THE EFFECT OF PREPAYMENT PENALTIES ON THE PRICING OF SUBPRIME MORTGAGES

Gregory Elliehausen,
Financial Services Research Program
George Washington University

Michael E. Staten,
Financial Services Research Program
George Washington University

and

Jevgenijs Steinbuks
Department of Economics
George Washington University

April 2007

THE EFFECT OF PREPAYMENT PENALTIES ON THE PRICING OF SUBPRIME MORTGAGES

ABSTRACT

This paper investigates the effect of prepayment penalties and state laws governing such penalties on the pricing of subprime mortgages. The paper is the first to consider that mortgage price and prepayment penalty may be chosen jointly, making single-equation estimates of the effect of prepayment penalty on price biased. Using a model that accounts for endogeneity of price, loan to value, and prepayment penalty, we find that prepayment penalties are associated with lower prices for subprime mortgages and that state laws restricting prepayment penalties are associated with higher prices. These findings are consistent with pricing of mortgage credit according to risk, a characteristic of the subprime market that allows lenders to make credit available to borrowers who would have difficulty obtaining such credit in the prime market. The findings are important because perceptions that prepayment penalties are not reflected in mortgage prices have led to regulation that risks reversing the gains in mortgage credit availability that were achieved over the last decade.

INTRODUCTION

The development of a subprime mortgage market has been an important innovation in U.S. mortgage markets over the last decade. The subprime market has expanded availability of mortgage credit to many borrowers who for one reason or another did not qualify for mortgage credit in the prime market. This expansion of mortgage lending to higher risk borrowers has come about because lenders, aided by technological advances that have facilitated the maintenance and analysis of comprehensive information on borrowers' credit histories, have been able to price loans according to the risk of the loan. Thus, higher risk borrowers pay higher prices for mortgage credit in the subprime market, rather than face limitations on loan size or turndowns in the prime market.

Pricing in the subprime market depends on a variety of factors, including a number that affects risk of payment. The factors include the size of the loan (smaller loans require a higher interest rate to recover relatively high fixed costs); the type of interest rate (e.g., fixed vs. adjustable, which affects the lender's interest rate risk); the ratio of loan amount to home value and the type of home (which may influence the borrower's incentive to pay or maintain the property); the extent of documentation of income or assets; income, debt payments relative to income and purpose of the loan (both of which reflect capacity to service the debt); and credit bureau score and other measures of payment performance. The presence of a prepayment penalty is also prominent among the risk factors that affect the price of a subprime loan.

A prepayment penalty is a fee that borrowers pay if they repay a mortgage within a specified period after origination, usually within the first two or three years. Borrowers may prepay for several reasons including purchasing another home, taking advantage of a

decline in interest rates, or refinancing the original loan in order to obtain additional cash, or restructure existing debts. Subprime borrowers may have an additional reason for prepayment: if their financial circumstances improve they may qualify for a lower interest rate. Subprime borrowers prepay at a significantly higher rate than prime borrowers (Phillips-Patrick, Hirschhorn, Jones, and LaRocca 2000). From the lender's standpoint, prepayment reduces the profitability of originating loans and the predictability of returns to investing in loans. Prepayment penalties offset some of that risk by encouraging borrowers to select loans based on their private information about the expected holding period and by compensating lenders in the event of prepayment. As a result, subprime mortgages with a prepayment penalty sell for higher prices in the secondary market than do mortgages without a penalty. For these reasons, price sheets for subprime loans typically contain adjustments that increase the price paid on loans without a prepayment penalty or with relatively short prepayment penalty periods.

Whether prices for subprime mortgages actually include such adjustments is subject to controversy. Advocacy groups generally view prepayment penalties as inherently abusive and question whether borrowers receive a lower loan price in exchange for accepting a prepayment penalty (e.g., Goldstein and Son 2003). One advocacy group has produced an empirical analysis that concludes that prepayment penalties are not associated with lower interest rates in securitized subprime loans (Ernst 2005). Using different data from several lenders, however, DeMong and Burroughs (2005) found that, other factors being equal, loans with prepayment penalties have lower interest rates than loans without prepayment penalties. Reconciling these studies is difficult. The differences in the studies' estimated effects of prepayment penalties do not appear to be solely a consequence of analyzing different databases. The studies examined different subprime mortgage products using different sets of explanatory variables. Both studies use only a small number of factors that lenders consider in pricing loans. Neither study accounted for effects of laws in many states that regulate prepayment penalties in various ways. And the estimated effect of prepayment penalties may be biased because of the failure to address possible endogeneity in choice of price and prepayment penalty.

Available evidence simply does not resolve the question of whether subprime mortgage prices reflect the presence of prepayment penalties. This paper improves on previous investigations in several ways: The improvements include (1) consideration of additional explanatory variables; (2) disaggregation in mortgage products to more closely reflect product definitions found in the market; (3) accounting for state regulation of prepayment penalties; and (4) consideration of endogeneity in interest rate, loan to value, and prepayment penalty choices.

METHODOLOGY

The data for this study are from the Financial Service Research Program's (FSRP) subprime mortgage database. The database contains loan-level data on all originations of the subprime subsidiaries of eight large financial institutions between the third quarter 1995 and the fourth quarter of 2004. The Federal Reserve estimated that the FSRP's subprime mortgage database covered nearly a quarter of the originations of higher priced

home purchase and refinance mortgages on owner-occupied homes in 2004, which reported risk premiums under the Home Mortgage Disclosure Act (Avery, Canner, and Cook 2005).[1] Estimates of coverage for earlier years are not available, because the Home Mortgage Disclosure Act (HMDA) did not require reporting of risk premiums for higher priced mortgages prior to 2004. Nevertheless, it seems reasonable to believe that the FSRP's subprime mortgage database captures a considerable share of all subprime mortgage lending.[2]

The lenders contributing to the subprime database originate loans through brokers, originate loans directly, and purchase loans from other lenders. Nearly a quarter of the loans originated in 2004 were purchased from other lenders, and 58 percent of all loans were originated through brokers. These percentages are typical of the lenders' loan acquisitions during the time period of the database.

