market may provide useful insights into the factors affecting yield spreads.

The GSEs play a major role in the mortgage and capital markets and, as a consequence, may impact the spread on residential mortgages. While they do not make mortgage loans to households directly, they purchase loans originated by financial institutions and then re-package loans into mortgage passthroughs and collateralized mortgage obligations (CMOs) securities that are enhanced by the GSE guaranty of timely payment of principal and interest. Liquidity is provided, allowing financial institutions to sell long-term typically fixed rate assets to the GSEs for cash or exchange them for more liquid mortgage-backed securities from which the credit risk has been removed. Financial institutions, of course, are free to either sell the mortgage loans to the GSEs or keep them in portfolio after origination. In practice, portfolio lenders typically focus on variable rate contract types to limit their interest rate risk.

GSE activity in particular, and securitization in general, is thought to cause downward pressure on yields by expanding the sources of funds available to lend (Phillips [1996]). But the extent to which the GSEs reduce mortgage rates is controversial (see e.g. Hendershott and Shilling [1989], Ambrose and Warga [1995], Cotterman and Pierce [1996], and Ambrose, Buttimer, and Thibodeau [2001]). Policymakers continue to debate the appropriate status of the GSEs in the market. Some of our findings here may be relevant to this controversy; in particular, our finding that securitization reduces credit spreads.

A large literature examines the magnitude and determinants of credit spreads and loan performance in a variety of markets. Research has examined the performance of corporate bonds (e.g. Altman [1989]) and high yield debt (e.g. Asquith, Mullins, and Wolf [1989] and Altman [1993]). In the mortgage market, early empirical research

includes Von Furstenberg [1974], Cambell and Dietrich [1983], and Cunningham and Capone [1990]. Quercia and Stegman [1992] and Vandell [1993] provide surveys focusing on default, while Kau, Keenan, and Kim [1994] develop theoretical predictions for mortgage default, given stochastic collateral values. In a related line of research, Angbazo, Mei and Saunders [1998] examine credit spreads for highly leveraged loans. Most recently, Deng, Quigley, and Van Order [2000] develop a competing risk model of mortgage termination accounting for unobserved borrower heterogeneity.

The determinants of firm failure have also been explored (see, for example, Ma, Rao and Peterson [1989]) and the wave of S&L and bank failures in the late 1980s and early 1990s prompted research focusing on the financial sector (e.g. Henebry [1996]). The general view has been that the credit spreads paid on the firm's debt reflect underlying financial risk that, in turn, depends importantly on firm capital structure. Recent research has focused on optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads (e.g. Leland and Toft [1998], Madan and Unal [2000]).

In terms of yield spreads and residential mortgage markets, Rothberg, Nothaft, and Gabriel [1989] focused on yield spreads on GNMA and Freddie Mac pass-through securities, using aggregated data from the secondary mortgage markets. They found that prepayment-related risk factors, including interest-rate volatility and term structure, were the primary determinants of changes in spreads. They also found a liquidity premium for GNMA securities. Our work is related to this important early work, however, thanks to loan level data set that includes individual risk characteristics and contract terms we are able to isolate the various components of the mortgage yield spread and focus, in particular, on credit risk.

Default and Prepayment Options in Mortgages

The general approach to mortgage pricing is now well established. Mortgages are contingent claims contracts in which the mortgage value (V^M) depends critically on two stochastic processes, the market interest rate, $r(t)$, and the house value, $H(t)$. For instance, we may specify the interest rate process with a CIR diffusion process:

$$d(r) = \mathbf{g}(\Theta - r)dt + \mathbf{s}_r \sqrt{r} dz_r \quad (1.)$$

where Θ is the steady state mean rate, \mathbf{g} is the speed of adjustment factor, \mathbf{s}_r is the volatility of interest rates.¹ Diffusion in collateral value affects mortgage value, too, so we may specify the evolution of house values, $H(t)$, by

$$\frac{dH}{H} = (\mathbf{a} - s)dt + \mathbf{s}_H dz_H \quad (2.)$$

where \mathbf{a} is the instantaneous total return to housing, s is the service flow, and \mathbf{s}_H is the volatility of housing returns. In (1) and (2), dz_r and dz_H are standard Wiener processes.

