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An empirical analysis of home equity loan and line performance ☆

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Abstract

Given the growth in home equity lending during the 1990s, it is imperative that lenders and regulators understand the risks associated with this segment of the residential mortgage market. Using a unique panel data set of over 135,000 homeowners with second mortgages, our analysis indicates that significant differences exist in the prepayment and default probabilities of home equity loans and lines, providing insights into bank minimum capital requirements. We find that households with equity loans are relatively more sensitive to changes in interest rates. By contrast, households with equity lines are more sensitive to appreciation in property value.
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1. Introduction

During the 1990s home equity lending in the form of home equity loans and home equity lines of credit increased significantly. According to Canner et al. (1998), commercial banks, savings institutions and credit unions held over $131 billion in home equity lines and another $129 billion in home equity loans at the end of 1997. Furthermore, they report that these figures are about 60 percent above their 1993 levels. More recently, evidence from the Survey of Consumer Finances suggests that the home equity lending market increased over 26 percent between 1998 and 2001 to $329 billion.[1] As a result, home equity credit now accounts for a sizeable segment of the consumer lending market. However, relatively little is known about the risk characteristics of these loans.

Standard mortgage option pricing models recognize that default risk increases as the mortgage amount increases relative to the collateral value (loan-to-value). Consistent with the positive relation between default risk and loan-to-value identified by option pricing models, home equity credit is usually classified as junior debt, having a lower priority claim on the underlying collateral relative to traditional first mortgage debt. As a result, default experiences may differ across portfolios of second and first mortgages.

In addition, traditional models of borrower choice of mortgage terms suggest that lenders offer various mortgage contracts as a mechanism for separating heterogeneous borrowers.[2] For example, Brueckner (1994) presents a model recognizing that lenders can utilize mortgage points to effectively induce borrowers to self-select mortgage contacts based on unobserved heterogeneity with respect to mobility. The implications of Brueckner's analysis suggest that unobserved differences could also exist among borrowers who choose to originate second mortgages versus those with only first mortgages. For example, borrowers wishing to tap current home equity, yet anticipate short mortgage tenure, may find the combination of low origination costs and higher contract interest rates associated with second mortgages more appealing than the higher origination costs and lower contract interest rates available on first mortgages. Furthermore, Campbell and Cocco's (2003) analysis of optimal first mortgage choice implies that borrower choice between second mortgage products (variable-rate credit lines versus fixed-rate loans) may also reveal unobserved heterogeneity in borrower risk profiles. As a result, prepayment and default performance across first and second mortgage products may differ.

While traditional loan performance models focus on primary mortgages, few studies have looked at the performance of home equity credit. With the exception of two recent empirical studies of home equity loans (Lai and Yang, 2003) and home equity (or credit) lines (Agarwal et al., 2005), little is known about why homeowners prepay or default on their second mortgages and no formal comparison of home equity line and home equity loan performance exists. Thus, the question this paper addresses is: Are there any system-

[1] Jim Follain at the Board of Governors of the Federal Reserve System provided the estimates of the 1998 and 2001 home equity lending market based on the 1998 and 2001 Survey of Consumer Finances.

[2] See Brueckner (1994), Posey and Yavas (2001), Saaadu and Sirmans (1995), Follain (1990), and Brueckner and Follain (1988), among many others, for theoretical and empirical models showing how borrower mortgage choice can be used as a screening mechanism for unobserved heterogeneity.

atic differences in the performance of home equity lines and loans and if so, what is the nature of these differences?

To answer this question, we empirically assess and compare the prepayment and default patterns of home equity lines and loans.[3] We use a loan level model to study the effects of market changes in home price values, borrower credit quality, macroeconomic conditions, as well as interest rate exposure on the likelihood that a homeowner prepays or defaults on his/her second mortgage. We accomplish our empirical objective using data on over 135,000 homeowners with home equity lines or home equity loans that were originated at multiple financial institutions between January 1994 and May 2001. This time period is especially important due to a highly fluctuating interest rate environment, dramatic appreciation in home prices, and a worsening labor market. Furthermore, we also compare the termination probabilities of home equity loans and credit lines with a sample of over 121,000 first mortgages originated by the same financial institutions during the same period. Thus, our study offers an analysis of the prepayment and default patterns of first and second mortgages while explicitly controlling for borrower risk characteristics. As a result, our analysis provides insights for policy makers considering the risks associated with various mortgage types when determining regulatory capital requirements for residential mortgages.

To preview our results, we find that prepayment and default behavior of borrowers of home equity lines differs from that of borrowers of home equity loans. We estimate that a one percentage point drop in mortgage interest rates increases the prepayment rate of home equity loans by 17.3 percent and credit lines by 9.6 percent. These results suggest that households holding home equity loans are highly sensitive to financial savings resulting from lower rates and thus may prepay and refinance their loans to take advantage of the interest savings.

Moreover, a 5 percent drop in borrower credit quality (as proxied by their FICO score) decreases the likelihood of a homeowner prepaying a home equity loan by 7.5 percent and a credit line by 3 percent. The same drop in borrower credit quality increases the probability of default for home equity loans by 17.2 percent and for home equity lines by 7.2 percent. We also find that a 10 percent appreciation in home prices raises the prepayment rate of loans by 4.8 percent and lines by 16.4 percent, suggesting that households with equity lines are relatively more sensitive to equity accumulation. The implications of this activity on proposed capital requirements are pronounced.

The remainder of the paper is structured as follows. Section 2 provides a brief discussion of the differences between consumers who originate home equity lines versus home equity loans and the potential motivation for prepayment and default of lines versus loans. Section 3 describes the empirical method and the data. Section 4 discusses the regression results for the prepayment and default behavior for loans and lines. Section 5 discusses the implications of the results with respect to recent Basel Accord proposals on minimum bank capital requirements. Finally, Section 6 offers concluding remarks.

[3] Consistent with previous literature (e.g. Ambrose and Capone, 2000) and accepted industry conventions, we classify loans as being in 'default' upon 90-days delinquency.

2. Differences between home equity lines and loans

The differences between bank "spot" loans and lines of credit with respect to business credit are well documented. For example, Strahan (1999) notes that firms utilize lines of credit to meet short-term liquidity needs, while 'term loans' primarily finance long-term investments. In consumer lending, the distinction between bank spot loans and credit lines is also substantial. Home equity credit is classified into either home equity loans (i.e. "spot" loans) or home equity lines (i.e. credit lines or lines of credit). A spot loan is a closed-end loan extended for a specified length of time requiring repayment of interest and principal in equal monthly installments. Interest on these loans is usually fixed at the time of loan origination. On the other hand, a credit line is an open-ended, variable rate, revolving credit facility that permits the consumer to borrow up to a predetermined amount (the line amount).[4] A typical line is open for five years during which the borrower is only required to pay interest on the used portion of the line (i.e., the takedown). After five years, the line is closed and converts to a fully amortizing loan.

Canner et al. (1998) document that consumers with lines typically own relatively expensive homes, have higher incomes, and have substantial home equity. In fact, they show that median household income for credit line borrowers is $10,000 more than that for spot loan borrowers. The median home equity among the line holders is $76,000 as opposed to $35,000 for loan holders. Finally, 23 percent of the loan holders are below the age of 34, whereas only 6 percent of the lines holders are below the age of 34. According the Survey of Consumers conducted from May to October 1997, there are other differences between line and loan consumers as well. For instance, the survey indicates that 49 percent of the households who prefer loans over lines are relatively more sensitive to interest rates—indicating that the variable rate feature of credit lines is a distinct disadvantage to certain consumers. In addition, the survey shows that 43 percent of households cite the "ease of use" as the primary motivation for choosing a line as opposed to 1 percent citing this feature as the motivation for choosing a loan.

As indicated in Table 1, our sample of home equity loan and credit line borrowers confirms the general trends observed by Canner et al. (1998). The home equity loans have fixed interest rates and are issued for 10 and 20 year terms, while the home equity credit lines have monthly adjusting interest rates. Based on the t-statistics testing for differences in the sample means, it is clear that borrowers who choose home equity loans have significantly lower credit quality scores and significantly higher initial loan-to-value ratios. However, credit line borrowers have significantly greater access to credit with a mean credit line of $62,404 versus a mean loan amount of $51,314.[5]

Previous studies of first mortgages have documented that borrower characteristics, such as expected mobility, play an important role in determining choice among mortgage contacts (e.g. Brueckner, 1994; Brueckner and Follain, 1988; and Dhillon et al., 1987). Thus, the differences in the characteristics of borrowers originating home equity spot loans and home equity credit lines also imply that the choice of home equity credit is endogenous.