Nearly all of the loans, 94 percent in 2004, in the database are closed-end. Forty percent of these closed-end loans were first liens. Table 1 describes selected characteristics of closed-end first mortgages, the type of loan analyzed in this study. The average loan size of closed-end first mortgages in 2004 was $130,000. Fixed-rate mortgages were on average smaller than variable-rate and hybrid mortgages. Overall, 23 percent of closed-end first mortgages were used for home purchases, but loan purpose varied substantially by type of interest rate. Variable-rate and hybrid loans were more than twice as likely to be used for home purchases as fixed-rate loans. Average annual percentage rates were 10.71 percent for fixed-rate mortgages, 8.43 percent for variable-rate mortgages, and 9.78 percent for hybrid mortgages. Borrowers obtaining fixed-rate loans had lower incomes and higher FICO scores than borrowers obtaining variable-rate or hybrid loans. Loan sizes, property values, and borrower income were lower in earlier year; and loan purpose distributions, annual percentage rate, and FICO scores varied during the entire 1995-2004 period. Nevertheless, the 2004 statistics illustrate the differences in loan products and borrower characteristics that prevailed during this period.

Model

We specify loan price as a function of loan terms, distribution channel, and borrower risk characteristics. Price is measured by the risk premium, which is defined as the annual percentage rate of interest less the rate for a Treasury security of comparable maturity. The annual percentage rate is the total mortgage price because it includes both the contract interest rate and any initial points or fees. The risk premium is used instead of the annual percentage rate to remove the effects of movements in the market interest rates.

---

[1] Financial Services Research Program was formerly named Credit Research Center. The center changed its name when it moved to George Washington University in August 2006.

[2] For an earlier version of the FSRB's subprime mortgage database, Wallace, Elliehausen, and Staten (2004) estimated that the number of loans in 2002 was nearly a quarter of the number of HMDA-reportable loans originated by lenders on the U.S. Department of Housing and Urban Development's list of subprime lenders. For further discussion of coverage of subprime databases, see Wallace, Elliehausen, and Staten (2004).

Lenders typically have different pricing schedules for different mortgage products. We, therefore, estimate separate models for (1) fixed-rate first mortgages, (2) variable-rate first mortgages, and (3) hybrid first mortgages that have a 30-year term to maturity. These products accounted for nearly all first mortgage loans originated by the eight subprime subsidiaries in the database.[3] We excluded loans with loan amounts greater than 90 percent of home value because such high loan-to-value loans are not generally available to most subprime borrowers.

Loan terms include loan amount, home value, the ratio of loan to value, and whether the loan is a reduced-documentation loan. Distribution channel is indicated by a dummy variable that equals one when the loan was originated by a mortgage broker and zero otherwise. Borrower risk characteristics include whether the home is owner-occupied, borrower income, and FICO risk score.

The loan term that is of particular interest for this paper is the presence of a prepayment penalty. Loans having a prepayment penalty are identified by a dummy variable, which equals one if the loan has a prepayment penalty and zero otherwise. If lenders charge higher prices on loans without prepayment penalties, then the presence of a prepayment penalty should be inversely related to the risk premium. Because loan price and presence of a prepayment penalty may be determined simultaneously, we first estimated a probit model predicting the presence of a prepayment penalty. The predicted probability that the loan has a prepayment penalty is used in place of the dummy variable in the simultaneous equation model.

Many states restrict prepayment penalties. Restrictions may limit the time period allowed for prepayment penalties, limit the size of the prepayment penalty, or prohibit prepayment penalties. Generally, restrictions on prepayment penalties would be expected to be positively related to risk premiums since such regulation would increase prepayment risk. Federal preemption allows certain lenders to offer loans with prepayment penalty terms that state laws prohibit other types of lenders from offering. This regulatory structure may influence competition and the range of loan offerings in regulated states and weaken the observed effect of state law on mortgage prices. We specify state regulation of prepayment penalties as a dummy variable that equals one if state law restricts or prohibits prepayment penalties.[4]

Descriptive statistics for the variables are reported in table 2.

Estimation

Previous papers examining the effect of prepayment penalties on mortgage prices (DeMong and Burroughs 2005; Ernst 2005) estimate a regression model predicting price as a function of the presence of a prepayment penalty, the ratio of loan to value, and other

[3] These companies also made small numbers of open-ended first mortgages and first mortgages with term to maturity of less than 30 years. Second mortgages are not included in this analysis because lack of information on the amount outstanding on the first mortgage precluded calculation of loan to value.
[4] See Ho and Pennington-Cross (2005) for a summary of state restrictions on prepayment penalties.

variables such as income and FICO risk score. A potential confounding factor is that the price may be chosen simultaneously with other loan terms such as loan amount (and therefore loan to value) and the presence of a prepayment penalty. Lenders typically offer a number of different equity and prepayment options, with each option entailing a different interest rate. The borrower chooses from among these options. Consequently, interest rate, loan to value, and the prepayment penalty option are all endogenous, a condition that causes single-equation coefficients to be biased and inconsistent. A biased parameter estimate will tend to either overestimate or underestimate the true parameter. An inconsistent estimate will not provide a smaller error as the number of observations increases. Ernst (2005) does consider loan to value as endogenous but treats prepayment penalty as exogenous. DeMong and Burroughs (2005) treat both terms as exogenous.

Failure to account for endogeneity in loan decisions can have serious consequences. In their assessment of models of mortgage rejection and default decisions, Yezer, Phillips, and Trost (1994) found that single-equation models did not provide reliable evidence on the structural parameters describing the behavior of borrowers or lenders. Simultaneity is one of several problems in modeling loan choices that may cause single-equation estimates of parameters to be biased and sensitive to differences in model specifications. Although we are interested in different choices than Yezer, Phillips, and Trost, simultaneity clearly is a consideration.