Kau et al (1995) show that under appropriate assumptions, the value of the mortgage (V^M) will satisfy the following partial differential equation (PDE):

¹ Equation (1) is the standard Cox, Ingersoll, and Ross [1985] interest rate model.

$$\begin{aligned}
& \frac{1}{2} H^2 \mathbf{s}_H^2 \frac{\mathbb{1}^2 V^M}{\mathbb{1} H^2} + r H \sqrt{r} \mathbf{s}_H \mathbf{s}_r \frac{\mathbb{1}^2 V^M}{\mathbb{1} H \mathbb{1} r} + \frac{1}{2} r \mathbf{s}_r^2 \frac{\mathbb{1}^2 V^M}{\mathbb{1} r^2} \\
& + \mathbf{g}(\mathbf{q} - r) \frac{\mathbb{1} V^M}{\mathbb{1} r} + (r - s) H \frac{\mathbb{1} V^M}{\mathbb{1} H} + \frac{\mathbb{1} V^M}{\mathbb{1} t} - r V^M = 0
\end{aligned} \tag{3.}$$

In (3.) the correlation between the movements of the two state variables (dz_H and dz_r) is \mathbf{r} .

Specifying the boundary conditions allows the valuation of the mortgage when the economic variables take on extreme values. With these boundary conditions, (3) can be solved to find the value of the mortgage contract.

We denote the present value of the remaining mortgage payments as $A(r(t), t)$. Since house prices and interest rates interact in determining the value of the right to terminate the mortgage, $J(r(t), H(t), t)$, the mortgage value is given as

$$V^M(r(t), H(t), t) = A(r(t), t) - J(r(t), H(t), t). \tag{4.}$$

The right to terminate the mortgage is composed of the right to prepay the mortgage, $C(r(t), H(t), t)$ and the right to default, $D(r(t), H(t), t)$.² Standard comparative statics show that $\partial V^M / \partial \mathbf{s}_H < 0$, $\partial V^M / \partial \mathbf{s}_r < 0$ and $\partial V^M / \partial H > 0$.³ Assuming that V^M represents the mortgage value at origination (net of any discount points), then the mortgage yield (y^M) is

² Kau, Keenan and Kim (1993, 1994) show that the option pricing technique can be utilized to determine the probability of default.

³ See Kau et al (1992) for a complete discussion of the comparative statics on fixed-rate mortgage contracts.

simply the internal rate of return that equates the expected mortgage payments (principal and interest) over the expected holding period to V^M .⁴

Following Merton (1974), we define the mortgage credit risk premium as the difference between the mortgage yield and the risk-free rate (y^M-r), where the Treasury bond rate normally serves as a proxy for the risk-free rate. Although Merton (1974) examined the relationship between the risk premium on discount debt issued by a firm, the comparative statics from the mortgage pricing model (4) and Merton's (1974) analysis of risky debt implies that the mortgage yield spread (y^M-r) is a function of the volatility of the underlying state variables (house values and interest rates) as well as the loan-to-value ratio at origination $\left(V^M(r(0), H(0), 0) / H(0) \right)$. Thus, consistent with Merton (1974) we have that

$$\frac{\partial S}{\partial s_H} > 0, \quad \frac{\partial S}{\partial s_r} > 0, \quad \text{and} \quad \frac{\partial S}{\partial \left(V^M(r(0), H(0), 0) / H(0) \right)} > 0$$

where $S = (y^M-r)$.

