THE JOURNAL OF REAL ESTATE RESEARCH

Efficient Mortgage Default Option Exercise: Evidence from Loss Severity†

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Abstract. **This paper extends options-based mortgage default theory to include transaction costs. When transaction costs are considered, the rational borrower will default only when the value of the collateral falls below the mortgage value by an amount equal to the net transaction costs. Since, for most borrowers, net transaction costs are positive, standard measures of equity may be significantly negative by the time the rational borrower exercises the default option. This research shows theoretically and empirically the effect of frictions on the individual strike price. The addition of transaction costs to the theory provides several testable implications for equity loss severity. First, the longer the foreclosure process and the period of free rent to the borrower, the lower the severity. Second, severity will be smaller when bankruptcy has been declared. Third, severity is decreasing in the contract rate. Fourth, severity is increasing in the market interest rate. Finally, severity is a decreasing function of the probability of a deficiency judgment. The empirical results, using servicing and foreclosure data from a large northeastern thrift, support the theoretical model.**

Introduction

This paper extends options-based mortgage default theory to include transaction costs. According to option theory, without frictions and without a value to future exercise, the borrower's put option is in the money and is exercised whenever the value of the collateral falls below the value of the mortgage. However, when transaction costs are considered, the rational borrower will default only when the value of the collateral falls below the mortgage value by an amount equal to the net transaction costs. These transaction costs include the costs of moving, brokerage fees, taxes, future deficiency payments, and the stigma associated with default; and are offset by free rents during delinquency. Since, for most borrowers, net transaction costs are positive, standard measures of equity may be significantly negative by the time the rational borrower exercises the default option. This research shows theoretically and empirically the effect of frictions on the individual strike price.

While the frictionless default option model provides significant structure to default analysis, its only implication for equity loss severity is that it is expected to be zero.[1] Under frictionless default, loss severity is not influenced by the origination loan-to-value ratio (LTV), the property's location, and many other variables that have been shown to alter its value. (See, for example, Clauretie, 1990; Quigley and Van Order, 1992; Lekkas, Quigley and Van Order, 1993.)

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The addition of transactions costs to the theory provides several testable implications for equity loss severity. First, the longer the foreclosure process and the period of free rent to the borrower, the lower the severity. Second, severity will be smaller when bankruptcy has been declared. Third, severity is decreasing in the contract rate. Fourth, severity is increasing in the market interest rate. Finally, severity is a decreasing function of the possibility of a deficiency judgment.

The paper proceeds as follows. Section two discusses related research. Section three presents two models of loss severity—the first is frictionless and the second includes transaction costs with the frictionless model as a special case. The data sources, analysis variables and sample exclusions are then discussed in section four. Then, empirical tests of the implications of the theory are presented in the fifth section. Finally, section six finishes with a discussion of the results.

Related Literature

Two strands of literature are important to this study. The first strand is concerned with state differential methods of foreclosure and transactions costs. The second is related to the put option structure of default modelling and the implications that derive from this structure.

Transaction Costs, State Laws and Severity

Clauretie (1987, 1990) and Clauretie and Herzog (1989, 1990) develop models to measure the effects of state laws on loan loss severity.[2] Absent bankruptcy, mortgage foreclosure is governed by state, not national laws. Roughly half the states require the lender to bring a judicial action to take title to the security. In these states, the court supervises a public auction of the property and the lender is typically the high bidder.

The primary alternative to judicial foreclosure is the power-of-sale foreclosure, available in nearly all the remaining states. The securing instrument in these cases is usually a deed of trust, a three-party instrument between a borrower, a lender and a third party, a trustee. The borrower conveys title to the trustee who has power of sale to satisfy the debt in case of default. Power-of-sale states tend to have shorter average foreclosure periods than judicial foreclosure states (Rosenblatt, 1994).

Phillips and Rosenblatt (1995) explore the effect on foreclosure of three major deviations from the typical foreclosure process: bankruptcy, preforeclosure sale, and deed in lieu of foreclosure. Under bankruptcy, a bankruptcy judge will supervise the foreclosure, superseding state foreclosure law. In preforeclosure, the home is sold to a third party, before foreclosure, and the proceeds are delivered to the lender. With deed in lieu of foreclosure, the deed is surrendered to the lender in lieu of a foreclosure sale.

