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The effect of prepayment penalties on the pricing of subprime mortgages

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Abstract

This paper investigates the effect of prepayment penalties on the pricing of subprime residential 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 loan prices. This finding is important because perceptions that prepayment penalties harm borrowers have led many states to restrict their use, regulation that may reverse the gains in credit availability achieved over the last decade.

Keywords: Subprime mortgages; Financial regulation; Prepayment penalties

1. Introduction

A prepayment penalty is a fee that borrowers pay if they repay a mortgage within a specified period after origination, usually within the first 2 or 3 years. Borrowers may choose to prepay for several reasons including to purchase another home, to refinance the original loan to take advantage of a decline in interest rates, or to refinance to obtain additional cash, or restructure existing debts. Subprime borrowers may have an additional reason for prepayment: if their

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financial circumstances improve they may qualify for a lower interest rate.[1] A significantly higher proportion of subprime borrowers prepay, relative to prime borrowers (Phillips-Patrick, Hirschhorn, Jones, & LaRocca, 2000).

From the lender's standpoint, prepayment reduces the profitability of originating loans and the predictability of returns to investing in loans. A prepayment penalty offsets some of the lender's prepayment risk by encouraging borrowers to select loans based on their private information about 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.[2] The higher cost of lending to subprime borrowers without a prepayment penalty is reflected in wholesale price sheets for subprime loans, which often contain discreet adjustments (e.g., 50 basis points) in loan rates that effectively raise the discount rate that a lender will use when purchasing loans without a prepayment penalty or with relatively short prepayment penalty periods.[3]

Whether consumer 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 & 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). However, DeMong and Burroughs (2005) found that, controlling for a limited number of borrower and loan characteristics, loans with prepayment penalties have lower interest rates than loans without prepayment penalties. This result suggests a tradeoff confronting borrowers who shop for mortgages in markets that allow such penalties. Nevertheless, as of early 2007, at least 28 states restricted prepayment penalties on residential mortgages (Lacour-Little, 2007).

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 portion of the 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, in both studies, 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.

[1] "The effect [in terms of qualifying for a lower interest rate] of even a small improvement in the credit history score is much larger for borrowers in the higher-priced segment of the home loan market than for those in the prime segment." Avery, Canner, and Cook (2005), p. 369.

[2] Through simulations using commercial loan valuation software on pools of subprime mortgages, Lacour-Little (2007) shows that "the economic value of prepayment penalties is substantial to lenders and investors, increasing asset values by over 2 percentage points in the case of subprime loans" p. 27.

[3] Price sheets are tables of interest rates and points that lenders are willing to accept for different loan products. Price sheets are issued on a daily basis or more frequently.

Table 1
Selected characteristics of closed-end first mortgages, 2004: by type of interest rate

Characteristic	All loans	Type of interest rate		
		Fixed	Variable	Hybrid
Average loan amount (dollars)	130,000	94,500	156,000	142,100
Loan purpose (%)				
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 (%)	76	73	80	78
Average borrower income (dollars)	54,000	44,100	64,300	60,200
Average FICO score	613	624	608	599

2. Methodology

The data for this study are from the Financial Service Research Program's (FSRP) subprime mortgage database.[4] 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 subprime mortgage database covered nearly a quarter of higher priced home purchase and refinance mortgages originated on owner occupied homes in 2004 (Avery, Canner, & Cook, 2005). Estimates of higher priced loan 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.[5]

Lenders that contribute loan data to the subprime database service loans that they originate directly, as well as acquire through brokers and via purchase from other lenders. Nearly a quarter of the loans originated in 2004 were purchased from other lenders, and 58% of all loans were originated through brokers. These percentages are typical of the lenders' loan acquisitions over the time period of the database.

Nearly all of the loans, 94% in 2004, in the database are closed-end.[6] 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 (initial fixed rate for an introductory period, followed by variable rate thereafter) mortgages. Overall, 23% of closed-end first mortgages were used for home purchases, but loan

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

[5] For further discussion of market coverage of various subprime databases, see Wallace, Elliehausen, and Staten (2004).

[6] Closed-end loans are loans in which the borrower receives the proceeds of the loan at closing with full repayment of interest and principal required on a predetermined date. Closed-end loans often have scheduled periodic payments of principal and interest during the term of the loan. In contrast, an open-end loan has a predetermined maximum loan amount that can be used repeatedly in any amount up to the maximum at the borrower's discretion.

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% for fixed-rate mortgages, 8.43% for variable-rate mortgages, and 9.78% 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 incomes were lower in earlier years, while loan purpose distributions, annual percentage rates, 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.

2.1. 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 minus the rate for a Treasury security of comparable maturity. The annual percentage rate 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.