Following the pioneering work of Merton (1974), numerous articles have proposed models of credit spreads in the corporate bond market.⁵ For example, Bakshi, Madan and Zhang (2000) test for the presence of firm-specific distress factors in defaultable discount rate models. Their results confirm that firm-specific factors (such as leverage and book-to-market ratios) as well as market interest rates explain differences in

⁴ In the empirical analysis, we assume a 10-year expected holding period rather than the full 30-year mortgage term.

corporate bond yields. Based on these results, we follow Bakshi et al (2000) and Ericsson and Renault (2000) and propose the following generalized model of the mortgage spread (S):

$$\ln S_i = \mathbf{a}_0 + \mathbf{a}_1 \mathbf{s}_{H_i} + \mathbf{a}_2 \mathbf{s}_{r_i} + \mathbf{a}_3 \left(\frac{V_i^M}{H_i} \right) + \mathbf{1}X_i + \mathbf{d}_1 YR_i + \mathbf{d}_2 MON_i + \mathbf{e}_i \quad (5.)$$

where X_i represents a vector of borrower-specific and market factors that may impact credit spreads, YR_i is a dummy variable denoting the year of origination and MON_i is a dummy variable denoting the month of origination.⁶

Data

The data used for this research is more completely described in LaCour-Little (1999, 2001). Records consist of event histories on 1,234 conventional fixed rate mortgages originated between March 1994 and December 1997 by a national lender that prefers anonymity. Loans are tracked through June of 1999, so we have between 2.5 and 5.25 years of history, depending on origination year, including the refinance boom that occurred in late 1998. Both conforming and non-conforming loans are included, although super-jumbos (loans with initial balances in excess of \$650,000) are not. The data is a stratified sample, over-sampling terminations relative to loans remaining active⁷. Of the total sample, 472 (38.2%) had prepaid by the end of the observation period, 469

⁵ For example, see Duffee (1998, 1999), Bakshi, Madan and Zhang (2000), Ericsson and Renault (2000), Collin-Dufresne, Goldstein, and Martin (1999), and Duffie and Singleton (1999).

⁶ We include the yearly dummy variable to capture any variation in market credit conditions not specifically identified. We include the monthly dummy variable to capture any seasonal effects associated with mortgage origination.

⁷ Since default is a relatively rare event, 100% of defaults were used plus approximately equally sized random samples of prepayments and loans in which neither event occurred.

(38.0%) had defaulted, and the remaining 293 (23.7%) were still active (censored). Default is defined as the first instance of a 90-day delinquency, regardless of ultimate outcome⁸. Loans were originated throughout the United States. Table 1 reports the distribution of the loans by origination year.

We have relatively complete micro-level data for each loan in the sample. In addition to geography, loan amount, and note rate, we observe points paid at time of loan origination. We also observe major credit quality indicators, including loan-to-value ratio (*LTV*), total debt burden (*OBLRATIO*), and borrower credit score at time of origination (*FICO*). Borrower characteristics available include age (*BRWAGE*) and income (*INCOME*). Table 2 reports the descriptive statistics for the sample, segmented by origination year. Mean LTV is 80.9%, with about 50% having LTV ratios below 80%, 14% having LTV ratios between 80% and 90%, 29% having LTVs between 90% and 95%, and approximately 7% with LTV ratios greater than 95% (see Table 2). In general, credit quality appears to have increased year over year, with declining LTVs and increasing credit scores, although this pattern may be an artifact of the stratified sampling scheme⁹.

Based on the theoretical model of mortgage credit spreads outlined above, we expect that mortgage spreads are directly related to volatility of house prices, volatility of interest rates, and the loan-to-value ratio. In selecting the parameters for the empirical model, we use the OFHEO annualized state-level volatility parameters estimates as a proxy for the housing price volatility (s_H). We use the standard deviation in the 1-year Treasury bond rate over the 15 months prior to origination as a proxy for the expected

⁸ See Ambrose and Capone (1998) for research regarding differential outcomes given default.

volatility in the risk-free interest rate. To reduce default risk, lenders impose LTV restrictions. However, since LTV is such an important component of underwriting, it can be argued that LTV, mortgage amount, and contract rate are jointly determined. In order to control for this endogenous relationship, and because the borrower chooses the amount of equity they wish to invest in the property, we estimate LTV via an instrumental variables regression and utilize the predicted loan-to-value ($L\hat{T}V$) in the subsequent regression. We estimate the following regression via OLS:

$$LTV_i = \mathbf{b}_0 + \mathbf{b}_1 * INCOME_i + \mathbf{b}_2 * BRWAGE_i + \mathbf{b}_3 * FICO_i + \mathbf{e}_i \quad (6.)$$

where $INCOME_i$ is borrower i 's income at origination, $BRWAGE_i$ is borrower age i 's at origination, and $FICO_i$ is the borrower i 's credit score at origination. Use of borrower age and income together provides a rough proxy for total wealth, or permanent income.