There also exist two important state-varying prerogatives: the borrower's right of statutory redemption and the lender's claim to a deficiency recovery. The statutory right of redemption is the right of the borrower in some states to redeem property, post-foreclosure, upon payment of principal, accrued interest and the lender's foreclosure costs. Deficiency recovery, the right of the lender to pursue the borrower for unsecured liabilities in excess of the value of the property, is available in all but six states.

Using FHA and mortgage insurance claim data, Clauretie (1987, 1990) and Clauretie and Herzog (1989, 1990) find that state foreclosure laws, right of redemption laws, and deficiency judgment laws influence loan loss severity. Clauretie (1990) finds that the

origination LTV accounts for a large amount of the variance in loss rates. Clauretie (1987) examines the joint determination of default rates and loan loss severity. This joint determination results from lenders determining the time to foreclose on delinquent mortgages as a function of expected default losses. Bible (1988) contrasts the different legal environment of judicial and power-of-sale states and describes some of the impediments to obtaining deficiency judgments against borrowers for funds never recovered, even where the state laws allow it.

Option Models of Default

Modelling mortgage defaults as a put option of the borrower, which the lender passively redeems, developed by Foster and Van Order (1984, 1985) and extended by Epperson, Kau, Kennon and Muller (1985), has become standard in the mortgage termination literature. According to the most simple version, the borrower will default when the value of the home falls below the value of the loan balance.

Cunningham and Hendershott (1984) introduce additional costs to the borrower such as stigma and credit problems and relocation costs, that may cause the borrower to defer default until the option is deeper in the money. Ambrose, Buttimer and Capone (1995) focus on the impact of the delay between the last paid installment and the foreclosure date—and the associated "free rent"—and its effect on the exercise of the default option. Vandell (1994) reviews default incidence evidence concerning the ruthlessness of the exercise of the default option. Kau and Kim (1994), and Kau, Keenan and Kim (1992) discuss future exercise of the default option as a motive for delaying the exercise of the default option until it is deeper in the money.

The research in this paper extends the work of Quigley and Van Order (1992) and Lekkas et al. (1993) who derive and test several implications from a frictionless default model with respect to equity loss severity. Their findings are that, for most of their tests, the frictionless model predictions are rejected and the frictionless model is an inadequate tool for predictions concerning severity. Crawford (1993a), using Fannie Mae data, also rejects these predictions.

Clauretie and Jameson (1990) find evidence that the foreclosure process for FHA-insured loans takes longer when market interest rates are lower than contract rates at the default date. The theory relies on moral hazard on the part of lenders who are reimbursed for lost interest by the FHA at the contract rate to the date of foreclosure.

Implications of Efficient Default Exercise for Equity Loss Severity

This section discusses two models of equity loss severity. Both models are based on an options-theoretic approach to mortgage default. The first model is of a frictionless world. The second includes transaction costs and other frictions and includes the frictionless model as a special case.

Frictionless Defaults and Equity Loss Severity

The put option pricing paradigm in a frictionless Modigliani-Miller world provides implications that are much stronger than many other economic theories allow.[3] The value of the put option and the probability of default are increasing in the mortgage amount,

the mortgage term, and the variance in home price appreciation. The value of the put option and the probability of default are decreasing in the property value and the discount rate.

These relationships have intuitive interpretations. An increase in the level of indebtedness increases the probability that the property value will be below the level of indebtedness and increases the probability of default. A longer mortgage term has two effects that are in the same direction. The first effect is that mortgage amortization is slower the longer the term. This higher level of indebtedness leads to a higher probability of default. The second effect is that a longer term increases the dispersion in the distribution of property values and increases the probability that at some time in the life of the mortgage the property value will fall below the level of indebtedness. An increase in the variance of property value increases the probability that the property value will fall below the level of indebtedness. An increase in the property value increases the probability that the property value will be above the exercise price, the level of indebtedness, and decreases the probability that default occurs.