An analysis of mortgage loan performance by Rose (2007) also supports consideration of simultaneity in mortgage decisions. Rose examined the effects of long prepayment penalty periods, balloon payments, and reduced documentation on foreclosures. He found that long foreclosure periods did not have a uniform effect on the probability across different loan products, which were defined by loan purpose and type of interest rate. Long prepayment penalty periods had no significant effects on foreclosures for purchase-fixed and adjustable-rate mortgages, a significant positive effect for refinance adjustable-rate mortgages, and a significant negative effect for fixed-rate purchase mortgages. Rose hypothesized that the different findings might be explained by borrowers choosing a long prepayment penalty period to signal that they may be better credit risks, which he argued would likely be more necessary for refinancings and more credible for fixed-rate mortgages. Thus, choice of prepayment penalty would be endogenous in the loan decision.

To address the endogeneity issue, we develop the following simultaneous equations model:

$$
\begin{aligned}
y_i &= ltv_i'\alpha_0 + d_i'\gamma_0 + X_i'\beta_0 + Z_{y,i}'\phi_0 + u_i \\
ltv_i &= y_i'\lambda_1 + X_i'\beta_1 + Z_{ltv,i}'\phi_1 + v_i \\
d_i &= y_i'\lambda_2 + X_i'\beta_2 + Z_{d,i}'\phi_2 + \xi_i .
\end{aligned}
\qquad (1)
$$

This system of simultaneous equations (2) comprises three endogenous variables—the interest rate, y_i; loan to value, ltv_i; and the presence of a prepayment penalty, d_i. Vector

d_i is the dummy variable indicating the presence of a prepayment penalty. As mentioned, borrowers typically choose from a menu of interest rate and loan-to-value options, and choice of a prepayment penalty triggers an adjustment to the interest rate. Thus, ltv_i and d_i are endogenous variables in the interest rate equation. We have no reason to believe that loan–to-value and prepayment penalty are simultaneously determined. Therefore, d_i does not appear in the loan-to-value equation, and ltv_i does not appear in the prepayment penalty equation. Matrix X_i comprises exogenous explanatory variables: loan characteristics (owner occupied, loan purpose, documentation requirements); borrower characteristics (income and FICO score); and distribution channel (broker origination). The last matrix in each equation $Z_{y,i}$, $Z_{ltv,i}$, or $Z_{d,i}$ comprises the instruments excluded from either of equations to identify our system of equations. This model is, of course, a simplification. Other terms such as type of interest rate, the term to maturity, and distribution channel may be endogenous as well. Nevertheless, by consideration of simultaneity in the choice of interest rate and prepayment penalty, we are able to address the issue of possible of bias in estimates of the effect of prepayment penalties on loan prices.

For the first equation explaining the risk premium, we use the prime rate as an instrument. This variable is primarily used to price business loans and reflects an opportunity cost of production of the mortgage loans. The prime rate is not widely used as an index rate for variable-rate or hybrid closed-end subprime mortgages.[5] The prime rate is an administered rate that changes relatively infrequently and is influenced by many considerations other than the cost of funds (see Nabar, Park, and Saunders 1993). As such, the prime rate is not very responsive to changes in market rates and is largely uncorrelated with borrowers' decisions to choose a higher a loan with or without a prepayment penalty.

For the second equation explaining loan to value, we use the age of the borrower and the average property value in borrower's ZIP code area as instruments. Use of these variables as instruments is motivated by observations that older households tend to have higher wealth than younger households, which may make them less likely to seek a large loan amount relative to home value, and that wealthier borrowers tend to choose higher value properties than less wealthy borrowers (Bucks, Kennickell, and Moore 2006). These values would not be expected to be correlated with borrower choices for risk premium or prepayment penalty.

For the last equation explaining choice of prepayment penalty, we use the share of home-owners that recently moved in the borrower's metropolitan area and a dummy variable indicating whether the borrower's state passed a law restricting prepayment penalties. A high share of homeowners that recently moved is an indication of high turnover in the local real estate market, which may lessen demand for mortgages with prepayment penalties. This indicator would be uncorrelated with the loan's interest rate or loan-to-

[5] By far, most variable-rate and hybrid mortgages in the subprime mortgage database use LIBOR or a constant maturities Treasury rate as an index. The prime rate is widely used in pricing open-end mortgages, but open-end mortgages are only a very small percentage of these lenders' originations.

value ratio. State laws restricting prepayment penalties directly affect the supply of loans with prepayment penalties. State laws would be uncorrelated with choice of loan to value.

Simultaneous equations systems can be estimated using a full information systems method such as full information likelihood or generalized method of moments or a limited, equation-by-equation method such as two-stage least squares. System procedures are asymptotically more efficient than equation-by-equation procedures if all equations in a system are specified correctly. However, any misspecification in a system of equations will be transmitted to the entire system of equations, and systems method estimates of parameters will be generally inconsistent (Wooldridge 2002, pp. 221-224). Equation-by-equation methods limit a misspecification problem to the equation in which it appears, making equation-by-equation methods more robust than systems methods. Because our dataset does not contain all of the information used in pricing loans, and other loan characteristics are also potentially endogenous, we opt for the more robust, equation-by-equation approach for estimation.

To identify first two equations in (1), we first fit probit model for the third equation using exogenous variables and instruments on the right-hand side to obtain predictor of d_i:

$$\hat{d}_i(\theta_0) = \frac{\phi(\tilde{Z}\theta_0)\tilde{Z}'\varepsilon_i}{\Phi(\tilde{Z}\theta_0)[1-\Phi(\tilde{Z}\theta_0)]} \quad , \tag{2}$$

where $\tilde{Z} = [Z : X]$, $\varepsilon_i = d_i - \Phi(\tilde{Z}\theta_0)$, and θ_0 is a unique solution to maximization of probit log-likelyhood function.