In the second stage, we estimate (5) using the predicted LTV from the first stage regression. The dependent variable is defined as the log of the effective mortgage yield spread over treasury, including the effect of points calculated over a 10-year holding period. To control for autocorrelation in the market default risk premium, we estimate (5) via maximum likelihood as an AR(1) process.

In calculating the effective yield spread, we recognize that lenders require borrowers with high LTV s purchase mortgage insurance – effectively increasing the effective yield. To capture this effect, we increase the mortgage contract rate by 32 basis points for loans with LTV between 80 percent and 85 percent, 52 basis points for loans

⁹ Since default probability tends to increase slowly as loans age, the loans in newer loan cohorts may not

with *LTV* between 86 percent and 90 percent, and 78 basis points for loans with *LTVs* greater than 90 percent. This breakdown of mortgage insurance by *LTV* roughly corresponds to the average premiums charged by private mortgage insurance firms during the period covering the mortgage sample origination period.¹⁰

The vector of credit risk variables X_i in (5) include the borrower credit score (*FICO*), borrower debt ratio (*OBLRATIO*), and dummy variables to indicate whether the loan was originated as a conforming loan saleable to the GSEs (*AGENCY*) or as a loan saleable as a private label MBS (*PVTLABEL*). The excluded category represents loans originated for portfolio (*PORTFOLIO*). Since mortgage markets are integrated with the overall capital markets, we also include a measure of market default risk premiums as proxied by the yield difference between the ‘AAA’ bond index and the ‘Baa’ bond index (*CREDSPD*) as well as a proxy for the contemporaneous yield curve (*YLDCURVE*), proxied as the difference between the 10-year and 1-year Treasury bond rates. We categorize the predicted *LTV* into groups based on the breakdown of mortgage insurance premiums – predicted *LTV* between 80 and 85 percent (*LTV8085*), predicted *LTV* between 86 and 90 percent (*LTV8590*), and predicted *LTV* greater than 90 percent (*LTV90*) with predicted *LTVs* less than 80 percent being the reference category.

Results

Table 3 shows results from the first stage regression (equation [6]) of *LTV* on the instrumental variables: borrower income, borrower age and borrower credit quality (*FICO* score). All variables in the regression are negative and significantly different from

have reached peak default probability as of the end of the study period.

zero indicating that lower LTVs are associated with borrowers with higher incomes, age and FICO scores. The F statistic (136.41) indicates that the instrumental variable regression is significant.

Table 4 shows the results for equation [5], the generalized mortgage spread model. The results are consistent with our expectations about the relationship between credit spreads and loan and borrower characteristics. Credit spreads are positively related to LTV while credit spreads are negatively related to the borrower's credit score. Furthermore, credit spreads are positively related to house price and interest rate volatility.

As expected, we find that borrowers with higher LTV ratios have higher credit spreads. Although the coefficients on the LTV dummy variables are significantly different from zero, we cannot reject the null hypothesis that three coefficients are equal. However, the results indicate that borrowers with LTV ratios less than 80 percent have credit spreads 14, 21, and 22 basis points lower than borrowers with LTV ratios between 80 and 85 percent, between 86 and 90 percent, and greater than 90 percent, respectively.

Turning to the effect of borrower credit on mortgage credit spreads, we simulated credit spreads over a range of borrower credit scores for mortgages originated for sale to the agencies, as private label MBS, or to be held in portfolio. We simulated these spreads assuming a borrower originated a mortgage with an LTV less than 80 percent in June of 1997. The simulation indicates that borrowers with very high credit scores (FICO=825) can expect to have credit spreads that are approximately 23 basis points lower on average than borrowers with very low credit scores (FICO=476). The simulation also allows us to examine the relative impact of a change in borrower credit on credit spreads. For

¹⁰ See Colquhite and Slawson (1997).

example, holding all else constant, our regression indicates that a borrower with a credit score at the lower end of the range usually classified by most lenders as prime (FICO=700) has a mortgage credit spread that is 1.3 basis points lower than a borrower usually classified as A- by most lenders (FICO score of 680).