[4] Demong and Lindgren (1995) document that 90 percent of all credit lines are variable rate loans.

[5] All loan amounts are expressed in May 2002 dollars.

Table 1
Summary statistics for loans and lines at origination (mean values)

Variable	Equity loans	Equity lines	*t*-stat for mean diff.
Prior fraud indicator	0.03%	0.01%	0.95
Prior delinquency indicator	2.43%	2.09%	1.73
Prior bankruptcy indicator	0.11%	0.10%	0.24
Prior foreclosure indicator	0.01%	0.02%	0.59
Prior liens indicator	0.82%	0.75%	0.59
Refi indicator	66.61%	52.34%	22.04*
Owner occupancy	98.60%	97.68%	5.07*
Debt to income	75.00%	34.00%	232.30*
Loan/line amount	$51,314	$62,404	19.30*
Balance at origination	$51,314	$25,385	194.20*
FICO score	723	735	14.72*
Loan to value	71%	54%	50.60*
No. of accounts	56,055	78,981	

* Significant at the 5% level.

For example, borrowers tapping into their home equity for debt consolidation or financing their current spending are more likely to choose home equity spot loans over credit lines due to the lower risk associated with spot loans having fixed interest rates. Alternatively, borrowers who anticipate future consumption expenditures may prefer home equity lines over spot loans since credit line facilities provide borrowers with the flexibility to take down credit when required, thus avoiding interest charges on unnecessary credit. Finally, credit lines may be preferred by borrowers with expectations of future credit shocks, since these shocks may limit future access to credit (e.g. Agarwal et al., 2005). The implication of these differences in origination reasons implies that borrower prepayment and default propensity may also vary depending upon loan or line choice.

Archer and Ling (1993) broadly categorize prepayment models into two types: call-motivated or endogenous prepayment and non-call-motivated or exogenous prepayment. The former theoretical work focuses on the valuation and exercise of the optimal embedded call option to prepay as mortgage rates fluctuate over time.[6] The theoretical option pricing model is based on the recognition that a mortgage can be viewed as a fixed-income instrument combined with American call and put options held by the borrower and written by the lender. The call option reflects the borrower's right to prepay the mortgage at any time while the put option captures the borrower's ability to default on the loan contract. Based on this framework, Kau et al. (1992, 1993) show that fixed and variable-rate mortgage values depend upon two stochastic processes, the market interest rate and the house value. As a result, the theoretical option-pricing model serves as a basis for specifying and testing empirical models of mortgage termination.

The implication of call prepayment is that homeowners are financially motivated to prepay their mortgages. When current mortgage rates are lower than their existing contract

[6] See Dunn and McConnell (1981), Green and Shoven (1986), Quigley (1987), Follain et al. (1992), Kau and Kim (1992), Kau et al. (1992), McConnell and Singh (1994), and Deng (1997), among others.

rates, households have an incentive to refinance and prepay their existing mortgages. The benefit to the household is a gain in their present value of wealth.

However, not all borrowers are able to refinance their mortgages even if there is equity or even if the call option is *in the money*. For example, borrower ability to refinance can be constrained by other factors such as transaction costs, unemployment, or lower borrower credit scores (see, e.g., Quigley, 1987; Archer and Ling, 1993; Stanton, 1995; Green and LaCour-Little, 1997; Archer et al., 1997; Peristiani et al., 1997). Households with limited savings and/or borrowers facing negative income shocks (e.g., unemployment) may be unable to absorb the refinancing transaction costs involved, despite the savings benefit of the interest rate reduction. Furthermore, these borrowers may also be credit constrained and thereby cannot refinance even if they want to absorb the savings benefits of the interest rate reduction and have the money to cover the refinancing costs. Furthermore, borrower mobility may result in prepayment when the call option is *out of the money* due to the common use of due-on-sale clauses in conventional mortgages. As a result, the second type of empirical mortgage termination model explicitly incorporates exogenous, non-financial factors into the borrower termination decision.

On the other hand, recent empirical patterns suggest that households prepay even when current market rates are above the existing contract rate (see, e.g., Agarwal et al., 2003), suggesting that borrowers sub-optimally refinance and prepay despite no gain in their overall present value of wealth. Stanton (1995) raises consumption smoothing as a possible reason for this empirical pattern. Hurst (1999) and Hurst and Stafford (2004) argue that households, particularly those who are credit or liquidity-constrained, refinance because they want to withdraw equity from their home in order to fund current and future consumption.[7] In particular, Hurst and Stafford (2004) show that credit or liquidity-constrained households use 60 percent of cashed-out equity to finance current consumption.

Conversely, borrowers may have little incentive to refinance and tap into equity if there is no or very little equity in the home. Caplin et al. (1997) argue that depreciation in property values make it less likely for homeowners to refinance and thereby may constrain borrowers from taking advantage of the interest rate reduction. They estimate that in states with weak property markets, the rate of refinancing is reduced by 50 percent compared to the refinancing rate of the remaining sample. Bennet et al. (2000) also empirically find that homeowners who face depreciation in their home have insufficient collateral to prepay their loans, despite financial incentives.

This consumption smoothing motive is especially important in light of the 1998–1999 stock market boom that led people to cash out home equity and invest it in the stock market and the 2000–2001 consumption boom during a slowing macroeconomic environment and

[7] Adverse liquidity shocks could include a homeowner encountering a loss of job, a large medical bill, divorce expenses, or tuition expenses of a child, all of which could force homeowners to draw down home equity. According to Canner et al. (1998), while 69 percent of homeowners cite home improvement as one of the motivating factors to cash out equity, 17 percent of homeowners cite children education, and 13 percent of homeowners cite vacation as the motivating factor. For further discussion on the reasons to refinance a mortgage also see Hurst (1999), Bennett et al. (1998, 2000), Agarwal et al. (2003), and Hurst and Stafford (2004).

falling stock market.[8] Some have attributed the impetus for this consumption boom to the ability to cash out home equity.[9]

The above factors that motivate or constrain homeowners to prepaying their mortgage can be extended to the prepayment of second mortgages—home equity loans and lines—particularly when homeowners use the underlying property to secure the credit and have the option to prepay at any time. However, while there is ample research on prepayment of primary mortgages, there is very little research on prepayment of second mortgages such as home equity loans and lines.[10] To the best of our knowledge, we only know two recent papers, one by Lai and Yang (2003) that studies the prepayment behavior of home equity loans, and another paper by Agarwal et al. (2005) that assesses the prepayment behavior of home equity lines.[11]

Lai and Yang (2003) estimate a discrete-time logistic regression using loan level data. They do not find substantial differences in the factors that affect the prepayment of first and second mortgage loans. As with first mortgages, they find that market interest rates, the homeowner's credit rating, and house price appreciation to be important in the homeowner's decision to prepay a home equity loan. Meanwhile, Agarwal et al. (2005) empirically estimate the impact of changes in credit risk on homeowner credit line utilization. They conclude that borrowers with higher expected future liquidity shocks originate credit lines to preserve financial flexibility. Moreover, they show that a rise in a borrower's credit quality increases the likelihood of prepayment of home equity lines.

3. Empirical method and data

Since it is well developed in the theoretical mortgage pricing literature that prepayment and default are substitutes (e.g. Kau et al., 1992), the standard approach in empirical mortgage modeling research recognizes the ability of the borrower to terminate the mortgage through either prepayment or default in a competing risks hazard framework. For example, Deng et al. (2000) and Ambrose and LaCour-Little (2001) explicitly recognize the interrelated prepayment and default options in fixed-rate and adjustable-rate mortgages,

[8] Quarterly refinancing data from Freddie Mac shows that during the 1998–1999 refinance wave roughly 50 percent of refinancing was cash-out. Even more striking was the fact that during the 2000–2001 refinance boom, over 80 percent were cash-out refinancing.

[9] A recent WSJ (7/26/2001) article cites several examples including a consumer who says, "I just didn't want to let $70,000 sit in the home." Examples of studies exploring the issues of households choosing to prepay and refinance to remove home equity to invest in the stock market, finance the expanding family, or due to unexpected adverse shocks are Dickinson and Heuson (1994), and VanderHoff (1996).

[10] Empirical research on primary mortgage prepayment has generally focused on single-family residential mortgages (e.g., Green and Shoven, 1986; Quigley, 1987; Quigley and Van Order, 1995; Archer et al., 1997; Deng et al., 2000; and Ambrose and LaCour-Little, 2001). Other empirical research use publicly available agency mortgage-pool data, in which information on the underlying *loans* is limited to pool type, issuer, time, and weighted average note rate (e.g., Richard and Roll, 1989; Schwartz and Torous, 1989; Mattey and Wallace, 2001).