Then, we estimate the first two equations in (1) by two-stage least squares (2SLS):

$$\{\hat{\alpha}_i, \hat{\lambda}_i\} = \left[\tilde{X}_i' Z_i (Z_i' Z_i)^{-1} Z_i' \tilde{X}_i\right]^{-1} \tilde{X}_i' \tilde{X}_i (Z_i' Z_i)^{-1} Z_i' Y_i \ , Y_i = \{y_i, ltv_i\}, \tilde{X}_i = [X_i : \hat{d}_i] \tag{3}$$

To identify the last equation in (1), we implement Amemiya (1978) Generalized Least Squares (AGLS) estimator for probit with endogenous regressors.[6]

FINDINGS

Single-equation estimates and two-stage least squares estimates of our equations are presented in Table 3. F-ratios indicate that each of the models estimated by ordinary least squares (OLS) for risk premium and loan to value are statistically significant (panels A and B, respectively). Chi-square statistics indicate that the probit models for prepayment penalty are statistically significant (Table 3, panel C). Statistical tests support the concern about endogeneity of loan to value and presence of a prepayment penalty. In each equation, a Hausman test rejects the hypothesis that the coefficients of the single equation and instrumental variable models are equal (Table 4). This result suggests that the single-equation model is inconsistent (Hausman 1978) and supports use of 2SLS.

[6] See also Newey (1987) for discussion.

Risk Premiums

The estimated equations for risk premium generally explain a large percentage of the variation in risk premiums. In the single-equation OLS models, the effect of loan to value on risk premiums is quite small and positive for fixed-rate and hybrid loans but small and negative for variable-rate loans. In the 2SLS models, the effects of loan to value on risk premiums are uniformly positive, consistent with expectations, and larger in absolute value. Thus, OLS estimates of loan-to-value coefficients appear to be biased toward zero.

The prepayment dummy variable in the single-equation models and the predicted probability of a prepayment penalty in the 2SLS models are statistically significant and negatively related to risk premiums. Single-equation and 2SLS results for prepayment penalties are not directly comparable because the prepayment variables are different. Multiplying the 2SLS parameter estimates by the difference in the mean-predicted probabilities for loans with and without prepayment penalties suggests that presence of a prepayment penalty reduces risk premiums by 38 basis points for fixed-rate loans, 13 basis points for variable-rate loans, and 19 basis points for hybrid loans (numbers not in table). These estimated reductions are smaller than the single-equation estimates for fixed-rate and variable-rate mortgages and larger than the single-equation estimate for hybrid mortgages. Our estimated reductions for prepayment penalties are within the size range of interest rate adjustments for prepayment penalties commonly found in lenders' loan pricing sheets. Risk price adjustments for factors such as loan purpose, owner occupancy, type of property, loan amount, and loan term are often of comparable magnitudes. In contrast, risk price adjustments for relatively low FICO scores or high loan-to-value percentages often exceed 100 basis points.

Parameter estimates for the exogenous variables are statistically significant in single-equation and 2SLS models. Borrower income and FICO risk score are both negatively related to risk premiums in all models, consistent with expectations. Higher income is generally associated with higher disposable income after providing for necessities. Higher FICO risk score indicates a lower probability of serious delinquency, bankruptcy, or other derogatory event. Signs of the other exogenous variables sometimes had different signs across products. The changes in signs across products may reflect correlations with explanatory variables that are not available in the dataset or possible endogeneity.

Loan to Value

The effect of risk premium on loan to value is positive in two of the three single-equation models (i.e., higher risk premiums are observed on loans with less borrower equity) but negative in all three 2SLS models. FICO risk score is positively related to loan to value for the single-equation models estimated by OLS but negatively related to loan to value for two of the three 2SLS models. Income is generally positively related to loan to value in both OLS and 2SLS models. Loans for owner-occupied homes have lower loan to

value in the 2SLS models and two of the three OLS models, and home purchase loans generally have greater loan to value than cash out refinance loans.

The estimates for risk premium and FICO score may reflect a selection issue not adequately addressed by our 2SLS model. Except for the lowest age and property value groups (the omitted groups), greater age and higher value of the property reduce loan-to-value, consistent with our expectation. However, it may be the case that some borrowers with higher incomes and wealth use mortgage debt to allocate a greater share of their wealth toward financial assets or to reduce the share of nonmortgage debt. Indeed, many of the high loan-to-value mortgages that we observe are owed by borrowers with relatively high incomes and FICO scores. Calomiris and Mason (1999) made a similar observation that high loan-to-value borrowers tend to be low credit risks, unlike other segments of the subprime market. The presence of such borrowers may confound results despite the exclusion of the highest loan-to-value loans.

Prepayment Penalties

Risk premium is inversely related to presence of a prepayment penalty for fixed-rate and variable rate mortgages and directly related to prepayment penalty for hybrid mortgages in both instrumental variable and single-equation probit models. Income is negatively related to prepayment penalty, except for the instrumental variable estimate for fixed-rate loans which is not significantly different from zero. Estimated coefficients for FICO score are positive for fixed-rate and hybrid loans but negative for variable-rate loans in the instrumental variable model. Fixed-rate and hybrid home purchase loans are significantly more likely to have a prepayment penalty than fixed-rate or hybrid cash-out refinance loans (the omitted loan purpose dummy variable). Estimated coefficients for other refinancings on fixed-rate and other refinance loans are not significantly different from zero but significant and negative on variable-rate loans. That estimated coefficients for these explanatory variables differ across types of interest rate should not be particularly surprising since differing circumstances may influence both choice of prepayment penalty and type of interest rate. A worthwhile area for further research is how borrower circumstances affect choices of prepayment penalty and choice of interest rate.

Loans originated through brokers are more likely to have prepayment penalties than loans originated directly by the lender. As evidence suggests that loans originated through brokers prepay faster than loans originated directly through lenders (LaCour-Little and Chun 1999), lenders may give brokers incentives to originate loans with prepayment penalties.[7] This result may be influenced by selection bias, however. Choice of distribution channel may itself be endogenous with choice of prepayment penalty.