Consistent the results for the credit score variable, we find that, as predicted, mortgage credit spreads are positively related the borrower's debt obligation ratio. The estimated coefficients indicate that a 10 percent increase in a borrower's debt obligation ratio (holding all else constant) would result in a one basis point increase in the mortgage credit spread. Thus, our results confirm that all factors normally associated with identifying borrower credit risk – LTV ratio, credit score, debt-obligation ratio, house price volatility and interest rate volatility – are positively related to mortgage credit spreads.

The results in Table 4 confirm our expectations regarding the relationship between credit spreads and origination type. Credit spreads are negatively related to mortgages that were originated for sale as private label MBS as well as for sale to the agencies. Furthermore, we reject the hypothesis that the coefficients for agency and private label are equal. The coefficient values indicate that mortgages originated for sale to agencies have credit spreads that are approximately twice as small as mortgages originated for sale as a private label MBS. Holding all else constant, we find that mortgages originated for sale to the agencies have credit spreads approximately 18 basis points lower than mortgages originated for portfolio and approximately 8 basis points lower than mortgages originated for sale as private label MBS. This result indicates that, controlling for the risk of the borrower, the agencies serve to lower credit spreads (and

mortgage interest rates) compared to mortgages retained by a lender. This result provides empirical evidence that lending institutions do not keep their “superior” loans and sell their “inferior” loans (or lemons) to the agencies. Nor does this empirical evidence support the contention that the agencies, using superior information about borrowers, earn abnormal returns in terms of lending rates. Thus, we cannot support the adverse selection and agency arguments advanced by Passmore and Sparks ([1996], [2000]).

Consistent with the general upward trend in mortgage rates over the sample period, we find that mortgage spreads were significantly lower in 1994 than in 1997, after controlling for other factors. We also found evidence of demand-induced seasonal effects, with mortgage credit spreads widening out in May, June and September, consistent with the peak home buying period observed in the housing market.

Finally, turning to the general macro-economic variables, we find that mortgage credit spreads are positively associated with changes in the general default risk premium and negatively related to changes in the yield curve. The positive coefficient for the bond market credit spread (*CREDSPD*) indicates that a one basis point increase in the corporate bond market credit spread results in a 2.3 basis point increase in mortgage yield spreads (assuming an LTV ratio greater than 90 percent), while a one basis point increase in the yield curve translates into approximately a one basis point decline in the mortgage credit spread. Figure 1 depicts credit spreads over time for credit ratings roughly corresponding to prime and subprime levels (greater than 720 and less than 620 FICO, respectively). While the two series move together, the average credit spreads for the lower quality borrowers is clearly higher than for the higher quality borrowers, as would be expected. We note in Figure 1 a clear spike to greater than 300 basis points for the

lower quality borrowers during the fall of 1998, when global events caused a widening of credit risk spreads in general.

Conclusions

In this paper, we find that residential mortgage spreads are positively related to borrower capital structure (loan-to-value ratio) and negatively related to borrower credit rating. Results are generally consistent with the corporate finance literature that finds credit spreads to be related to firm capital structure and rating agency assignments. We also find that mortgages that are securitized, either for sale to the GSEs or in private label securities, have lower credit spreads, after controlling for borrower and loan level risk characteristics. In the next stage of this research we hope to further decompose the components the mortgage spread and examine *ex-post* loan performance.