[11] Other studies have looked at second mortgages but not with respect to their prepayment behavior (e.g. Manchester and Poterba, 1989; and Ambrose and Sanders, 2005). On the other hand, Westhoff and Feldman (1997) focused on prepayment of home equity securities.

respectively, while Ambrose and Capone (2000) also empirically model cases of borrowers with multiple defaults in a competing risks framework.[12]

As with Ambrose and LaCour-Little (2001), we estimate a competing risk model of mortgage termination following the methodology employed by Deng et al. (2000), which is based on the maximum likelihood estimation approach for the proportional hazard model with grouped duration data developed by Han and Hausman (1990), Sueyoshi (1992), and McCall (1996). We assume that the time to prepayment, T_p, and time to default, T_d, are random variables that have continuous probability distributions, $f(t_j)$, where t_j is a realization of T_j $(j = p, d)$. The joint survivor function conditional on factors θ_p, θ_d, r, H, X, and Z, $S(t_p, t_d \mid r, H, X, Z, \theta_p, \theta_d) = Pr(T_p > t_p, T_d > t_d \mid r, H, X, Z, \theta_p, \theta_d)$, is defined as

$$S(t_p, t_d \mid r, H, X, Z, \theta_p, \theta_d) = \exp\left(-\theta_p \sum_{n=1}^{t_p} \exp\left(\alpha_{pn} + g_{pn}(r, H, X) + \beta_p' Z\right) - \theta_d \sum_{n=1}^{t_d} \exp\left(\alpha_{dn} + g_{dn}(r, H, X) + \beta_d' Z\right)\right) \tag{1}$$

where $g_{jn}(r, H, X)$ are time-varying functions of the relevant interest rates (r), property values (H), and borrower characteristics (X), Z represents macroeconomic factors (possibly time-varying), and θ_p and θ_d are unobservable heterogeneity factors.[13] The parameters α_{jn} are the baseline hazard parameters estimated as

$$\alpha_{jn} = \log\left[\int_{n-1}^{n} \lambda_j(t)\,\mathrm{d}t\right] \tag{2}$$

where $\lambda_j(t)$ is the underlying continuous-time baseline hazard function, and $j = p, d$.

Following Deng et al. (2000), we note that the dataset consists of M distinct borrower groups with the joint distribution of unobservable heterogeneity factors (θ_p and θ_d) modeled by assuming that the unobserved borrower types occur with frequency γ_m, $m = 1, \ldots, M$. Furthermore, following McCall (1996), we note that only the duration associated with a particular termination type is observed ($t = \min(t_p, t_d)$). Thus, we define the probabilities of mortgage termination as[14]

$$\begin{aligned} A_p(t \mid \theta_p, \theta_d) = {} & S(t, t \mid \theta_p, \theta_d) - S(t+1, t \mid \theta_p, \theta_d) - 0.5\big\{S(t, t \mid \theta_p, \theta_d) \\ & + S(t+1, t+1 \mid \theta_p, \theta_d) - S(t, t+1 \mid \theta_p, \theta_d) \\ & - S(t+1, t \mid \theta_p, \theta_d)\big\}, \end{aligned} \tag{3}$$

[12] Competing risks models are well developed in the labor economics literature (see Mealli and Pudney, 1996; Burdett et al., 1985; Narendranathan and Steward, 1993; and Flinn and Heckman, 1982). These models are based on techniques of survival analysis, which was originated in biological studies of mortality and have found frequent application in industrial engineering failure-time studies as well as economic studies related to employment and labor issues. Kalbfleisch and Prentice (1980), and Cox and Oakes (1985) provide a classic statistical discussion of the topic; Kiefer (1988) provides a review of the economic literature on duration modeling.

[13] See McCall (1996), Appendix B.

[14] The dependence of the functions in Eqs. (3)–(5) on r, H, X, and Z has been omitted for ease of exposition.

$$A_d(t \mid \theta_p, \theta_d) = S(t, t \mid \theta_p, \theta_d) - S(t+1, t \mid \theta_p, \theta_d) - 0.5\big\{S(t, t \mid \theta_p, \theta_d) + S(t+1, t+1 \mid \theta_p, \theta_d) - S(t, t+1 \mid \theta_p, \theta_d) - S(t+1, t \mid \theta_p, \theta_d)\big\}, \tag{4}$$

and

$$A_c(t \mid \theta_p, \theta_d) = S(t, t \mid \theta_p, \theta_d). \tag{5}$$

The probabilities of mortgage termination by prepayment and default are represented by the functions A_p and A_d, respectively, while A_c represents the probability that the observation is censored due to the ending of the data collection period. The term in braces in Eqs. (3) and (4) is the adjustment factor necessary due to discrete time measurement of duration.

The unconditional probabilities are given by

$$A_j(t) = \sum_{m=1}^{M} \gamma_m A_j(t \mid \theta_{pm}, \theta_{dm}), \quad j = p, d, c, \tag{6}$$

and the log-likelihood function of the competing risks model is given by

$$\log L = \sum_{i=1}^{N} \delta_{pi} \log\big(A_p(T_i)\big) + \delta_{di} \log\big(A_d(T_i)\big) + \delta_{ci} \log\big(A_c(T_i)\big) \tag{7}$$

where δ_{ij}, $j = p, d, c$, are indicator variables denoting that the ith loan is terminated by prepayment, default, or is censored. Equation (7) is estimated via maximum likelihood.

As described above, our dataset consists of 135,036 owner-occupied home equity loans and lines originated by multiple financial institutions from January 1994 to May 2001 with performance data observed over the period from May 1998 to May 2002. Thus, we create a monthly record of each loan denoting whether the mortgage prepaid, defaulted, or is still current as of May 2002. During this period, 21,152 (27 percent) credit lines prepaid and 17,441 (29 percent) home equity loans prepaid.[15] The dataset contains loan level characteristics, such as the original loan amount, the current loan to value ratio (reflecting both the first mortgage and the home equity loan or line), and the contract interest rate. Borrower characteristics include the credit score (FICO) at origination as well as quarterly updates over the sample period. To provide a baseline comparison, we also collected performance information on 121,303 traditional 30-year fixed-rate (FRM) first mortgages originated by the same financial institution in the same geographical region and over the same time period.[16]

In modeling the probability of prepayment for credit lines and home equity loans, we incorporate a set of explanatory variables that capture financial incentives and consumption

[15] We excluded from the analysis loans or lines that had origination dates less than three months from end of the study period, that had terms greater than 20 years, and that were paid off but still carried on the lender's books.

[16] Unfortunately, we are unable to determine whether the first-mortgage borrowers subsequently originated a credit line or home equity loan. To the extent that subsequent debt may impact the borrower's ability to refinance, the presence of junior debt may alter the default and prepayment probabilities of the first mortgage.

smoothing motives of prepayment and refinancing. For example, to approximate the value of the borrower's prepayment option, we follow the approach outlined in Deng et al. (2000) and estimate the prepayment option as

$$OPTION_{i,t} = \frac{V_{i,t} - V^*_{i,t}}{V_{i,t}} \tag{8}$$

where $V_{i,t}$ is the market value of loan i at time t (i.e., the present value of the remaining mortgage payments at the current market mortgage rate), and $V^*_{i,t}$ is the book-value of loan i at time t (i.e., the present value of the remaining mortgage payments at the contract interest rate).[17] For the set of first mortgages, we calculate $V_{i,t}$ using the Freddie Mac 30-year fixed-rate mortgage interest rate survey for month t as a proxy for the current market mortgage rate at time t.[18] For the set of home equity lines and home equity loans, we calculate $V_{i,t}$ by using the current period t market interest rate on home equity lines and home equity loans, respectively.[19] Since consumers are more likely to prepay and refinance following a decline in the prevailing mortgage rate relative to the original coupon rate, a positive value for *OPTION* is indicative of an "in-the-money" prepayment option. In order to account for any non-linearity in the prepayment option, we also include the square of *OPTION*.

Following Lai and Yang (2003), we also include two additional variables that capture the financial incentives to prepay. First, we create a dummy variable denoting periods when the borrower's call option is in the money (*InMoney*), and second, a variable *DSpread* that captures the interaction between *InMoney* with the prepayment option (*OPTION*). We hypothesize that borrowers considering prepaying should be more sensitive to the call-option being in the money as compared to those borrowers with call-option "out of the money." The coefficient for *DSpread* is expected to be positive indicating a positive impact on the likelihood of borrower prepayment.