[7] LaCour-Little and Chun hypothesized that lenders encounter an agency problem when third parties, such as brokers or correspondents, originate mortgages because third-party originators receive revenue from originations, not from the stream of mortgage payments. Since completing transactions with previous customers is often easier than finding new customers, third-party originators have an incentive to contact previous customers about refinancing existing loans. Third-party originators would also have little incentive to discourage refinancing if contacted by previous customers.

Finally and not surprisingly, state regulation of prepayment penalties influences the likelihood of a prepayment penalty for loans in the sample.[8] Loans in states with restrictions on prepayment penalties are significantly less likely to include prepayment penalties than loans in states with no restrictions. This estimated relationship influences the predicted probability of a prepayment penalty, which is used in place of the prepayment penalty dummy for the 2SLS risk-premium model.

RELATIONSHIP TO OTHER STUDIES

In order to assess whether our findings are unique to the companies contributing data to the FSRP's subprime mortgage database, we used the database to attempt to replicate the DeMong and Burroughs (2005) and Ernst (2005) studies that investigated the relationship between prepayment penalties and mortgage prices. We found that specifications similar to those in previous studies produced similar results in the FSRP's subprime mortgage database.

DeMong and Burroughs (2005)

DeMong and Burroughs (2005) estimated a single-equation model using OLS. The data consisted of 961,344 mortgages from several large national subprime lenders during 2004. The dependent variable was the annual percentage rate. They used five explanatory variables: (1) the FICO risk score, (2) the borrower's income, (3) the loan-to-value ratio, (4) a dummy variable indicating that the loan had reduced documentation requirements, and (5) a dummy variable indicating whether or not the loan had a prepayment penalty. FICO score, income, and the loan-to-value ratio were included as continuous variables. They estimated their model for first mortgage loans with a 30-year term to maturity.

We estimated the same model using data from 2004. We obtained similar results. FICO risk score and income were negatively related to the annual percentage rate. Reduced documentation requirements were positively related to the annual percentage rate (Table 5). The presence of a prepayment was negatively related to the annual percentage rate. All estimated coefficients were statistically significant.

Ernst (2005)

Ernst (2005) estimated a model explaining the interest rate as a function of loan to value, FICO risk score, the borrower's debt-to-income ratio, whether or not income was fully documented, dummy variables indicating property type, whether or not the loan conforms to Fannie Mae /Freddie Mac lending limit; the proportion of the population in the ZIP code area that is minority (non-whites); dummy variables for month of origination; and a dummy variable indicating whether or not the loan had a prepayment penalty. Data were from the Loan Performance System's subprime asset-backed securities database. The

[8] Recall some loans in the sample may be exempt from state level regulations that restrict prepayment penalties.

model was estimated for 30-year first mortgages originated in 2000, 2001, and 2002. The model was estimated for home purchase and refinance loans. Ernst used an instrumental value in place of the actual loan to value.

Differences in databases precluded exact replication of Ernst's model. The FSRP subprime mortgage database does not contain information on the type of property or the borrower's debt-to-income ratio. Also, for the 2000-2002 period, jumbo loans were not included and documentation was not reported. Type of property, documentation, and jumbo loan status could not be included. We substituted a proxy for the debt to income ratio, which was calculated as a ratio of the average debt per person in the borrower's zip code area and borrower's reported income.[9] We also used actual loan to value rather than an instrumental value in place of loan to value. Ernst did not provide information on how the instrumental variable was obtained.

Despite the few differences between our model and Ernst's model, we did replicate Ernst's key finding that the presence of prepayment penalties was associated no difference in interest rates or higher interest rates. Table 6 shows results for originations in 2002. Results for other years were similar.

However, the FSRP's subprime mortgage database contains additional risk-related variables, which are not available in the Loan Performance System database. These variables include borrower income, whether owner-occupied or not, and whether the loan was originated by a broker. With these variables added to Ernst's model, the estimated effect of a prepayment penalty is negative. Table 7 shows results for 2002 originations. Again, results for other years were similar.

CONCLUSIONS

This paper investigates the effect of prepayment penalties and the state laws that govern such penalties on the pricing of subprime mortgages. The paper is the first to consider that mortgage price and prepayment penalty may be chosen jointly, making single-equation estimates of the effect of prepayment penalty on price biased. Using a model that accounts for endogeneity of price, loan to value, and prepayment penalty, we find that prepayment penalties are associated with significantly lower prices for subprime mortgages. This finding is consistent with pricing of mortgage credit according to risk, a characteristic of the subprime market that allows lenders to make credit available to borrowers who would have difficulty obtaining such credit in the prime market. The finding is important because perceptions that prepayment penalties are not reflected in mortgage prices have led to regulation that could reduce the gains in mortgage credit availability that were achieved over the last decade.

Our estimates from 2SLS models—which address endogeneity of price, loan to value, and presence of a prepayment penalty—suggest that prepayment penalty reduces risk

[9] Average debt per person was obtained from TransUnion's TrenData database. TrenData provides aggregate statistics on credit use and payment behavior for different geographic areas. These statistics derived from a large sample of borrowers' credit files. See http://products.trendatatu.com/.

premiums by 38 basis points for fixed-rate loans, 13 basis points for variable-rate loans, and 18 basis points for hybrid loans. Our estimated reductions for prepayment penalties are within the size range of interest rate adjustments for prepayment penalties commonly found in lenders' loan pricing sheets and comparable in magnitude to common risk pricing adjustments for terms such as loan purpose, owner occupancy, type of property, loan amount, and term to maturity. Our estimated reductions in price for prepayment penalties are smaller than the single-equation estimates for fixed-rate and variable-rate mortgages and larger than the single-equation estimate for hybrid mortgages.

It is doubtful that our results are unique to our database of subprime mortgages. We replicate the models of two previous studies of the pricing of prepayment penalties using our database and find similar results in our study. Consideration of additional variables in one model reverses the previous author's finding on the effect of prepayment penalties on price. Clearly, results are sensitive to model specification and cautious interpretation of findings is warranted.