A frictionless world is characterized by no transaction costs, no taxes, full information, i.e., no measurement error, no flows to the borrower from the asset, and no value to future exercise of the option.[4] Here, the borrower's default rule is to default if $V^* \leq L$, where V^* is the current property value and L^* is the discounted present value of the future mortgage payments. The implication is that there is no severity since $V^* - L = 0$ at default: borrowers default as soon as they have zero equity and do not delay defaulting until they have negative equity.

Default Frictions and Equity Loss Severity

There are several reasons for default exercise and loss severity to differ from that predicted in the model described above. This section discusses these differences and formally includes many of them in the model.

First, properties provide either non-pecuniary or pecuniary value to the borrower. Shelter to owner-occupants provides non-pecuniary value and rental income to investors provides pecuniary value. Between default and foreclosure, and in some states between foreclosure and the end of the redemption period, the borrower may enjoy these benefits as free rents.

Second, borrowers face a tax liability for the income that is gained when the default option is exercised. The taxable amount is roughly the difference between the loan amount and the property value. This is the extent to which the option to default is "in the money" when it is exercised.

Third, borrowers may face deficiency judgments for all or a portion of the loss that they cause the lender by defaulting.

Fourth, borrowers who have a discount mortgage, where the contract rate is less than the market rate, may lose the value of the discount in default. Borrowers who have a premium mortgage gain back the value of the premium when they default.

Finally, transaction or stigma costs exist and differ across borrowers. These transaction costs can be pecuniary, taking the form of increased future borrowing costs, as well as non-pecuniary, taking the form of negative social reaction to default.

If transaction costs, flows to the borrower from the asset, and deficiency judgments are included in the model, while full information is still assumed, then the borrower's

decision rule is to default if the loss to the borrower is less than or equal to the gain to the borrower.

$$V^* + c \cdot L + pr(DJ)(L - V^* + r \cdot L \cdot FM) + L - L_m \leq L + r \cdot L \cdot FM\,,$$

where:

V^* = the current value of the house;
c = transaction or stigma costs (that are not explicitly modeled elsewhere in the equation) per dollar of loan amount;
L = the current mortgage balance;
L_m = the market value of the mortgage;
DJ = a deficiency judgment;
$pr(DJ)$ = the probability of a deficiency judgment ($pr(DJ) \in (0,1)$);
r = the contract interest rate; and
FM = months in foreclosure.

The left side, the loss to the borrower, includes the current value of the house V^*, the transaction costs $c \cdot L$, a potential deficiency judgment equaling the losses to the lender $L - V^* + r \cdot L \cdot FM$, with probability $pr(DJ)$, and the difference between the current mortgage balance and the market value of the mortgage $L - L_m$, due to interest-rate change since origination. The right side, the gain to the borrower, is the current mortgage balance L and the value of the free rent during the foreclosure months $r \cdot L + FM$.

The ratio of the value of the property to the current loan amount is one measure of the degree to which the option is "in the money" when exercised. At default, the ratio of the value of the property to the current loan amount, if L_m is approximated by $L\frac{r}{r_m}$ where r_m is the market interest rate,[5] is:

$$\frac{V^*}{L} = \frac{[1 - pr(DJ)](1 + r \cdot FM) - c - \dfrac{r_m - r}{r_m}}{1 - pr(DJ)}\,.$$

The expression $\frac{r_m - r}{r_m}$ is the difference between the market rate and the contract rate as a fraction of the market interest rate.

Equity loss severity can be expressed as:

$$Severity = -\frac{L - V^*}{L} = \frac{[1 - pr(DJ)]r \cdot FM - c - \dfrac{r_m - r}{r_m}}{1 - pr(DJ)}\,.$$

If net transaction costs are positive, then the ratio of the value of the property to the current loan amount $\frac{V^*}{L}$ is greater than one and severity is positive when the rational borrower exercises the default option.[6] This hypothesis is testable with the data used in this research.