To determine the impact of changing property values on loan and line termination probabilities, we matched each observation with the ZIP Code level Case—Shiller Home Price Indices. In cases where we are unable to match to zip code level price indices, we use the OFHEO MSA level repeat sales indices.[20] Based on the estimated changes in house prices, we construct time-varying loan-to-value ratios (*CLTV*) where the loan value is the total outstanding loan balance that includes the first mortgage.[21] We expect *CLTV* to be negatively related to prepayment since depreciation in property values, holding other things constant,

[17] This is the equivalent to the prepayment option value used by Archer et al. (1996) scaled by the mortgage book-value.

[18] http://research.stlouisfed.org/fred2/series/MORTG/114.

[19] Current period t home equity line and home equity loan market interest rates were obtained from the Heitman Group (http://www.heitman.com).

[20] Overall, 12.4 percent of the observations use the OFHEO index. Moreover, since both the Cash–Shiller and the OFHEO indices use the same underlying index construction methodology they are highly correlated (see Case et al., 2003).

[21] The CLTV ratio does not account for first mortgage amortization since details concerning first mortgage interest rates and terms are unknown. As a result, our CLTV variable overstates the borrower's total debt position and the resulting bias increases as the first mortgage ages. However, significant principal amortization occurs mainly toward the end of the mortgage term, and, given the historically high refinancing activity during the study

serves as a collateral constraint for households to secure a new loan. Therefore, while house price appreciation (lower *CLTV*) may promote households to tap into their home equity, house price depreciation (higher *CLTV*) is expected to reduce of the likelihood of a borrower prepaying. We also include the square of *CLTV* to control for any non-linearity.

In addition to changes in the underlying property values relative to the debt burden, we also capture changes in borrower credit constraints via the time-varying borrower credit score (*FICO*). Borrower credit history is one of the key determinants of mortgage loan approval. Borrowers with good credit history are able to obtain credit with ease; thus, they are able to take advantage of refinancing opportunities. Conversely, borrowers with poor credit scores are credit-constrained since they may have difficulty qualifying for new credit at any price or, if credit is available, the interest rate or transaction costs make the new loan prohibitively expensive (see Peristiani et al., 1997; and Bennet et al., 2000). Similarly, Agarwal et al. (2005) show that liquidity-constrained borrowers (e.g., borrowers with deteriorating credit quality), who have home equity lines, are more likely to raise their utilization rates rather than pay down the line. Thus, we expect the *FICO* score to be positively related to prepayment, implying that borrowers with lower current *FICO* scores are less likely to prepay their home equity loans and lines. We also include the square of *FICO* to capture any non-linearity present in borrower credit scores.

Local economic conditions also impact mortgage termination decisions. For example, borrowers facing a possible job loss are more likely to refinance in order to tap into their accumulated equity, given the negative income shock, to smooth their consumption (Hurst and Stafford, 2004). We use the current county unemployment rate (*UnempRate*) as a proxy for local economic conditions.

Lastly, we also include a number of variables to control for state specific effects, account seasoning (*AGE* of account, and *AGE*-square), and calendar time effects. $AGE_{i,t}$ is the number of months since origination at time t, and, as Gross and Souleles (2002) point out, allows for loan seasoning. That is, *AGE* accounts for changes in the prepayment and default propensity as loans mature. In addition, Gross and Souleles (2002) note that the age variables allow the competing-risks hazard rates to vary with duration. Our quadratic specification of *AGE* allows the prepayment and default hazards to vary non-parametrically. The dummy variables corresponding to calendar quarters (Q3:99–Q1:02) at origination capture unobserved shifts over time in economic conditions or borrower characteristics that may impact the propensity to prepay or default. Finally, we include a series of dummy variables that denote the borrower's location (state).

Table 2 provides summary statistics for first mortgages, home equity loans and lines. The average credit score for home equity lines is 730 and that for the loans is 717 while the credit score for first mortgages is 718. The average current loan-to-value (*CLTV*) for the lines is 37 percent as compared to 55 percent for loans.[22] Finally, we note that substantial differences exist in the location of our sample. For example, 22 percent of the loans were

period, we expect that the majority of first mortgages were originated relatively recently; as a result, we believe that the first mortgage amortization during the study period is marginal and the resulting CLTV bias is minor.

[22] Since the current loan-to-value ratio (*CLTV*) includes the underlying senior mortgage balance as well as the line or loan amount, it is apparent that home equity line borrowers have significantly less debt exposure than home equity loan borrowers.

Table 2
Summary statistics for first mortgages, equity loans and equity lines

Variable	First mortgages	Equity loans	Equity lines	t-stat for mean diff. (first mortgage and equity loans)	t-stat for mean diff. (first mortgage and equity lines)
Origination in CT	13.68%	17.94%	13.58%	−1.89*	0.45
Origination in MA	35.74%	22.32%	52.01%	2.49*	−9.24*
Origination in NM	5.45%	4.00%	4.64%	1.32	10.89*
Origination in NJ	8.57%	7.05%	1.15%	1.41	4.32*
Origination in RI	6.60%	7.63%	7.48%	−1.18	−1.07
Origination in NY	26.84%	40.44%	20.89%	−14.23*	2.43*
Origination in PA	3.12%	0.62%	0.24%	1.92**	2.04*
$FICO_{t-12}$	718	717	730	2.89*	−27.23*
$CLTV_{t-12}$	57%	55%	37%	1.20	14.91*
$UnempRate_{t-12}$	4.31%	4.65%	4.02%	−0.55	0.53
$BalanceRatio_{t-12}$	73%	69%	41%	4.19*	37.74*
APR_{t-12}	7.94%	10.28%	9.00%	−7.10*	−2.93*
No. of accounts	121,303	56,055	78,981		

* Significant at the 5% level.
** Idem., 10%.

originated in Massachusetts, while 40 percent were originated in New York. On the other hand, 52 percent of the credit lines were originated in Massachusetts and 20 percent were originated in New York. There are also smaller differences in the distribution of both loans and lines in Connecticut, New Hampshire, New Jersey, and Pennsylvania.

4. Results

As a first step in the analysis, we estimate the baseline cumulative prepayment and default rates over the sample period controlling for origination year (or vintage). For example, Figs. 1 and 2 present the baseline cumulative prepayment and default rates, respectively, for loans originated in 1996. Considering prepayment first, it is clear from Fig. 1 that home equity lines have a higher probability of prepayment than do home equity loans. Furthermore, the prepayment rates for lines and loans are greater than the prepayment rate for first mortgages during the first three to four years after origination. However, as expected with the decline in interest rates during 2000 and 2001, the prepayment rate on first mortgages increased significantly.[23] Recall that home equity loans are fixed rate contracts, and thus, retain the embedded option giving the borrower the right to refinance when interest rates decline. Thus, the lower prepayment rate is surprising. Below, we explore whether home equity borrowers have credit constraints that may reduce the value of the prepayment option.

[23] The cumulative prepayment rates for subsequent origination cohorts display a similar pattern of home equity lines having higher rates than home equity loans and 1st mortgages during the early period after origination.