References

- Altman, Edward I. And Anthony Saunders. 1998. Credit Risk Measurement: Developments Over the Last 20 Years. *Journal of Banking and Finance* 21: 1721-1742.
- Ambrose, Brent and Charles A. Capone. 1998. Modeling the Conditional Probability of Foreclosure in the Context of Single-Family Mortgage Default Resolutions, *Real Estate Economics* 26 (3): 391-430.
- Ambrose, Brent, Charles A. Capone, and Yongheng Deng. 2001. Optimal Put Exercise: An Empirical Examination of Conditions for Mortgage Foreclosure. *Journal of Real Estate Finance and Economics* 23 (2): 213-234.
- Ambrose, Brent and Arthur Warga. 1995. Pricing Effects in Fannie Mae Agency Bonds. *Journal of Real Estate Finance and Economics* 11: 235-249.
- Angbazo, L., J. Mei and Anthony Saunders. 1998. Credit Spreads in the Market for Highly Leveraged Transaction Loans, *Journal of Banking and Finance* 22, 1249-1282.
- Bakshi, G., D. Madan, and F. Zhang. 2000. What Drives Default Risk? Lessons from Empirically Evaluating Credit Risk Models, University of Maryland mimeo.
- Campbell, Tim. and J. Kimball Dietrich. 1983. The Determinants of Default on Conventional Residential Mortgages. *Journal of Finance* 48 (5): 1569-1581.
- Collin-Dufresne, P., R. Goldstein, and S. Martin. 1999. The Determinants of Credit Spread Changes, *Journal of Finance* .
- Colquitt, L. Lee and V. Carlos Slawson. 1997. Understanding the Cost of Private Mortgage Insurance. Louisiana State University, Dept of Finance, mimeo.
- Cotterman, Robert F. and James E. Pearce, The Effects of the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation on Conventional Fixed-Rate Mortgage Yields. in U.S. Department of Housing and Urban Development, *Studies on Privatizing Fannie Mae and Freddie Mac* (1996), pp. 97-168.
- Cunningham, D. and Charles Capone. 1990. The Relative Termination Experience of Adjustable to Fixed-Rate Mortgages. *Journal of Finance* 45(5): 1687-1703.
- Deng, Yongheng, John M. Quigley, and Robert Van Order 2000. Mortgage Terminations, Heterogeneity and the Exercise of Mortgage Options. *Econometrica* 68(2): 275-307.
- Duffie, G., 1998. The Relation Between Treasury Yields and Corporate Bond Yield Spreads, *Journal of Finance* 53: 2225-2242.

Duffie, G., 1999. Estimating the Price of Default Risk, *Review of Financial Studies*, 12(1): 197-226.

Duffie, D., and K. Singleton. 1999. Modeling Term Structures of Default Risky Bonds, *Review of Financial Studies* 12(4) 687-720.

Elmer, Peter, and Steve Seelig. 1998. The Long-Run Trend in Single-Family Default and Foreclosures. FDIC Working Paper.

Ericsson, J. and O. Renault. 2000. Liquidity and Credit Risk, McGill University mimeo.

Foster, Chester, and Robert Van Order. 1984. An Option-Based Model of Mortgage Default. *Housing Finance Review* 3(4): 351-372.

Green, Richard. K. and Michael LaCour-Little. 1999. Some Truths About Ostriches: Who Never Refinances Their Mortgage and Why They Don't. *Journal of Housing Economics* 8, 233-248.

Hendershott, Patric H. and James D. Shilling. 1989. The Impact of Agencies on Conventional Fixed-Rate Mortgage Yields. *Journal of Real Estate Finance and Economics* 2: 201-115.

Henebry, Kathleen L. Do Cash Flow Variables Improve the Predictive Accuracy of a Cox Proportional Hazards Model for Bank Failure? 1996. *Quarterly Review of Economics and Finance* 36 No. 3.

Jarrow, Robert, Lando and Turnbull. 1997. A Markov Model for the Term Structure of Credit Risk Spreads, *Review of Financial Studies* 10 (2), 481-523.

Kau, James B., Donald C. Keenan, Walter J. Mueller, and James Epperson. 1992. A Generalized Valuation Model for Fixed-Rate Residential Mortgages. *Journal of Money, Credit, and Banking* 24: 279-299.

Kau, James B., Donald C. Keenan, Walter J. Muller, III, and James F. Epperson. 1993. Option Theory and Floating-Rate Securities with a Comparison of Adjustable- and Fixed-Rate Mortgages. *Journal of Business* 66(4), 595-618.

Kau, James B., Donald C. Keenan, and Taewon Kim. 1994. Default Probabilities for Mortgages. *Journal of Urban Economics* 35: 278-296.