Comparative Statics Results from a Model with Frictions

Comparative statics relating the ratio of the value of the property to the current loan amount $\frac{V^*}{L}$ to the other variables in the model provide testable implications of the default model that incorporate transaction costs and other frictions. First, the ratio of the value of the property to the current loan amount is decreasing in transaction costs c. This relationship becomes more negative as the likelihood of a deficiency judgment increases.

$$\frac{\partial\left(\frac{V^*}{L}\right)}{\partial c} = \frac{-1}{1 - pr(DJ)} < 0 .$$

The ratio of the value of the property to the current loan amount is increasing in the number of months in foreclosure FM. This relationship is increasing in the contract interest rate r, an approximation of the monthly value of free rent.

$$\frac{\partial\left(\frac{V^*}{L}\right)}{\partial FM} = r > 0 .$$

The ratio of the value of the property to the current loan amount is decreasing in the market interest rate r_m. The borrower who defaults will face alternative housing costs that are an increasing function of the market interest rate. This relationship becomes more negative as the likelihood of a deficiency judgment increases.

$$\frac{\partial\left(\frac{V^*}{L}\right)}{\partial r_m} = \frac{-\frac{r}{r_m^2}}{1 - pr(DJ)} < 0 .$$

The ratio of the value of the property to the current loan amount is increasing in the contract interest rate r. Borrowers with high contract rates are quicker to abandon the mortgage by defaulting, while borrowers with low contract rates value their low rates and delay defaulting. This relationship becomes stronger as the likelihood of a deficiency judgment increases.

$$\frac{\partial\left(\frac{V^*}{L}\right)}{\partial r} = \frac{[1 - pr(DJ)]FM + \frac{1}{r_m}}{1 - pr(DJ)} > 0 .$$

The relationship between the ratio of the value of the property to the current loan amount and the probability of a deficiency judgment is indeterminate. For most borrowers, however, the relationship is likely to be positive. This relationship will be negative only for premium mortgages where the contract rate exceeds the market rate as a fraction of the market rate by an amount greater than the transaction costs c.

$$\frac{\partial\left(\frac{V^*}{L}\right)}{\partial pr(DJ)} = \frac{-c - \frac{r_m - r}{r_m}}{[1 - pr(DJ)]^2} .$$

Data

To test these implications, this research uses data from the servicing and foreclosure tracking systems of a large northeastern thrift. This thrift serviced nearly twenty billion dollars in residential and commercial real estate mortgage loans throughout the country. Due to uninsured commercial real estate losses, this thrift was resolved by the Resolution Trust Corporation in January 1991. The average annual default rate of about 1% for this period is somewhat higher than the national average. Though this default rate was high by industry standards, nearly 90% of foreclosed residential loans were covered by mortgage insurance. Thus, the financial impact of these residential loan defaults did not play an integral role in the bank's ultimate insolvency. The insolvency was caused from uninsured commercial defaults.

From a cumulative set of over 200,000 residential real estate loans, data are available for 2,619 defaults that occurred between August 1987 and December 1991.[7] For all 2,619 defaults, the property's state, the property's metropolitan statistical area (MSA), the unpaid principal balance, the contract interest rate, the original property value (the lesser of the appraised value or the purchase price), the date of default, and the date borrower turns over the deed are available from the servicing system. For 1,256 loans, the date of the real estate-owned (REO) disposition sale and the proceeds of the REO sale are known from a foreclosure tracking system.

The analysis data set includes all owner-occupied loans originating from 1979 through 1989 and consists of 2,295 observations. Last paid installments for these loans are from 1987 through 1991 with foreclosures occurring from 1988 through 1992. Exhibit 1 presents summary statistics for this data set.

Two methods are used to construct the ratio of the value of the property to the loan amount at the time of the exercise of the default option $\frac{V^*}{L}$. One measure uses the REO disposition sale price while the other uses the lesser of the original appraised value of the property and the original purchase price of the property. In both methods the property values are adjusted to the default option exercise date (approximated by the date of the last paid installment) by a price index to reflect changes in home prices. The home price indices used are Fannie Mae repeat-transaction home price indices based on merged Fannie Mae and Freddie Mac data at the least aggregated level—either the MSA level or the state level—with a valid index for the entire first quarter 1979 through third quarter 1994 period (see Li, 1995a, 1995b). In both measures, the measure of the loan amount is the unpaid principal balance from the servicing records. Obviously, different measures of the value of the property obtain from these two methods. Exhibit 2 presents correlation coefficients for these measures. Crawford (1993b) comments on a few possible reasons for differences between measures of property values derived from REO sale prices and property values derived from origination sale prices.