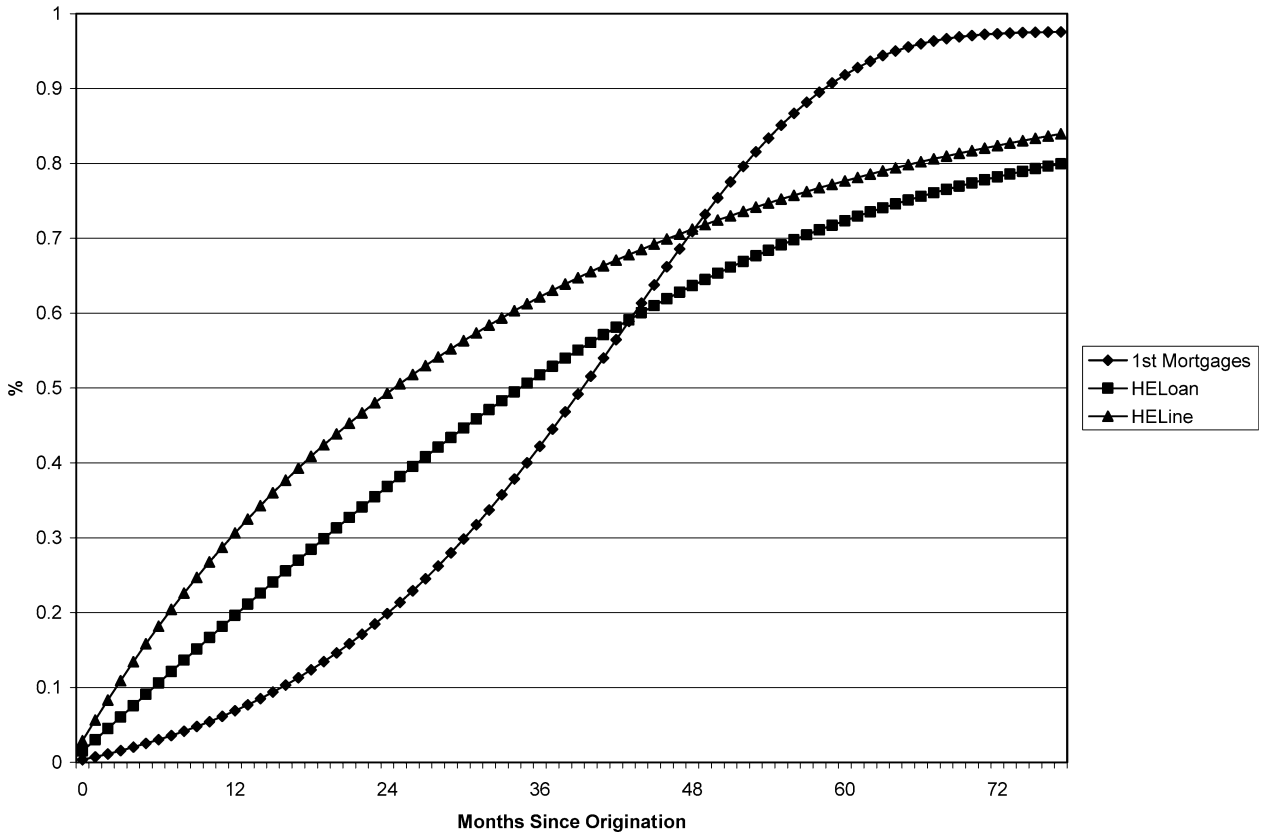

Fig. 1. Cumulative prepayment rates for first mortgages, home equity loans (HELoan), and home equity lines of credit (HELine) originated during 1996.

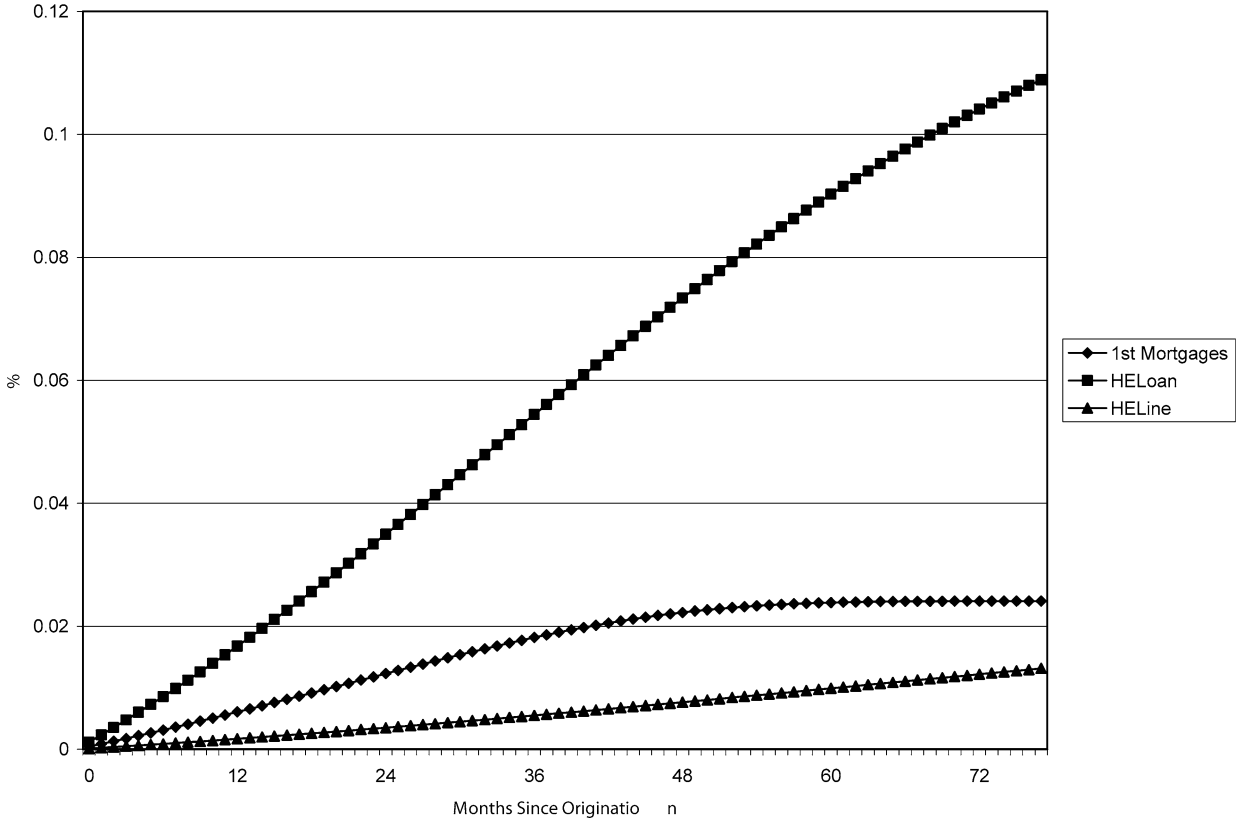

Fig. 2. Cumulative default rates for first mortgages, home equity loans (HELoan), and home equity lines of credit (HELine) originated during 1996.

Figure 2 shows the baseline default cumulative default rates for the 1996 vintage loans, lines, and first mortgages. Given that home equity credit is junior in priority to first mortgages, it is not surprising that home equity loans have higher default rates than first mortgages. However, it is interesting to note the lower default rates on home equity lines, which indicates a clear difference in risk profile across these loan types. In our formal analysis below, we explore the factors that contribute to these differences.

In order to fully determine the sensitivity of home equity credit performance to economic risk factors, Tables 3, 4, and 5 present the competing risks model parameter estimates for first mortgages, home equity loans, and home equity lines, respectively. Since economic interpretation of the competing risks model coefficients is not transparent, Table 6 presents the marginal effects on prepayment and default for changes in current LTV, interest rates, unemployment rate, and borrower credit quality, holding all else constant. We present the first mortgage estimates as a baseline for comparing the home equity loan and line models. Consistent with expectations, we find that borrower credit quality (twelve month lagged FICO score) is inversely related to default probability and positively related to prepayment probability.[24] That is, borrowers with higher credit quality indicators have significantly higher prepayment rates and significantly lower default rates.

In order to provide a direct comparison of the sensitivity of prepayment and default probabilities to changes in borrower credit quality, Table 6 shows the marginal effects of a 5 percent decline in borrower FICO score on the probability of prepayment or default at the 36th month. We note that a 5 percent decline in the FICO score translates into a 15.9 percent and 17.2 percent increase in the probability of default for first mortgages and home equity loans, respectively. However, the same shock to borrower credit quality only results in a 7.2 percent increase in the default probability for home equity lines.

On the prepayment side, a 5 percent drop in borrower credit quality results in a 3.2 percent decrease in the probability of prepayment for first mortgages, a 7.5 percent drop in home equity loan prepayment probability, and a 3.0 percent drop in home equity line prepayment probability. This finding is also consistent with the results reported by Agarwal et al. (2005), who find that borrowers with deteriorating credit quality are less likely to prepay and are more likely to increase their usage of the available line. Thus, our results confirm that borrower prepayment propensity is different for home equity lines. That is, home equity loans and first mortgages are approximately two times as sensitive to credit quality shocks as home equity lines of credit.

Turning to the impact of changes in house prices, we find that the current LTV ratio (CLTV) is directly related to default and negatively related to prepayment. The negative relationship with prepayment is consistent with the results of Lai and Yang (2003) for home equity loans and prepayment studies of primary mortgages (see, e.g., Bennet et al., 2000; Peristiani et al., 1997; and Archer et al., 1996, 1997). The marginal effects in Table 6 show the impact a change in house price on the probabilities of prepayment and default

[24] In the competing risks hazard model, all time-varying economic variables (*FICO, CLTV, OPTION, InMoney, DSpread*, and *UnempRate*) were lagged by 12 months to control for possible time discontinuities in variable measurement. Since we have no theoretical guidance for the appropriate lag length, the choice of twelve months is arbitrary. However, we estimated the model using alternate lag lengths (i.e., 4-months, 6-months, and 9-months) and found the estimated coefficients (signs and magnitude) to be robust to choice of lag length.