Mortgage choices are complex decisions involving simultaneous consideration of numerous loan terms. Choices may be influenced by borrower interactions with loan officers, mortgage brokers, or real estate agents. Data on mortgage transactions often do not include information on variables that play an important role in decisions. Such decisions require careful modeling to avoid biases due to simultaneity and selection. We share Yezer, Phillips, and Trost's (1994) skepticism of the ability of simple single-equation models to provide reliable estimates of many of the structural parameters of complex mortgage choices that are of interest for public policy and economic modeling.

REFERENCES

Amemiya, Takeshi. (September 1978). The Estimation of a Simultaneous Equation Generalized Probit Model. *Econometrica* (46): 1193-1205.

Avery. Robert B., Glenn B. Canner, and Robert E. Cook. (Summer 2005). New Information from HMDA and Some Implications for Fair-Lending Enforcement. *Federal Reserve Bulletin* (91): 344-94.

Bucks, Brian K., Arthur B. Kennickell, and Kevin B. Moore (March 2006). Recent Changes in U.S. Family Finances. *Federal Reserve Bulletin* (92): A1-A38.

Calomiris, Charles W. and Joseph R. Mason. (1999). *High Loan-to-Value Mortgage Lending: Problem or Cure?* Washington: AEI Press.

DeMong, Richard F. and James E. Burroughs. (2005). Prepayment Fees Lead to Lower Interest Rates. Working Paper. Charlottesville, Virginia, University of Virginia, McIntire School of Commerce.

Elliehausen, Gregory, Michael E. Staten, and George J. Wallace. (2005). Are Legislative Solutions to Abusive Mortgage Lending Practices Throwing Out the Baby with the Bathwater? *The Art of the Loan in the 21st Century: Producing, Pricing, and Regulating Credit*. Proceedings of the 41st Annual Conference on Bank Structure and Regulation. Chicago: Federal Reserve Bank of Chicago.

Ernst, Keith. (Jan. 2005) Borrowers Gain No Interest Rate Benefits from Prepayment Penalties on Subprime Mortgages. Research Report. Durham, N.C.: Center for Responsible Lending.

Goldstein, Debbie and Stacy Strohauer Son. (April 2, 2003). Why Prepayment Penalties are Abusive in Subprime Loans. CRL Policy Paper No. 4. Durham, North Carolina: Center for Responsible Lending.

Hausman, Jerry A. (November 1978). Specification Tests in Econometrics. *Econometrica* (46): 1251-1271.

Ho, Giang and Anthony Pennington-Cross. (June 2005). The Impact of Local Predatory Lending Laws. Working Paper 2005-049A. St. Louis, Missouri: Federal Reserve Bank of St. Louis.

LaCour-Little, Michael and Gregory H. Chun. (January 1999). Third Party Originators and Mortgage Prepayment Risk: An Agency Problem? *Journal of Real Estate Research* (17): 55-70.

Newey, Whitney K. (November 1987). Efficient Estimation of Limited Dependent Variable Models with Endogenous Explanatory Variables. *Journal of Econometrics* (36): 231-250.

Nabar, Prafulla G., Sang Yong Park, and Anthony Saunders. (January 1993). Prime Rate Changes: Is There an Advantage to Being First? *Journal of Business* (66): 69-92.

Phillips-Patrick, Fred, Eric Hirschhorn, Jonathan Jones, and John LaRocca. (June 2000). What about Subprime Mortgages?" *Mortgage Market Trends,* vol. 4. U.S. Department of the Treasury, Office of Thrift Supervision.

Rose, Morgan. (March 2007). Predatory Lending Practices and Subprime Foreclosures—Distinguishing Impacts by Loan Category. Paper presented at Financing Community Development, Federal Reserve System Community Affairs Research Conference, Washington, D.C.

Wallace, George, Gregory Elliehausen, and Michael Staten. (April 2004). Are Legislative Solutions to Abusive Mortgage Lending Practices Throwing Out the Baby With the Bath? Guidance from Empirical Research. Working Paper No. 68. Washington, D.C: Georgetown University, McDonough School of Business, Credit Research Center.

Woolridge, Jeffrey M. (2002) *Econometric Analysis of Cross Section and Panel Data.* Cambridge, Mass.: MIT Press.

Yezer, Anthony M.J., Robert F. Phillips, and Robert P. Trost. (Nov. 1994) Bias in Estimates of Discrimination and Default in Mortgage Lending: The Effects of Simultaneity and Self-Selection. *Journal of Real Estate Finance and Economics* (9): 197-217.

Table 1. Selected Characteristics of Closed-End First Mortgages, 2004: By Type of Interest Rate

	All	Type of Interest Rate		
	Loans	Fixed	Variable	Hybrid
Characteristic				
Average loan amount (dollars)	130,000	94,500	156,000	142,100
Loan purpose (percent)				
Home purchase	23	14	34	29
Cash-out refinancing	51	66	13	62
Other refinancing	25	19	53	9
Average appraised value of property (dollars)	162,300	132,000	190,000	188,300
Average annual percentage rate	10.07	10.71	8.43	9.78
Average loan to value (percent)	76	73	80	78
Average borrower income (dollars)	54,000	44,100	64,300	60,200
Average FICO score	613	624	608	599

Table 2. Descriptive Statistics of Regression Variables

Variable	Mean	Standard Deviation
Risk premium (percent)	5.06	1.96
Loan to value	.75	.18
Prepayment penalty (dummy variable)	.60	.49
Monthly income (dollars)	4,252	3,481
FICO score	605	62
Loan purpose (dummy variables)[1]		
Home purchase loan	.19	.40
Refinance loan, no cash-out	.25	.43
Owner occupied (dummy variable)	.90	.30
Broker origination (dummy variable)	.59	.49
Documentation (dummy variables)[1]		
Full documentation	.05	.21
Low documentation	.07	.26
Borrower age (dummy variables)[1]		
Age 20-44 years	.39	.49
Age 45-59 years	.40	.49
Age 60 or older	.20	.40
Value of homes in ZIP code area (proportion)[1]		
$100,000-199,999	.37	.19
$200,000-299,999	.10	.10
$300,000-499,999	.04	.07
$500,000 or more	.02	.04
Homeowner mobility in ZIP code area (proportion)[1]		
Moved within last year	.10	.04
Moved 1-4 years ago	.24	.06
Moved 5-10 years ago	.18	.04
Prepayment penalties restricted (dummy variable)	.15	.36