The market interest rate is the average interest rate for the quarter for thirty-year, fixed-rate, 80% loan-to-value ratio, conventional mortgages from the Freddie Mac Primary Mortgage Market Survey.

The bankruptcy variable indicates that the borrower declared bankruptcy before foreclosure. Bankruptcy is one measure of the additional transactions costs that foreclosure brings to the borrower. Since a borrower who has declared bankruptcy already has had his credit rating and future borrowing opportunities damaged and has suffered any social stigma associated with bankruptcy, the additional costs of foreclosure may be smaller.

Exhibit 1
Summary Statistics

Variable Label	N	Mean	Std Dev.
1/*LTV*_1 Marked to market 1/*LTV* from REO sale	1191	.7816	.2986
1/*LTV*_2 Marked to market 1/*LTV* from origination	2295	1.2785	.6061
BANKRUPT Bankruptcy declared	2295	.0928	.2902
*FORMTHS*2 Fannie Mae average months from LPI to foreclosure	2295	13.2614	3.0587
*FORMTHS*1 Actual months from LPI to foreclosure	2295	11.1509	4.7552
JUDICIAL Judicial foreclosure state indicator	2295	.4148	.4928
REDEMP Redemption state indicator	2295	.1508	.3579
*MKT_RAT*1 Market rate at LPI	2295	10.4599	.2939
*CNT_RAT*1 Contract rate at LPI	2295	11.7027	1.7511
DEFIC Deficiency judgment state indicator	2295	.9272	.2598
PRE_FOR Preforeclosure sale indicator	2295	.1129	.3165
DEEDLIEU Deed in lieu indicator	2295	.0196	.1387
RTC_DISP RTC disposition indicator	2295	.3482	.4765

There are four potential measures of the period that the borrower can receive free rent. Three are measures of foreclosure time. One is the measure of the ability of the borrower to live rent free after the foreclosure date. The first measure of foreclosure time is the average number of months from last paid installment to foreclosure for that property's state based on Fannie Mae historical foreclosure records. This is potentially a measure of the vast array of foreclosure laws and their effects on foreclosure time. The second is the actual number of months from last paid installment to foreclosure for the loan under consideration. Finally, an indicator variable of judicial foreclosure states is considered. Judicial foreclosure usually has the effect of lengthening the foreclosure time. Exhibit 2 presents correlation coefficients for these three measures of the free rent period. The judicial foreclosure state indicator variable is highly correlated with the average number of months from last paid installment to foreclosure for that property's state based on Fannie Mae historical foreclosure records. A measure of the ability of the borrower to live rent free after the foreclosure date is the redemption state indicator. While this is only a rough measure, the right to redemption does provide the borrower with additional time to claim the property.

The deficiency judgment state variable indicates whether state laws allow the borrower to be subject to a deficiency judgment. Preforeclosure sale and deed-in-lieu indicators are

Exhibit 2
Pearson Correlation Coefficients of Selected Variables

Pearson Correlation Coefficients
Prob > | R | under Ho: *Rho* = 0
Number of Observations

	1/*LTV*_1	1/*LTV*_2
1/*LTV*_1	1.0000	.5349
Marked to market 1/*LTV* from REO sale	.0	.0001
	1191	1191
1/*LTV*_2		1.00000
Marked to market 1/*LTV* from origination		.0
		2295

	*FORMTHS*2	*FORMTHS*1	*JUDICIAL*
*FORMTHS*2	1.0000	.3558	.8767
Fannie Mae avg. months from LPI to foreclosure	.0	.0001	.0001
	2295	2295	2295
*FORMTHS*1		1.0000	.2860
Actual months from LPI to foreclosure		.0	.0001
		2295	2295
JUDICIAL			1.0000
Actual months from LPI to foeclosure			.0
			2295

also available for analysis. The RTC disposition indicator variable indicates that the Resolution Trust Corporation disposed of the REO property.