Table 3
Prepayment and default behavior of first mortgages

Variables	Default			Prepayment		
	Coeff. value	Std. err.	t-value	Coeff. value	Std. err.	t-value
Intercept	−8.735	0.208	−41.92*	−10.084	0.983	−10.25*
State dummy CT	2.759	0.458	6.02*	−0.918	0.388	−2.37*
State dummy MA	−1.784	0.818	−2.18*	0.262	0.225	1.17
State dummy NH	1.769	0.618	2.86*	−0.909	0.227	−4.00*
State dummy NJ	−2.584	0.493	−5.24*	0.414	0.137	3.01*
State dummy NY	−3.848	1.174	−3.28*	−0.339	0.188	−1.80
State dummy PA	−0.838	0.293	−2.86*	0.227	0.061	3.69*
Q3:99	−2.975	1.244	−2.39*	0.443	0.074	5.96*
Q4:99	−2.792	1.217	−2.29*	0.695	0.393	1.77
Q1:00	−1.498	0.434	−3.45*	0.586	0.042	14.08*
Q2:00	−1.673	0.555	−3.02*	0.539	0.184	2.94*
Q3:00	1.280	0.340	3.77*	−0.331	0.192	−1.72
Q4:00	−0.763	0.202	−3.77*	−0.287	0.290	−0.99
Q1:01	0.376	0.175	2.15*	−0.013	0.086	−0.15
Q2:01	−0.923	0.305	−3.03*	0.128	0.099	1.29
Q3:01	−0.817	0.453	−1.80	−0.370	0.122	−3.04*
Q4:01	−0.274	0.314	−0.87	−0.771	0.131	−5.89*
Q1:02	−0.315	0.140	−2.25*	−0.339	0.117	−2.89*
Age	0.004	0.001	7.33*	0.001	0.000	2.86*
Age-square	−2.0E–05	5.0E–06	−3.92*	7.4E–05	3.6E–05	2.06*
$FICO_{t-12}$	−1.4E–04	1.4E–05	−9.78*	1.3E–04	3.0E–05	4.41*
$FICO\text{-square}_{t-12}$	−2.0E–06	3.0E–06	−0.47	1.0E–06	0.0E+00	10.77*
$CLTV_{t-12}$	3.3E–03	3.4E–04	9.80*	−1.3E–03	7.4E–05	−17.75*
$CLTV\text{-square}_{t-12}$	6.0E–06	1.0E–06	10.67*	1.0E–06	1.0E–06	1.08
$Option_{t-12}$	0.536	0.150	3.56*	0.848	0.095	8.90*
$Option\text{-square}_{t-12}$	0.037	0.020	1.86**	0.035	0.035	1.01
$InMoney_{t-12}$	0.044	0.023	1.93**	0.342	0.095	3.58*
$DSpread_{t-12}$	−0.721	0.323	−2.23*	−0.143	0.056	−2.56*
$UnempRate_{t-12}$	0.361	0.093	3.89*	0.146	0.063	2.31*
Loc1	4.689	0.189	24.75*	0.529	0.067	7.86*
Loc2	2.728	0.294	9.27*	0.859	0.049	17.43*
Mass2	1.895	0.089	21.18*	0.240	0.027	8.78*
Default/prepay	2193			23,999		
Number of obs.	1,794,360					
Log-likelihood	2480					

Notes. The model is estimated by ML approach treating both prepayment and default outcomes as correlated competing risk estimated jointly. A bivariate distribution of unobserved heterogeneous error terms is also estimated simultaneously with the competing risk hazard. Loc1 and Loc2 are the location parameters and Mass2 is the mass points associated with Loc1 (Mass1 is normalized to 1).

* Significant at the 5% level.
** Idem., 10%.

through a shock to the current LTV. For example, normal amortization of a 30-year fixed-rate mortgage with a 6 percent contract rate and an 80 percent LTV at origination would result in a 77 percent LTV by month 36 (assuming the collateral value remains constant).

Table 4
Prepayment and default behavior of home equity loans

Variables	Default			Prepayment		
	Coeff. value	Std. err.	t-value	Coeff. value	Std. err.	t-value
Intercept	−5.118	0.338	−15.12*	−4.418	0.674	−6.56*
State dummy CT	−1.120	0.494	−2.27*	−1.037	0.277	−3.74*
State dummy MA	−1.389	0.215	−6.46*	1.014	0.274	3.71*
State dummy NH	1.329	0.556	2.39*	−0.811	0.513	−1.58
State dummy NJ	0.909	0.223	4.08*	−0.204	0.184	−1.11
State dummy NY	0.893	0.727	1.23	0.939	0.490	1.91**
State dummy PA	−1.828	0.710	−2.57*	−0.655	0.871	−0.75
Q3:99	−0.792	0.190	−4.16*	−0.222	0.090	−2.46*
Q4:99	−0.694	0.194	−3.59*	−0.546	0.189	−2.89*
Q1:00	0.989	0.557	1.78	−0.626	0.310	−2.02*
Q2:00	0.922	0.844	1.09	−0.526	0.099	−5.30*
Q3:00	−0.810	0.370	−2.19*	0.210	0.140	1.50
Q4:00	−0.322	0.120	−2.67*	−0.670	0.310	−2.16*
Q1:01	0.767	0.458	1.68	−0.910	0.142	−6.39*
Q2:01	−0.292	0.122	−2.40*	−0.432	0.692	−0.62
Q3:01	−1.028	0.517	−1.99*	0.140	0.320	0.44
Q4:01	0.263	0.100	2.63*	0.101	0.090	1.13
Q1:02	−0.162	0.091	−1.78	0.359	0.054	6.61*
Age	0.022	0.006	3.74*	−0.028	0.003	−9.18*
Age-square	−2.3E–03	9.0E–04	−2.57*	8.1E–03	3.3E–03	2.43*
$FICO_{t-12}$	−1.3E–02	3.5E–03	−3.84*	7.5E–03	1.8E–03	4.28*
$FICO\text{-square}_{t-12}$	2.3E–05	1.2E–05	1.89**	3.3E–05	1.4E–05	2.36*
$CLTV_{t-12}$	5.3E–03	1.3E–03	4.20*	−3.1E–03	1.3E–03	−2.34*
$CLTV\text{-square}_{t-12}$	2.3E–05	3.8E–05	0.61	2.0E–05	1.0E–05	2.00*
$Option_{t-12}$	8.123	2.778	2.92*	1.343	0.377	3.57*
$Option\text{-square}_{t-12}$	0.841	0.329	2.56*	0.344	0.456	0.75
$InMoney_{t-12}$	1.315	0.171	7.70*	0.337	0.091	3.70*
$DSpread_{t-12}$	−8.947	4.789	−1.87**	−1.839	0.335	−5.49*
$UnempRate_{t-12}$	0.194	0.085	2.27*	0.125	0.064	1.96*
Loc1	1.838	0.234	7.86*	1.958	0.189	10.37*
Loc2	0.390	0.089	4.37*	1.839	0.300	6.13*
Mass2	1.980	0.989	2.00*	2.059	0.220	9.37*
Default/prepay	1289			17,441		
Number of obs.	680,954					
Log-likelihood	2685					

See Notes in Table 3.
* Significant at the 5% level.
** Idem., 10%.

Thus, a 10 percent shock (decrease) to the LTV at month 36 implies that the collateral value would have increased by 11 percent over the value at loan origination. It is interesting to note that the probability of default on first mortgages is the most sensitive to changes in the underlying house price. A 10 percent decline in current LTV produces an 11.3 percent drop in the probability of default for first mortgages, while the probabilities of default