[1] **Excluded categories: Loan purpose, cash-out refinancings; documentation, unknown; borrower age, less than 20; value of homes, less than $100,000; homeowner mobility, moved more than 10 years ago.**

Table **3. Regression Results**

A. Risk Premium Equation

	Two-Stage Least Squares			Ordinary Least Squares		
Variable	**Fixed rate**	**Variable rate**	**Hybrid**	**Fixed rate**	**Variable rate**	**Hybrid**
Loan to value	0.027**	0.051**	0.167**	0.008**	-0.006**	0.008**
	26.39	77.14	79.56	39.56	36.95	46.75
Prepayment penalty	-5.328**	-6.442**	-2.252**	-0.462**	-0.299**	-0.037**
	108.7	141.99	51.98	70.78	75.82	7.68
Monthly income	-0.008**	-0.021**	-0.045**	-0.010**	-0.014**	-0.021**
	13.01	56.25	49.41	17.22	44.13	43.69
FICO score	-0.008**	-0.009**	-0.013**	-0.010**	-0.007**	-0.010**
	154.75	232.81	173.42	232.93	252.87	280.02
Home purchase loan	0.184**	-0.01	-0.147**	0.162**	-0.013*	0.283**
	16.32	1.56	13.85	17.02	2.37	58.25
Refinance, no cash out	-0.951**	-0.082**	-0.051**	-1.037**	-0.108**	0.214**
	143.19	14.16	3.77	156.77	21.99	29.27
Owner occupied	-0.460**	0.467**	-1.381**	-0.556**	0.467**	-0.850**
	47.59	65.31	85.21	56.99	77.93	102.76
Broker origination	0.903**	-0.078**	0.650**	0.156**	-0.293**	0.274**
	103.04	13.58	50.11	24.07	61.79	42.38
Full documentation	-1.509**	-0.890**	n.a.	-1.747**	-0.599**	n.a.
	136.06	154.43		165.52	129.75	
Low documentation	-0.991**	-0.488**	n.a.	-1.261**	-0.158**	n.a.
	65.8	75.58		84.04	31.12	
Prime rate	0.172**	0.602**	0.170**	0.184**	0.588**	0.131**
	104.02	503.48	82.05	110.73	593.14	115.34
Constant	10.643**	7.059**	2.647**	10.594**	5.900**	10.871**
	115.39	149.14	21.82	305.71	273.17	390.97
Observations	263,775	327,566	351,646	263,775	327,564	351,645
R-squared	0.44	0.55	0.05	0.43	0.66	0.24
F-statistic	20,314**	45,188**	4,538**	17,981**	58,896**	12,259**

Table **3. Regression Results (continued)**

B. Loan-to-Value Equation

	Two-Stage Least squares			Ordinary Least Squares		
	Fixed rate	**Variable rate**	**Hybrid**	**Fixed rate**	**Variable rate**	**Hybrid**
Risk premium	-1.215**	-0.974**	-5.425**	0.240**	-1.114**	0.418**
	13.68	50.98	18.75	13.1	79.88	24.77
Monthly income	0.250**	0.142**	0.075**	0.263**	0.143**	0.163**
	45.5	39.27	11.26	47.10	39.74	36.86
FICO score	-0.005**	0.023**	-0.027**	0.009**	0.022**	0.024**
	5.69	63.25	10.49	19.59	62.73	68.73
Home purchase loan	4.106**	0.522**	4.736**	3.911**	0.497**	3.064**
	44.96	8.15	48.72	43.66	7.77	69.23
Refinance, no cash out	-1.747**	-2.227**	3.095**	-0.245**	-2.269**	1.891**
	15.28	39.81	31.68	3.5	40.69	28.3
Owner occupied	-2.002**	-3.282**	-0.563*	-1.171**	-3.268**	3.943**
	19.04	47.2	2.39	12.78	47.12	51.05
Broker origination	-1.254**	-0.053	-0.820**	-1.253**	-0.118*	-0.597**
	19.52	0.97	11.25	19.73	2.17	9.6
Full documentation	-1.587**	-0.948**	n.a.	1.438**	-1.153**	n.a.
	7.63	16.49		13.92	21.36	
Low documentation	-2.166**	-1.716**	n.a.	0.025	-1.872**	n.a.
	11.1	29.17		0.18	32.71	
Age 20-44 years	0.318**	-0.108	-5.649**	0.590**	-0.028	0.915**
	3.22	0.17	17.08	6.12	0.04	16.42
Age 45 - 59 years	-2.199**	-3.432**	-7.442**	-1.899**	-3.398**	-1.020**
	22.31	3.59	22.75	19.84	3.56	15.24
Age 60 or older	-6.332**	-0.244	-12.049**	-5.806**	-0.176	-4.348**
	46.49	0.11	29.44	44.23	0.08	33.55
% of housing units	21.125**	14.305**	12.024**	20.988**	14.434**	-7.777**
$100,000-199,999	24.41	30.31	5.74	24.55	30.60	4.87
% of housing units	15.615**	12.302**	5.601**	17.723**	12.297**	-8.127**
$200,000-299,999	17.54	25.75	2.81	20.36	25.74	5.02
% of housing units	8.192**	9.095**	-11.493**	10.426**	9.048**	-25.124**
$300,00-499,999	9.38	19.37	6.46	12.22	19.27	17.67
% of housing units	-1.786	0.708	-4.905	0.44	0.794	-16.521**
$500,000 or more	1.29	0.97	1.45	0.32	1.09	5.72
Constant	69.385**	61.009**	120.171**	51.007**	62.168**	64.805**
	48.07	113.5	36.27	55.07	118.14	40.02
Observations	263,775	327,566	351,646	263,774	327,570	351,643
R-squared	0.06	0.10	0.01	0.08	0.10	0.07
F-ratio	1,355**	2,007**	1,245**	1,387**	2,243**	1,680**