Empirical Results

The relationship between the ratio of the value of the property to the current loan amount $\frac{V^*}{L}$ is estimated as a linear function of the number of months in foreclosure FM, the contract interest rate r_c, the market interest rate r_m, the probability of a deficiency judgment $pr(DJ)$ and transactions or stigma costs c. The available data discussed in the preceding section provide measures of these variables.

Estimates using the REO sale price to calculate the ratio of the value of the property to the current loan amount $\frac{V^*}{L}$ are presented in Exhibit 3. Estimates using the original property value to calculate are presented in Exhibit 4. While measures of goodness of fit are low, almost all of the signs of the explanatory variables are as the theory predicts. Also, the significance of the parameters and the magnitudes are fairly robust across specifications.

Specifications with and without a preforeclosure sale indicator, a deed in lieu indicator, and a RTC disposition indicator are included in both tables. While these variables are not in the theoretical model, they are considered because of their potential to affect the REO sale price. The inclusion of these variables does influence the analysis of the other

Exhibit 3
Severity Equation with Marked to Market 1/*LTV* from REO Sale[a]

	(1)	(2)	(3)	(4)	(5)
Intercept	1.9084**	1.8054**	1.7410**	1.8435**	1.7890**
	(.323)	(.333)	(.331)	(.330)	(.334)
Bankruptcy declared	.0525*	.0507*	.0141	.0430	.0489*
	(.028)	(.028)	(.031)	(.029)	(.029)
Fannie Mae average months LPI to foreclose	.0025	.0026**			.0024
	(.003)	(.003)			(.003)
Actual months from LPI to foreclose			.0056		
			(.002)		
Judicial foreclosure state indicator				−.0275	
				(.019)	
Redemption state indicator	.0528**	.0550**	.0577**	.0442*	.0544**
	(.025)	(.026)	(.026)	(.026)	(.026)
Market rate at LPI	−.1166**	−.1071**	−.1041**	−.1080**	−.1064**
	(.030)	(.031)	(.031)	(.031)	(.031)
Contract rate at LPI	.0091*	.0093*	.0094**	.0095**	.0097**
	(.005)	(.005)	(.005)	(.005)	(.005)
Deficiency judgment state indicator	−.0615*	−.0614*	−.0582*	−.0459	−.0609*
	(.032)	(.032)	(.031)	(.032)	(.032)
Preforeclosure sale indicator		.0635	.0723	.0727	.0670
		(.063)	(.063)	(.063)	(.064)
Deed in lieu indicator		−.0705	−.0445	−.0613	−.0678
		(.055)	(.055)	(.054)	(.055)
RTC disposition indicator					.0110
					(.018)
Number of observations	1191	1191	1191	1191	1191
R-squared	.02	.03	.03	.03	.03

[a]Standard errors are in parentheses.
**significant at the .05 level; *significant at the .10 level

parameters.

In Exhibit 3, the parameters of redemption state indicator, the market rate, and the contract rate are all significant at the .05 level. The parameters of bankruptcy and the deficiency judgment state indicator are significant at the .10 level. All of these parameters have the predicted signs.

In Exhibit 4, the parameters of the measures of foreclosure months, the redemption state indicator, and the contract rate are all significant at the .05 level. The parameters of the market rate and the judgment state indicator are significant at the .10 level. All of these parameters have the predicted signs.

Discussion and Conclusions

This paper extends options-based mortgage default theory to include transaction costs. When transaction costs are considered, the rational borrower will default only when the value of the collateral falls below the mortgage value by an amount equal to the net transaction costs. These transaction costs include the costs of moving, brokerage fees,

Exhibit 4
Severity Equation with Marked to Market 1/*LTV* from Origination[a]