Leland, Hayne and Klaus Toft. 1998. Optimal Capital Structure, Endogenous Bankruptcy, and the Term Structure of Credit Spreads. *Journal of Finance* 51(3).

Ma, Christopher, Ramesh Rao and Peterson. 1989. The Resiliency of the High-yield Bond Market: The LTV Default, *Journal of Finance* 44(4), 1085-1097.

Madan, Dilip and Haluk Unal. 2000. A Two-Factor Hazard-Rate Model for Pricing Risky Debt and the Term Structure of Credit Spreads. *Journal of Financial and Quantitative Analysis*, March 2000.

Mattey, Joe and Nancy Wallace. 2001. Housing-Price Cycles and prepayment Rates of U.S. Mortgage Pools. *Journal of Real Estate Finance and Economics* 23(2): 161-184.

Merton, Robert C. 1974. On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Journal of Finance* 29(2): 449-470.

Passmore, Wayne and Roger Sparks. 1996. Putting the Squeeze on a Market for Lemons: Government-sponsored Mortgage Securitization. *Journal of Real Estate Finance and Economics* 13: 27-43

Passmore, Wayne and Roger Sparks. 2000. Automated Underwriting and the Profitability of Mortgage Securitization. *Real Estate Economics* 28(2): 285-306.

Phillips, Susan M. The Place of Securitization in the Financial System: Implications for Banking and Financial Policy. 1996. In Leon T. Kendall and Michael J. Fishman: *A Primer on Securitization*, Cambridge, MIT Press.

Rothberg, James P., Frank E. Nothaft, and Stuart A. Gabriel. 1989. On the Determinants of Yield Spreads Between Mortgage Pass-Through and Treasury Securities, *Journal of Real Estate Finance and Economics*, December 1989: 301-15.

Quercia, Roberto G. and Michael A. Stegman 1992. Residential Mortgage Default: A Review of the Literature. *Journal of Housing Research* 3(2): 341-376.

Vandell, Kerry. 1993. Handing Over the Keys: A Perspective on Mortgage Default Research. *AREUEA Journal* 21(3): 211-246.

Von Furstenberg, George., and R. J. Green. 1974. Home Mortgage Delinquency: A Cohort Analysis. *Journal of Finance* 29:1545-48.

Table 1
Distribution of Mortgage Loans by Origination Year

Year	Frequency	Percent
94	184	14.91
95	381	30.88
96	229	18.56
97	440	35.66
Total	1234	100.00

Table 2
Descriptive Statistics
(Standard deviations reported in parentheses)

Variable	Label	1994	1995	1996	1997
YLD_SPD	Effective yield – 10-yr Treasury Rate	0.681 (0.830)	1.832 (0.428)	1.632 (0.369)	1.558 (0.336)
YIELD	Effect yield (10 yr. Hold)	0.084 (0.008)	0.082 (0.006)	0.082 (0.005)	0.078 (0.004)
LTV	Average LTV	0.891 (0.115)	0.848 (0.156)	0.772 (0.153)	0.761 (0.155)
LTV80	LTV <= 80%	0.212 (0.410)	0.331 (0.471)	0.655 (0.476)	0.700 (0.459)
LTV8090	LTV > 80% and LTV <= 90%	0.092 (0.290)	0.131 (0.338)	0.162 (0.369)	0.152 (0.360)
LTV9095	LTV >90% and LTV <= 95%	0.668 (0.472)	0.436 (0.496)	0.114 (0.318)	0.089 (0.285)
LTV95	LTV > 95%	0.027 (0.163)	0.102 (0.304)	0.070 (0.255)	0.059 (0.236)
FICO1	Fair Isaac Credit Score	673.315 (65.522)	689.583 (65.582)	720.424 (64.803)	720.891 (65.375)
OBLRATIO	Debt Obligation Ratio	35.022 (8.995)	34.192 (9.462)	32.425 (12.297)	33.255 (11.522)
AGENCY	1=originated for sale to agency	0.223 (0.417)	0.493 (0.501)	0.712 (0.454)	0.693 (0.462)
PORTFOLIO	1=originated for retained portfolio	0.500 (0.501)	0.281 (0.450)	0.083 (0.276)	0.032 (0.176)
PVTLABEL	1=originated as private label mbs	0.277 (0.449)	0.226 (0.419)	0.205 (0.405)	0.275 (0.447)
BRWAGE	Borrower age	37.153 (11.421)	38.361 (11.000)	40.832 (11.844)	42.044 (11.546)
INCOME	Borrower income	43.991 (25.485)	54.159 (43.658)	74.915 (49.219)	84.216 (66.305)