Table 3. Regression Results (continued)

C. Prepayment Penalty Equation

	Instrumental Variable Probit			Probit		
	Fixed rate	Variable rate	Hybrid	Fixed rate	Variable rate	Hybrid
Risk premium	-0.022*	-0.023**	0.382**	-0.120**	-0.107**	0.008**
	2.57	8.56	36.67	66.16	56.11	3.96
Monthly income	0.001*	-0.005**	-0.003**	-0.001	-0.008**	-0.012**
	2.22	12.07	4.69	0.97	19.64	24.31
FICO score	0.001**	-0.000**	0.003**	0.000**	-0.001**	-0.001**
	13.31	5.59	26.51	6.36	18.04	15.7
Home purchase loan	0.094**	0	0.110**	0.123**	-0.012	0.248**
	9.54	0.02	15.24	13.03	1.32	42.44
Refinance, no cash out	0.017	-0.066**	0.037**	-0.075**	-0.096**	0.141**
	1.65	8.25	3.89	11.48	12.23	16.16
Owner occupied	0.039**	-0.021*	0.256**	-0.01	0.041**	-0.054**
	3.73	2.24	19.38	0.99	4.37	5.45
Broker origination	0.443**	0.115**	0.144**	0.438**	0.072**	0.272**
	74.11	15.24	17.15	74.14	9.73	37.69
Full documentation	0.235**	-0.193**	n.a.	0.037**	-0.312**	n.a.
	11.59	24.07		3.30	41.54	
Low documentation	0.279**	-0.236**	n.a.	0.130**	-0.317**	n.a.
	13.44	29.15		7.98	40.43	
% moved within last year	0.008**	0.027**	0.040**	0.005**	0.026**	0.015**
	6.92	30.64	17.96	4.43	28.67	7.5
% moved 1-4 years ago	-0.006**	-0.002**	0.058**	-0.005**	-0.002**	0.070**
	7.52	4.12	40.2	6.44	3.82	53.2
% moved 5-10 years ago	0.023**	0.021**	0.019**	0.021**	0.020**	0.023**
	23.43	28.57	10.83	22.03	27.29	13.75
Prepayment penalty restricted	-0.318**	-0.079**	-0.641**	-0.318**	-0.108**	-0.521**
	44.43	10.33	77.05	44.74	14.36	72.73
Constant	-0.739**	0.551**	-5.701**	0.506**	1.302**	-1.333**
	6.55	13.84	44.78	12.84	36.66	30.76
Observations	263,775	327,564	351,645	263,774	327,568	351,642
Chi-squared	12,946**	5,253**	26,186**	17,797**	8,531**	3,0106**

Notes: t-ratios or chi-squared statistics are below coefficients.
**** Significant at 1 percent level**
*** Significant at 5 percent level**
n.a. Not available

Table 4. Hausman Test

Loan Type	Chi-Squared
A. Mortgage price equation	
Fixed rate	599.87**
Variable rate	10,300**
Hybrid	19,300**
B. Loan-to-Value Equation	
Fixed rate	288.40**
Variable rate	114.40**
Hybrid	550.20**
C. Prepayment Penalty Equation	
Fixed rate	140.10**
Variable rate	1,886.55**
Hybrid	1,474.73**

**** Significant at 1 percent level.**

5. Replication of DeMong and Burrows (2005)

Variable	Coefficient	t-Statistic
A. Fixed-Rate Loans		
FICO score	-0.012**	190.45
Income	0.000**	57.57
Loan to value	2.274**	94.63
Low documentation	-0.424**	33.41
Full documentation	-1.085**	121.40
Prepayment penalty	-0.560**	63.76
Constant	14.899**	357.39
R-squared	0.44	
F-ratio	12,186**	
B. Variable-Rate Loans		
FICO score	-0.007**	180.65
Income	-0.000**	13.27
Loan to value	0.369**	17.67
Low documentation	0.249**	4.13
Full documentation	-.212**	3.51
Prepayment penalty	-0.277**	52.30
Constant	12.434**	190.31
R-squared	0.29	
F-ratio	6,794**	
C. Hybrid Loans		
FICO score	-0.011**	206.41
Income	0.000**	0.00
Loan to value	1.883**	0.00
Low documentation	n.a.	n.a.
Full documentation	n.a.	n.a.
Prepayment penalty	-0.246**	37.14
Constant	11.690**	167.00
R-squared	0.27	
F-ratio	11,686**	

Notes:
Values reported as 0.000 are less than 0.0005 in absolute value.
**** Significant at 1 percent level.**
n.a. Not available.

Table 6. Replication of Ernst (2005), 2002 Originations

Variable	Coefficient	t-Statistic
Prepayment penalty	1.197**	97.33
Loan to value	0.005**	16.67
Debt to income	0.000**	3.94
Minority share	0.181**	9.49
FICO score	-0.008**	127.84
Constant	11.935**	213.21
R-squared	0.26	
F-ratio	5,306 **	

Notes:
Coefficients of monthly dummy variables are not shown.
Values reported as 0.000 are less than 0.0005 in absolute value.
**** Significant at 1 percent level.**

Table 7. Augmented Ernst Model, 2002 Originations

Variable	Coefficient	t-Statistic
Prepayment penalty	-0.212**	15.72
Loan to value	0.014**	31.00
Debt to income	1.714**	43.35
Minority share	0.654**	10.25
Owner occupied	-1.244**	62.13
Broker originated	0.180**	9.62
Borrower's income	0.00**	3.68
FICO score	-0.011**	116.48
Constant	11.614**	147.33
R-squared	0.30	
F-ratio	8,602**	

Notes:
Coefficients of monthly dummy variables are not shown.
**** Significant at 1 percent level.**