	(1)	(2)	(3)	(4)	(5)
Intercept	1.7331**	1.6968**	1.7876**	2.0491**	1.5486**
	(.397)	(.409)	(.411)	(.413)	(.407)
Bankruptcy declared	.0616*	.0583*	−.0613	.0457	.0423
	(.035)	(.035)	(.038)	(.036)	(.035)
Fannie Mae average months LPI to foreclose	.0262**	.0269**			.0256*
	(.004)	(.004)			(.004)
Actual months from LPI to foreclose			.0155**		
			(.003)		
Judicial foreclosure state indicator				.0689**	
				(.023)	
Redemption state indicator	.1614**	.1691**	.1576**	.1647**	.1634**
	(.031)	(.032)	(.032)	(.033)	(.031)
Market rate at LPI	−.0685*	−.0659*	−.0600	−.0679*	−.0591
	(.037)	(.038)	(.038)	(.039)	(.038)
Contract rate at LPI	.0187*	.0189**	.0191**	.0184**	.0228**
	(.006)	(.006)	(.006)	(.006)	(.006)
Deficiency judgment state indicator	−.4039**	−.4032**	−.3706**	−.4025**	−.3983**
	(.0389)	(.039)	(.039)	(.041)	(.038)
Preforeclosure sale indicator		.0130	.0440	.0188	.0362
		(.063)	(.078)	(.079)	(.078)
Deed in lieu indicator		−.1480**	−.0461**	−.1201*	−.1239*
		(.067)	(.068)	(.068)	(.067)
RTC disposition indicator					.0989**
					(.022)
Number of observations	1191	1191	1191	1191	1191
R-squared	.12	.13	.11	.09	.14

[a]Standard errors are in parentheses.
**significant at the .05 level; *significant at the .10 level

taxes, future deficiency payments, and the stigma associated with default; and are offset by free rents during delinquency. Since, for most borrowers, net transaction costs are positive, standard measures of equity may be significantly negative by the time the rational borrower efficiently exercises the default option. The empirical results support the model; while measures of goodness of fit are low, almost all the signs of the explanatory variables are as the theory predicts. Also, the significance of the parameters and their magnitudes are fairly robust across specifications.

The consideration of transaction costs in default modelling is important for loss-per-risk forecasting and accurate mortgage pricing. First, it is important to recognize that these frictions influence a borrower's strike price and that these vary in a predictable manner. Second, the variables that increase severity are the variables that reduce the probability of default. This implies that default probability and loss severity are not independent.

This modelling approach also highlights the effect of the borrower's behavior on

severity. Strategic foreclosure behavior on the part of the lender is not required to obtain differences in severity across states or across market interest rates.

There are several considerations that should be included in future modelling efforts. Delaying the exercise of the default option as studied in Kau and Kim (1994), and Kau et al. (1992) should be combined in a theoretical model that includes transaction costs to give an empirical framework to test these potentially competing hypotheses.

Since borrowers face a potential tax liability for the income that is gained when the default option is exercised, these tax liabilities should be included as another friction in the model. The potentially taxable gain is roughly the difference between the loan amount and the property value. This is the gain to the borrower from defaulting or the extent to which the option to default is "in the money" when it is exercised. Also, borrowers lose mortgage interest and other deductions with default. Tax rates differing across states and localities and differential tax liabilities across states could be examined.

Also, properties provide either non-pecuniary or pecuniary value to the borrower. Shelter to owner-occupants provides non-pecuniary value and rental income to investors provides pecuniary value. A measure of owner-occupancy at default should be included to determine its effect on the default decision.

Notes

[1]Equity loss severity, hereafter loss severity or simply severity, is the difference between the loan amount and the value of the property when the borrower ceases payment on the mortgage. This contrasts with a common definition of severity, loan loss severity, which is the total of all default-related losses to the lender and/or the insurer.

[2]See Note 1 for a definition of loan loss severity.

[3]For a good presentation of this topic see Black and Scholes (1973).

[4]In a frictionless world, future exercise of an option has no value, since it could be exercised and repurchased repeatedly without transaction costs.

[5]This approximation is exact only for an interest-only perpetual loan. The accuracy is decreasing in the portion of the monthly payment comprised by principal. So, the approximation is most accurate early in the life of a mortgage.

[6]The ratio of the value of the property to the current loan amount $\frac{V^*}{L}$ differs from severity by a constant and is perfectly negatively correlated with severity.

[7]There were actually over 5,000 defaults from the 200,000 loans at risk between 1985 and 1990. Due to missing data tapes, only 2,619 defaults were recorded in the foreclosure data system and are available for analysis.

References

Ambrose, B. W., R. J. Buttimer, Jr. and C. A. Capone, The Impact of the Delay Between Default and Foreclosure on the Value of Mortgage Default, manuscript, March 1995.