Table 5
Prepayment and default behavior of home equity lines

Variables	Default			Prepayment		
	Coeff. value	Std. err.	t-value	Coeff. value	Std. err.	t-value
Intercept	−5.578	0.899	−6.20*	−4.997	1.240	−4.03*
State dummy CT	0.813	0.349	2.33*	−0.328	0.134	−2.44*
State dummy MA	−0.287	0.103	−2.78*	−0.935	0.485	−1.93**
State dummy NH	0.926	0.475	1.95*	−0.138	0.254	−0.54
State dummy NJ	0.854	0.393	2.17*	−0.375	0.139	−2.70*
State dummy NY	1.773	0.911	1.95*	0.835	0.296	2.82*
State dummy PA	1.998	1.026	1.95*	−0.478	0.134	−3.56*
Q3:99	−0.189	0.163	−1.16	0.367	0.135	2.73*
Q4:99	−0.400	0.184	−2.18*	0.375	0.191	1.96*
Q1:00	−0.609	1.001	−0.61	−0.144	0.034	−4.18*
Q2:00	0.492	0.113	4.37*	−0.143	0.335	−0.43
Q3:00	−0.460	0.269	−1.71	0.856	0.576	1.49
Q4:00	0.357	0.132	2.71*	−0.083	0.405	−0.21
Q1:01	−0.194	0.193	−1.00	−0.286	0.376	−0.76
Q2:01	−0.934	0.195	−4.79*	0.012	0.042	0.29
Q3:01	0.370	0.203	1.82	0.254	0.050	5.11*
Q4:01	0.904	0.337	2.68*	0.112	0.029	3.89*
Q1:02	−0.444	0.239	−1.86**	0.334	0.128	2.60*
Age	0.041	0.006	6.40*	−0.035	0.013	−2.71*
Age-square	−6.9E–04	9.1E–05	−7.53*	1.5E–04	8.2E–05	1.86**
$FICO_{t-12}$	−1.4E–02	3.5E–03	−4.02*	−3.4E–03	6.3E–04	−5.46*
$FICO\text{-square}_{t-12}$	5.2E–05	7.1E–05	0.73	−2.0E–06	4.0E–06	−0.55
$CLTV_{t-12}$	1.9E–02	8.3E–03	2.32*	−2.8E–02	6.4E–03	−4.46*
$CLTV\text{-square}_{t-12}$	6.0E–05	1.9E–05	3.13*	−3.1E–03	8.0E–04	−3.83*
$Option_{t-12}$	2.557	1.187	2.15*	1.523	0.602	2.53*
$Option\text{-square}_{t-12}$	1.354	0.622	2.18*	0.906	0.705	1.29
$InMoney_{t-12}$	0.603	0.273	2.21*	0.242	0.924	0.26
$DSpread_{t-12}$	−1.459	3.853	−0.38	−1.857	0.859	−2.16*
$UnempRate_{t-12}$	0.013	0.012	1.13	−0.145	0.055	−2.64*
Loc1	0.928	0.100	9.33*	0.219	0.046	4.79*
Loc2	0.424	0.093	4.56*	0.122	0.026	4.74*
Mass2	0.612	0.028	21.50*	0.148	0.026	5.75*
Default/prepay	483			21,152		
Number of obs.	985,890					
Log-likelihood	2240					

See Notes in Tables 3 and 4.
* Significant at the 5% level.
** Idem., 10%.

for home equity loans and lines decline 9.4 percent and 4.9 percent, respectively. On the other hand, the probability of prepayment for home equity lines is the most sensitive to changes in current LTV. Here, we find that a 10 percent decline in current LTV results in a 16.4 percent increase in the probability of home equity line prepayment, while the

Table 6
Marginal effects on prepayment and default at the 36th month

	Prepayment (%)			Default (%)		
	First mortgages	Equity loans	Equity lines	First mortgages	Equity loans	Equity lines
10% Drop in current LTV	6.0	4.8	16.4	−11.3	−9.4	−4.9
100 Basis point drop in APR	15.9	17.3	9.6	8.3	13.2	4.7
1% Rise in unemployment rate	4.1	5.8	−2.2	9.1	8.8	9.2
5% Drop in FICO score	−3.2	−7.5	−3.0	15.9	17.2	7.2

prepayment probabilities of first mortgages and home equity loans rise by 6.0 percent and 4.8 percent, respectively.

Examining the impact of financial incentives to terminate, we find that the estimated prepayment option value (*OPTION*) is significantly positive in both models indicating that prepayment and default are more likely following a decline in the prevailing mortgage interest rate relative to the original contract rate. Equally important, the dummy coefficients denoting borrowers with an "in the money" call-option (*InMoney*) are positive and significant, suggesting that the average prepayment rate is higher for borrowers with call-options that are "in the money" ($InMoney = 1$) than borrowers with call-options "out of the money" ($InMoney = 0$). The marginal effects in Table 6 show the sensitivity of the prepayment and default probabilities to a 100 basis point decline in the market interest rate relative to the contract rate at origination. The marginal effects indicate that a one percentage point drop in the market interest rate increases the probability of prepayment by 15.9 percent for first mortgages, 17.3 percent for home equity loans, and 9.6 percent for home equity lines. In other words, our analysis indicates that the performance of home equity loan is almost twice as sensitive to changes in interest rates as that of home equity lines of credit. Furthermore, consistent with expectations, the results indicate that prepayment and default are significantly more likely when the borrower's call option is 'in-the-money.' As expected, the interaction effect (*DSpread*) is significantly negative, reinforcing the strong impact that interest rate movements have on the option to terminate.

Finally, the results show that prepayment and default are positively associated with unemployment rates. That is, during periods of higher unemployment, borrowers are more likely to default as well as prepay. This is consistent with the theory that during periods of economic uncertainty, borrowers are more likely to relocate to areas with better employment prospects (triggering prepayment) as well as default due to lost income. The marginal effects in Table 6 show the impact of a one percentage point increase in the unemployment rate on the probabilities of prepayment and default. It is interesting to note that a one percentage point rise in the unemployment rate has roughly the same impact on the probability of default. However, an increase in the unemployment rate results in a decline in the home equity line prepayment but an increase in the first mortgage and home equity loan prepayment. The unemployment rate effect suggests that economic uncertainty does not constrain borrowers from prepaying their home equity loans. While previous studies argue that income-constrained households may find it difficult to secure a new loan (e.g., Archer et al., 1996), our result is consistent with the fact that, since the transaction costs associated with refinancing and prepaying home equity loans are relatively small (compared with first

mortgages), economic uncertainty does not constrain homeowners from prepaying their second mortgage. The negative coefficient in the home equity line prepayment model is consistent with the notion that home equity line borrowers have the option to increase the utilization of their available line as opposed to prepaying and refinancing the line. Hence, borrowers facing economic uncertainty do not need to prepay their takedowns (i.e., equity lines used) in order to increase their credit; they can simply increase their usage of the available line.

5. Implications for bank capital requirements

Current bank risk-based capital regulations are based on the 1988 Basel Capital Accord (commonly referred to as Basel I) developed by the Basel Committee on Banking Supervision. These regulations determine the minimum capital that a regulated financial institution is required to maintain based on the assets held in the institution's portfolio. For example, Basel I regulations established a series of risk weightings for various assets relative to the 4 percent standard for tier one equity capital. The regulations specified that most performing residential mortgages have a risk-weighting of 50 percent implying a minimum tier one equity capital set aside of 2 percent.[25] In response to changes in the financial markets and the development of improved risk management practices during the 1990s, the Basel Committee proposed a revised Basel Capital Accord (Basel II) in 2003 that is scheduled for implementation in 2006.[26] As Calem and LaCour-Little (2004) point out, Basel II introduces new capital requirements, creates guidelines for supervision of bank risk management systems, and encourages market discipline through greater transparency. Decamps et al. (2004) present a dynamic model of bank behavior in response to the interaction of the three pillars of Basel II (capital requirements, supervision, and market discipline). The model shows that market discipline can be used to ensure that banks maintain minimum capital requirement, especially if there is a threat of regulatory supervision.

As Calem and Follain (2003) discuss, implementation of Basel II in the United States, with respect to regulatory capital charges for single-family residential mortgage credit, is especially challenging. The challenge results from the size of the US mortgage market as well as the significant share that residential mortgages comprise of US bank portfolios. For example, Calem and Follain (2003) report that residential mortgages and mortgage backed securities represent 26.8 percent of the total assets held by the ten largest US commercial banks. Furthermore, with home equity loan and lines accounting for over $329 billion in assets at US commercial banks, home equity credit represents a sizeable risk exposure for financial institutions. Given the size of this market and the volume of these loans held in the portfolio of financial institutions, small changes in regulatory capital requirements could have significant effects on lenders.

[25] See Avery and Berger (1991) for a discussion of the Basel I regulations.

[26] The final Basel II rule was released in Fall 2003. Calem and LaCour-Little (2004) provide a detailed comparison of the Basel I and Basel II regulations. In addition, Dangl and Lehar (2004) compare the risk taking incentives for banks under Basel I regulations and value-at-risk regulations (the basis for Basel II).

One of the key features of the Basel II Accord is the Advanced Internal-Ratings-Based (A-IRB) method for determining a bank's minimum regulatory capital charge. The A-IRB method is designed to align bank minimum capital requirements with the economic risks associated with the bank's investments. Furthermore, Gordy (2003) notes that implementing an A-IRB type method would require knowledge of credit losses at the "instrument" level. Thus, given the growth in the home equity lending sector, it is imperative that regulatory agencies and individual lenders have information pertaining to the performance of home equity credit.

Our analysis in the previous section indicates that first mortgages, home equity lines, and home equity loans have significantly different default rates. Furthermore, combining this analysis with the evidence presented in Agarwal et al. (2005) concerning the factors that lead to utilization of credit, it is clear that home equity lines are significantly less risky than home equity loans. As a result, bank capital regulations should reflect these risk differences.