Table 3
Instrumental Variables Regression of LTV

Variable	Label	Parameter			
		Estimate	Std. Error	t-statistic	P-value
Intercept	Intercept	1.4346	0.0423	33.9	<.0001
INCOME	Borrower income	-0.0004	0.0001	-5.0	<.0001
BRWAGE	Borrower age	-0.0049	0.0003	-13.9	<.0001
FICO	Credit Score	-0.0006	0.0001	-9.4	<.0001
Adjusted R ²		0.257			
F-statistic		136.41			<.0001

Table 4
Credit Spread Regression

$$\ln S_i = a_0 + a_1 s_{H_i} + a_2 s_{r_i} + a_3 \left(\frac{V_i^M}{H_i} \right) + 1X_i + d_1 YR_i + d_2 MON_i + e_i$$

Variable	Label	Parameter			
		Estimate	Std. Error	t-statistic	P-value
Intercept	Intercept	0.029	0.357	0.08	0.934
AGENCY	1=originated for sale to agency 1=originated for sale to private	-0.102	0.026	-3.87	0.000
PVTLABEL	label MBS	-0.056	0.026	-2.11	0.035
OBLRATIO	debt obligation ratio	0.001	0.001	1.89	0.059
LTV8085	LTV > 80 and LTV <= 85	0.072	0.021	3.51	0.001
LTV8590	LTV > 85 and LTV <=90	0.104	0.026	4.01	<.0001
LTV90	LTV > 90	0.110	0.033	3.37	0.001
CREDSPD	Credit Spread ('AAA – BAA')	1.094	0.529	2.07	0.039
FICO	Borrower FICO Score	-3.37E-4	1.54E4	-2.19	0.028
σ_H	House Price Volatility	3.576	1.227	2.91	0.004
σ_r	Interest Rate Volatility	0.316	0.124	2.54	0.011
YLDCURVE	Yield Curve Proxy ¹	-0.463	0.095	-4.89	<.0001
YR94	Origination Year = 1994	-0.290	0.167	-1.74	0.083
YR95	Origination Year = 1995	-0.001	0.078	-0.01	0.989
YR96	Origination Year = 1996	-0.004	0.080	-0.05	0.959
MON1	Origination Month = Jan.	0.134	0.200	0.67	0.502
MON2	Origination Month = Feb.	0.035	0.101	0.35	0.727
MON3	Origination Month = Mar.	-0.007	0.095	-0.08	0.938
MON4	Origination Month = Apr.	0.020	0.091	0.22	0.824
MON5	Origination Month = May.	0.154	0.082	1.88	0.060
MON6	Origination Month = Jun.	0.156	0.072	2.18	0.029
MON7	Origination Month = Jul.	0.104	0.069	1.50	0.133
MON8	Origination Month = Aug.	0.022	0.069	0.32	0.748
MON9	Origination Month = Sep.	0.132	0.065	2.03	0.043
MON10	Origination Month = Oct.	0.046	0.059	0.77	0.439
MON11	Origination Month = Nov.	0.035	0.051	0.69	0.490
AR(1)		-0.228	0.029	-7.96	<.0001
R ²		0.4221			
	Hypothesis Tests	DF	F-Stat.	p-value	
H ₀	AGENCY = PVTLABEL	1	5.46	0.0197	
H ₁	LTV8085=LTV8590=LTV90	2	1.06	0.3485	
H ₂	YR94=YR95=YR96	2	3.36	0.0352	
H ₃	MON1 = ... = MON11	10	2.59	0.0048	

¹ - Yield Curve = 10-year Treasury Rate less the 1-year Treasury Rate.

Figure 1
Average Yield Spreads for Subprime and Prime Borrower Groups