Bible, D. S., An Empirical Study of Residential Mortgage Foreclosures with an Emphasis on Appraised and Assessed Values, *Real Estate Appraiser and Analyst*, Winter, 1988, 54: 30–39.

Black, F. and M. Scholes, The Pricing of Options and Corporate Liabilities, *Journal of Political Economy*, 1973, 81, 637–59.

Clauretie, T. M., A Note on Mortgage Risk: Default vs. Loss Rates, *AREUEA Journal*, 1990, 18:2, 202–207.

———, State Foreclosure Laws, Risk Shifting, and the Private Mortgage Insurance Industry, *Journal of Risk and Insurance*, 1989, 46:3, 544–54.

———, The Impact off Interstate Foreclosure Cost Difference and the Value of Mortgages on Default Rates, *AREUEA Journal*, 1987, 15:3, 152–67.

Clauretie, T. M. and T. N. Herzog, The Effect of State Foreclosure Laws on Loan Losses; Evidence From the Mortgage Insurance Industry, *Journal of Money, Credit & Banking*, 1990, 22:2, 221–33.

———, How State Laws Affect Foreclosure Costs, *Secondary Mortgage Markets*, Spring 1989, 25–28.

Clauretie, T. M. and M. Jameson, Interest Rates and the Foreclosure Process, *Journal of Risk and Insurance*, December 1990, 57, 701–11.

Crawford, G. W., The Losses Associated with Foreclosed Properties, manuscript, Washington, D.C.: Federal National Mortgage Association, January 1993a.

———, Market Duration Characteristics of REO Properties, manuscript, Washington, D.C.: Federal National Mortgage Association, January 1993b.

Cunningham, D. and P. H. Hendershott, Pricing FHA Mortgage Default Insurance, *Housing Finance Review*, 1984, 3:4, 373–92.

Epperson, J. F., J. B. Kau, D. C. Kennan and W. J. Muller, 1985, Pricing Default Risk in Mortgage, *AREUEA Journal*, 13:3, 261–72.

Foster, C. and R. Van Order, FHA Terminations: A Prelude to Rational Mortgage Pricing, *AREUEA Journal*, 1985, 13:3, 273–91.

———, An Option-Based Model of Mortgage Default, *Housing Finance Review*, 1984, 3:4, 351–72.

Kau, J. B., D. C. Keenan and T. Kim, Default Probabilities for Mortgages, manuscript, University of Georgia, November 1992 (forthcoming *Journal of Urban Economics*).

Kau, J. B. and T. Kim, Waiting to Default: The Value of Delay, *Journal of the American Real Estate and Urban Economics Association*, 1994, 22:3, 539–51.

Lekkas, V., J. M. Quigley and R. Van Order, Loan Loss Severity and Optimal Mortgage Default, *Journal of the American Real Estate and Urban Economics Association*, 1993, 21:4, 202–207.

Li, Y., Metropolitan Statistical Area Home Price Changes Based on Fannie Mae/Freddie Mac Repeat Transactions Data, memorandum, Washington, D.C.: Federal National Mortgage Association, January 1995a.

———, Quarterly Home Price Trends, memorandum, Washington, D.C.: Federal National Mortgage Association, January 1995b.

National Association of Realtors, *Home Buying and Selling Process: 1989*. Chicago, Ill.: National Association of Realtors, 1989, 64–65.

Phillips, R. and E. Rosenblatt, An Empirical Analysis of the Choice of Foreclosure Alternatives, unpublished manuscript, 1995.

Quigley, J. M. and R. Van Order, More on the Efficiency of the Market for Single Family Homes: Default, working paper, Berkeley, Calif.: University of California Center for Real Estate and Urban Economics, June 1992.

Rosenblatt, E., The Effect of Conflict and Negotiation on the Dissipation of Residential Mortgage Collateral, unpublished dissertation, Rutgers University, 1994, Ch. 4.

Vandell, K. D., How Ruthless is Mortgage Default? A Review and Synthesis of the Evidence, *Research Issues in Pricing Mortgage-Backed Securities, Research Roundtable Series*, Washington, D.C.: Fannie Mae, September 1994.