To demonstrate the risk exposure to a bank holding a portfolio of first mortgages, home equity loans, and home equity lines, Table 7 reports the cumulative 36 month probability of default for a baseline and three economic stress scenarios.[27] The baseline probabilities reflect the assumption that house prices, credit quality, interest rates, and unemployment remain constant at their average values for the 36 months period, and the three scenarios represent increasing degrees of economic stress. The first simulation compares the baseline probability of default (holding all factors constant) with the stress scenario I. Under these

Table 7
Estimated 36 month cumulative prepayment and default rates assuming various economics scenarios

	Prepayment (%)			Default (%)		
	First mortgages	Equity loans	Equity lines	First mortgages	Equity loans	Equity lines
Baseline[a]	18.3	20.3	8.7	1.43	1.93	0.46
Stress scenario I[*]	15.32	16.46	8.36	1.85	2.45	0.54
Stress scenario II[**]	12.30	12.48	7.80	2.42	3.52	0.65
Stress scenario III[***]	5.04	2.37	5.89	4.94	7.51	1.45

[a] Average values for house price, credit quality, interest rates, and unemployment.

[*] 10% drop in house prices, 10% drop in average credit quality, 50 basis point rise in interest rates, and 2 percentage point rise in unemployment.

[**] 20% drop in house prices, 20% drop in average credit quality, 200 basis point rise in interest rates, and 4 percentage point rise in unemployment.

[***] 40% drop in house prices, 40% drop in average credit quality, 500 basis point rise in interest rates, and 8 percentage point rise in unemployment.

[27] Stress scenario I is defined as a 10 percent decline in house prices, a 50 basis point increase in interest rates, a 10 percent decline in average borrower credit quality, and a 2 percentage point increase in the unemployment rate. Stress scenario II corresponds to a 20 percent decline in house prices, a 200 basis point increase in interest rates, a 20 percent decline in average borrower credit quality, and a 4 percentage point increase in the unemployment rate. Stress scenario III reflects a 40 percent decline in house prices, a 500 basis point increase in interest rates, a 40 percent decline in average borrower credit quality, and an 8 percentage point increase in the unemployment rate. Finally, the base case holds all factors constant at the sample means.

conditions, the probability of default of home equity lines increases 8 basis points from 0.46 percent to 0.54 percent while the probability of default for home equity loans rises 53 basis points from 1.93 percent to 2.45 percent. Similar comparison for stress scenario II and stress scenario III show that default probabilities for home equity lines increase 19 basis points and 99 basis points, respectively, and the default probabilities for home equity loans increase 159 basis points and 558 basis points, respectively. In comparison, the 36 month cumulative probability of first mortgage default increases 351 basis points between the baseline scenario and stress scenario III.[28] The results clearly indicate that the probability of default for home equity lines is less sensitive to changes in economic conditions than either home equity loans or first mortgages.

Although estimation of the regulatory capital mandated under the Basel Accord for each product is beyond the scope of this paper, we utilize the expected percentage loss given default (LGD) for mortgages, lines, and loans to estimate the differences in regulatory capital that would be required for each product.[29] By multiplying the LGD by the probability of default, we obtain the expected loss rate utilized in the Basel capital regulations. Additionally, for the lines of credit we add the product of LGD, probability of default, and additional draw down. According to Calem and LaCour-Little (2004), the normal procedure for calculating regulatory capital is to take "the difference between a selected far-tail loss rate and the mean of the simulated probability distribution—a quantity termed value-at-risk."[30] Assuming that stress scenario III is representative of the "far-tail loss" and the baseline case represents the "mean of the simulated probability distribution," we estimate that the economic capital required is 0.351 percent for first mortgages, 0.346 percent for home equity lines, and 1.395 percent for home equity loans.[31,32] This implies that home equity loans would require 297 percent more regulatory capital than a portfolio of first mortgages and 303 percent more regulatory capital than a portfolio of home equity lines. In contrast, a portfolio of home equity lines actually requires 1.4 percent less regulatory capital than a portfolio of first mortgages. Again, these results indicate heterogeneous risks across the

[28] The default rates for first mortgages under the three stress scenarios are 2.76 percent, 3.61 percent, and 7.36 percent, respectively. Though not relevant for the Basel II accord, Table 7 also reports the prepayment rates for all three products under the three scenarios.

[29] The estimated loss given default (LGD) for first mortgages is 10% and the LGD for home equity loans and lines is 25%. Furthermore, we estimate the additional draw down of the line of credit in the event of default at 40%. Basel II requires banks to determine the exposure at default (EAD) for all revolving lines of credit (i.e. home equity lines of credit). These estimates represent the average values used by the banks in our analysis.

[30] Calem and LaCour-Little (2004), page 664.

[31] The regulatory capital estimates are calculated as follows:

$$\begin{aligned}
&\text{First mortgages:} && (0.0494 - 0.0143) * 0.1 = 0.00351,\\
&\text{Home equity loans:} && (0.0751 - 0.0193) * 0.25 = 0.01395,\\
&\text{Home equity lines:} && [(0.0145 - 0.0046) * 0.25] + [(0.0145 - 0.0046) * 0.25 * 0.4] = 0.00346.
\end{aligned}$$

The second term in the home equity line regulatory capital calculation reflects the necessary adjustment for the average line draw-down.

[32] Additionally, the stressed LGD estimate for a "far-tail loss" would be 30% for first mortgages and 50% for home equity loans and lines and the stressed EAD estimate would be 90% for home equity lines. These stressed loss levels would cause the capital estimates from footnote 30 to increase to 0.0105 for first mortgages, 0.0279 for home equity loans, and 0.0094 for home equity lines.

residential mortgage products, suggesting that the implementation of Basel II minimum capital requirements should recognize these differences.

6. Conclusion

In this paper, we empirically assess and compare the responsiveness of prepayment and default of home equity loans, home equity lines, and first mortgages to financial incentives and consumption smoothing incentives. Since the new Basel II regulations require lenders to set aside capital based on risk, the results should provide some guidance to bank regulators. Consistent with the theory that risk is heterogeneous across the residential mortgage product spectrum, our results show that the prepayment and default behaviors of borrowers of home equity lines differ from those of loans. Our findings suggest that both equity loans and lines prepay to take advantage of declining interest rates (financial management motives) and/or cash out home equity (consumption smoothing motives) when facing appreciating property values. However, we find that home equity loans are almost twice as sensitive as home equity lines to interest rate changes. Furthermore, only home equity loan prepayment appears sensitive to credit shocks, e.g., deterioration in credit risk profile and facing unemployment.

We estimate that a 1 percent drop of mortgage rates relative to the original contract interest rate increases the prepayment rate of loans by 17.3 percent and of lines by 9.6 percent, suggesting that home equity loan borrowers may be more sensitive to financial incentives. In comparison, a 1 percent drop in mortgage rates increases the prepayment rate on first mortgages by 15.9 percent. On the other hand, a 10 percent appreciation in home prices raises the prepayment rate of loans by 4.8 percent and that of lines by 16.4 percent. Furthermore, for a 1 percent rise in local unemployment rate, the prepayment rate increases by 5.8 percent for loans, but declines 2.2 percent for lines, suggesting that borrowers of loans facing negative income shocks are more likely to cash out home equity. The marginal effects indicate that default probabilities are roughly the same across home equity lines, loans and first mortgages for a 1 percent increase in the unemployment rate. On the other hand, following a 5 percent drop in FICO score, the prepayment rate increases by 7.5 percent for loans, 3.0 percent for lines and 3.2 percent for first mortgages, suggesting that borrowers of equity loans facing credit deterioration are more likely to cash out home equity. Our results for home equity lines support Agarwal et al. (2005), who empirically find that individuals who face credit shocks are more likely to increase utilization than prepay their home equity line. Since the option to increase utilization does not exist for loans, we see higher prepayment rates following a credit shock.

In summary, our analysis indicates that prepayment and default risks differ across the residential mortgage product spectrum. Given that one of the key features of the Basel II Accord is the recognition that bank minimum capital requirements should be aligned with the economic risks associated with various bank investments, the results from this study suggest that the implementation of the new regulations will require that banks recognize the heterogeneous risks characteristics various residential mortgages products contained in their portfolios. As a rough approximation based on the estimated cumulative 36 month probability of default, we note that a portfolio of home equity lines would require 1 percent

less regulatory capital than a portfolio of first mortgages while a portfolio of home equity loans would require 297 percent more regulatory capital than a portfolio of first mortgages.

One of the obvious implications of this analysis concerns the impact of regulatory capital requirements on the relative pricing across mortgage products. Since home equity loans should require substantially higher regulatory capital than home equity lines or first mortgages, interest rates charged on home equity loans should reflect this difference. The results from this analysis suggest that an area for future research is the linkage between loan pricing and regulatory capital requirements across various mortgage products.

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