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. We excluded loans with loan amounts greater than 90% 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.[7] 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 borrower income, FICO risk score, and whether the home is owner occupied.[8]

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 should increase risk premiums since such regulation would increase the prepayment risk to lenders. Federal preemption allows certain lenders to offer loans with prepayment penalty terms that other types of lenders are prohibited from offering under state laws. This regulatory structure may influence competition and the range of loan

[7] A reduced documentation loan is a loan in which income, assets, or employment are not fully verified by the lender or documented by bank statements or tax documents.

[8] A FICO risk score is the widely used risk-scoring product developed by Fair, Isaac Corp.

Table 2
Descriptive statistics of regression variables

Variable	Mean	Standard deviation
Risk premium (%)	5.06	1.96
Loan to value	0.75	0.18
Prepayment penalty (dummy variable)	0.60	0.49
Monthly income (dollars)	4,252	3,481
FICO score	605	62
Loan purpose (dummy variables)[a]		
Home purchase loan	0.19	0.40
Refinance loan, no cash out	0.25	0.43
Owner occupied (dummy variable)	0.90	0.30
Broker origination (dummy variable)	0.59	0.49
Documentation (dummy variables)[a]		
Full documentation	0.05	0.21
Low documentation	0.07	0.26
Borrower age (dummy variables)[a]		
Age 20–44 years	0.39	0.49
Age 45–59 years	0.40	0.49
Age 60 or older	0.20	0.40
Value of homes in ZIP-code area (proportion)[a]		
$100,000–199,999	0.37	0.19
$200,000–299,999	0.10	0.10
$300,000–499,999	0.04	0.07
$500,000 or more	0.02	0.04
Homeowner mobility in ZIP-code area (proportion)[a]		
Moved within last year	0.10	0.04
Moved 1–4 years ago	0.24	0.06
Moved 5–10 years ago	0.18	0.04
Prepayment penalties restricted (dummy variable)	0.15	0.36

[a] Excluded categories: loan purpose, cash out refinancings; documentiation, unknown; borrower age, less than 20; value of homes, less than $100,000; homeowner mobility, moved more than 10 years ago.

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.[9] Descriptive statistics for the variables are reported in Table 2.

2.2. Estimation

Previous papers examining the effect of prepayment penalties on mortgage prices (DeMong & 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 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),

[9] See Ho and Pennington-Cross (2005) for a summary of state restrictions on prepayment penalties.

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 either to 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) investigated bias by conducting Monte Carlo experiments and found that single-equation models did not provide reliable evidence on the structural parameters describing the behavior of borrowers or lenders. Depending on the experiment, single-equation estimates were sometimes significant when the structural parameter was zero or insignificant when the parameter was not zero, or the magnitude of the estimated coefficient was considerably different from that of the structural parameter. Simultaneity is a factor in modeling loan choices that may cause single-equation estimates of parameters to be biased in an unknown direction and sensitive to differences in model specifications.[10] 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 (more than 3 years), 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, 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. Thus, choice of prepayment penalty would be endogenous in the loan decision.

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

$$\begin{aligned} y_{\mathrm{i}} &= ltv_{\mathrm{i}}'\alpha_0 + d_{\mathrm{i}}'\gamma_0 + X_{\mathrm{i}}'\beta_0 + Z_{y,\mathrm{i}}'\phi_0 + u_{\mathrm{i}} \\ ltv_{\mathrm{i}} &= y_{\mathrm{i}}'\lambda_1 + X_{\mathrm{i}}'\beta_1 + Z_{ltv,\mathrm{i}}'\phi_1 + v_{\mathrm{i}} \\ d_{\mathrm{i}} &= y_{\mathrm{i}}'\lambda_2 + X_{\mathrm{i}}'\beta_2 + Z_{d,\mathrm{i}}'\phi_2 + \xi_{\mathrm{i}} \end{aligned} \tag{1}$$

This system of simultaneous equations (1) 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

[10] See also Brueckner (1994) and LaCour-Little (2001).

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 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.[11] 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, & 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 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, & 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 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 (see Woolridge, 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.

[11] 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.

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

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

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-likelihood function.

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

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

To identify the last equation in (1), we implement Amemiya (1978) Generalized Least Squares (AGLS) estimator for probit with endogenous regressors.[12]

3. Findings

Two-stage least squares (2SLS) and single-equation estimates of our equations are presented in Table 3 . *F*-ratios indicate that each of the models estimated 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 (panel C). Statistical tests support the concern about endogenity 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.

3.1. Risk premiums

The estimated equations for risk premium generally explain a large percentage of the variation in risk premiums. In the two-stage least squares models, the effects of loan to value on risk premiums are uniformly positive, consistent with expectations, and larger in absolute value. In the single-equation ordinary least squares (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. Thus, OLS estimates of loan to value coefficients appear to be biased toward zero.

The predicted probability of a prepayment penalty in the 2SLS models and the prepayment dummy variable in the single-equation models are statistically significant and negatively related to risk premiums.[13] 2SLS and single-equation results for prepayment penalties are not directly

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

[13] 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. Neither of those studies allowed for endogeneity in the choice of loan price and prepayment penalty. We found that model specifications similar to those in previous studies produced similar results in the FSRP subprime mortgage database, including the key Ernst result of no relationship between loan price and prepayment penalty. However, the FSRP subprime mortgage database contains additional risk-related variables (borrower income, whether the home was owner-occupied, and whether the loan was originated by a broker) which are not available in the Ernst database. With these variables added to the Ernst model, the

Table 3
Regression Results

Variable	Two-stage least squares			Ordinary least squares		
	Fixed rate	Variable rate	Hybrid	Fixed rate	Variable rate	Hybrid
(A) Risk premium equation						
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**
(B) Loan to value equation						
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

Table 3 (*Continued*)

Variable	Two-stage least squares			Ordinary least squares		
	Fixed rate	Variable rate	Hybrid	Fixed rate	Variable rate	Hybrid
% 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**

Variable	Instrumental variable probit			Probit		
	Fixed rate	Variable rate	Hybrid	Fixed rate	Variable rate	Hybrid
(C) Prepayment penalty equation						
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**

Note: *t*-ratios or chi-squared statistics are below coefficients. n.a. Not available.

** Significant at 1% level.

* Significant at 5% level.

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% level.

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). The magnitude of the bias is notable, even if the sign of the coefficients is the same. These estimated reductions are 21% and 131% smaller than the single-equation estimates for fixed-rate and variable-rate mortgages, respectively and 3 3/4 times larger than the single-equation estimate for hybrid mortgages.

Our estimated effects for prepayment penalties are within the 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 price sheets. 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 generally statistically significant. 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 sign across products may reflect correlations with explanatory variables that are not available in the dataset or possible endgogenity.

3.2. Loan to value

The effect of risk premium on loan to value is negative (i.e., higher risk premiums are observed on loans with more borrower equity) in the 2SLS equations (and in one of the OLS equations). These results may reflect self-selection. Age, a proxy for wealth, has the expected negative effect

estimated effect of a prepayment penalty on loan price is negative. For more details see Elliehausen, Staten, and Steinbucks (2007).

on loan to value. Mortgages in areas with large proportions of moderately valued homes have larger loan to value ratios, especially in the $100,000–199,999 range but to lesser extents in the $200,000–299,999 and $300,000–499,999 ranges. A larger proportion of homes valued $500,000 or more is not significantly related to loan to value, however. Income is positively related to loan to value. 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 non-mortgage 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.

3.3. 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. Estimated effects of income, FICO score, and loan purpose vary by type of interest rate. That the estimated coefficients for these explanatory variables differ 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 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 & Chun, 1999), lenders may give brokers incentives to originate loans with prepayment penalties.[14] This result may be influenced by selection bias, however. Choice of distribution channel may itself be endogenous with choice of prepayment penalty.

Finally and not surprisingly, state regulation of prepayment penalties influences the likelihood of a prepayment penalty for loans in the sample.[15] 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.

4. Conclusions

Mortgage choices are complex decisions involving simultaneous consideration of numerous loan terms. This 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. Our estimates from two-stage least squares models – which address endogeneity of price,

[14] 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.

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

loan to value, and presence of a prepayment penalty – suggest that 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. These estimated reductions for prepayment penalties are within the range of interest rate adjustments for prepayment penalties commonly found in lenders' wholesale loan pricing sheets and are comparable in magnitude to the risk pricing adjustments for other loan features such as loan purpose, owner occupancy, type of property, loan amount, and term to maturity.

These findings contradict the negative perceptions regarding prepayment penalties that have led to restrictive regulation in many states. Risk-based pricing has enabled lenders to make credit available to many borrowers who would have difficulty obtaining such credit in the prime market. Where allowed, prepayment penalties offer borrowers a lower price in exchange for assuming some of the risk (and associated costs) of prepayment. Our results suggest that limits on the tools lenders use to offset higher risk – such as prepayment penalties – effectively raise prices to borrowers.

It is doubtful that our results are unique to our particular database of subprime mortgages. Using our database, we re-estimated the models used in two previous studies of the pricing of prepayment penalties, and found results similar to those of the original authors. However, consideration of additional variables in one model reversed 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. We share Yezer et al.'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.

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