An Empirical Investigation of Collateral and Sorting in the HELOC Market

By

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Abstract

This research explores the role that collateral plays in sorting borrowers according to risk classes in the secured credit market. Two distinct paradigms exist in the commercial loan market literature on risk-sorting based on collateral: (a) the *sorting-by-observed-risk paradigm*, which predicts a positive association between collateral and borrower risk; and (b) the *sorting-by-private-information paradigm*, which postulates a negative relationship. We empirically test which of these paradigms explains the risk/interest rate dispersion in the market for collateralized Home Equity Lines of Credit (HELOCs). Whereas for traditional loans the focus is on Loan-to-Value ratios, here we introduce the concept of Borrowing-to-Value ratio, which is the relevant criterion for lines of credit since credit extended is not necessarily borrowed. Using a maximum likelihood procedure, we simultaneously estimate the HELOC borrowing level and the HELOC rate of interest. Our results support the *sorting-by-private-information paradigm*.

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1. Introduction

Collateral has always played an important role in commercial and real estate lending. With the emerging importance of home equity lending, secured credit is also gaining ground in the consumer market for lines of credit. The dispersion of interest rates in the secured credit market depends primarily on the role that collateral plays in sorting borrowers according to their riskiness. In this regard, theoretical studies have predicted different roles for collateral in sorting equlibria of the secured credit market. The two major explanations of the collateral-risk/interest rate connection are: (a) the *sorting-by-observed-risk paradigm* whereby observably riskier borrowers are required to pledge more collateral than less risky borrowers; and (b) the *sorting-by-private-information paradigm* whereby low-risk borrowers signal their credit worthiness by pledging more collateral than their high-risk counterparts. These opposing hypotheses have not been tested in the market for HELOCs. Here we empirically investigate their validity in the market for collateralized HELOCs and find that the *sorting-by-private-information paradigm* dominates. The higher the amount of collateral pledged, the lower is the rate of interest charged by banks for HELOCs. Furthermore, we point out that the Loan-to-Value (LTV) criterion often used by banks to price HELOC loans fails to take account of the main feature of a line of credit, namely that there is a difference between the loan extended and the actual amount borrowed. Here we introduce the concept of the Borrowing-to-Value ratio (BTV), which is the appropriate measure of risk, and hence the relevant determinant of interest rates, in the market for secured lines of credit such as HELOCs.

Background and Previous Literature

Although issues concerning the use of collateral have been explored in a variety of settings in the previous literature on the credit market, most of this work has focused on commercial loans. This earlier work includes Barro (1976), Jensen and Meckling (1976), Scott (1977), Smith and Warner (1979), and Stulz and Johnson (1985). An explanation for the secured lending arrangement which was not specifically addressed in this earlier literature is the sorting role of collateral in asymmetrically informed environments. In the banking community, however, the use of collateral has been associated with observably riskier borrowers (Morsman, 1986). This is referred to as the *sorting-by-observed-risk paradigm*. Consistent with this view, Swary and Udell (1988) provided a motivation for the use of collateral by suggesting that secured debt may be useful in enforcing optimal firm closure (or bankruptcy). Boot, Thakor, and Udell (1991) considered a model where the borrower's risk type is observable to the lender while the borrower's action is privately known, and they derived sufficient conditions under which observably riskier borrowers pledge more collateral in equilibrium. Boot and Thakor (1994), using a model of multi-period loan contracts, have also found evidence in favor of this paradigm.

Another strand of the theoretical literature in the commercial loan market has focused on information about risk known only to borrowers, leading to the *sorting-by-private-information paradigm*. Besanko and Thakor (1987a) found that lenders are at an informational disadvantage with respect to borrower default probabilities, and in equilibrium, low-risk borrowers pledge more collateral than their high-risk counterparts. Besanko and Thakor (1987b) found a similar negative relationship between collateral and borrower risk under loan contracting with a multi-dimensional pricing menu. Chan and Kanatas (1985) and Bester (1985) found that low-risk borrowers pledge more collateral than high-risk borrowers because collateral-associated costs produce different marginal rates of substitution between collateral and interest rates. Bester incorporated collateral as screening mechanism in the Stiglitz and Weiss (1981) credit rationing model and showed that rationing then becomes unnecessary. Chan and Thakor (1987) examined the form of the optimal secured loan contract assuming the existence of both adverse selection and moral hazard. Igawa and Kanatas (1990), assuming moral hazard exists due to the use of collateral, showed that the optimal secured loan contract for higher quality borrowers involves over-collateralization; whereas self-financing and unsecured credit are chosen by the intermediate and lowest quality borrowers respectively. Empirical studies of collateral and risk based on bank files and survey data in the market for commercial loans include that of Orgler (1970), Hester (1979), and Berger and Udell (1990), who concluded that riskier borrowers pledge more collateral. Berger and Udell (1995) found that collateral use decreases significantly with the length of the relationship with the bank, a fact that was theoretically explained in the earlier paper by Boot and Thakor (1994).

More recent theoretical work on the use of collateral in commercial loans has been put forward in a context of symmetric information with the existence of entrepreneurs' overoptimistic evaluation of their project (de Meza and Southey, 1996) or costly state verification (Bester, 1994).

Previous studies involving collateralization in the consumer loan market have largely focused on mortgage and auto loans. Although recently the research on secured consumer credit has expanded to include Home Equity Loans (HELs) and HELOCs, none of this work, to our knowledge, has addressed the issue of sorting by collateral (Chen and Jensen, 1985; Canner, Fergus and Luckett, 1988; DeMong and Lindgren, 1990; Eugeni, 1993; Canner and Luckett, 1994; Eisenhauer, 1994; Delaney, 1994; Salandro and Harrison, 1997; Canner, Durkin, and Luckett, 1998; and Aizcorbe, Kennickell, and Moore, 2003).

Loan-to-Value vs. Borrowing-to-Value

Loan-to-Value ratio (LTV) has traditionally been a major explanatory variable in the assessment of the risk assumed by the banks and hence in the determination of the rate of interest. For traditional loans, the amount of credit extended by a bank is actually borrowed; and therefore banks assume the risk of the entire loan amount provided to the borrower. LTV (as opposed to the value of the collateral alone) should logically explain a significant portion of the risk/interest rate spread of in both the consumer and corporate secured credit market. However, it is not appropriate to use LTV to explain the interest dispersion of collateralized lines of credit such as HELOCs. A line of credit allows a consumer to borrow *up to* a predetermined credit limit. Banks do not assume any risk unless the borrower, irrespective of his/her risk-type, borrows on the line. Therefore the broader category of Borrowing-to-Value ratio (BTV), and not LTV, is the relevant measure of the risk assumed by banks in the case of lines of credit – a point which has been neglected in previous research. Actual borrowing is typically not observed *a priori* by banks during the determination of their risk exposure, and hence the interest rate, for lines of credit. However, banks can use their substantial information on consumer borrowing patterns to make estimates of borrowing. Such borrowing estimates, as well as the value of collateral pledged, should ideally be considered when setting the terms of the loan and loan-price dispersion for collateralized lines of credit such as HELOCs.

In this paper, we empirically investigate of the relationship between the value of collateral and credit risk within the market for HELOCs. The econometric model that we use estimates the borrowing of a household with the HELOC rate of interest as an endogenous variable. The HELOC rate of interest is determined by the amount of the collateral pledged by borrowers, borrowers' credit histories, and such characteristics of agreed secured loan contracts as the required frequency and rate of repayment. We examine the nature of the information asymmetry that exists between borrowers and lenders in the HELOC market and explain how the value of collateral, along with *estimated borrowing*, helps to mitigate this information asymmetry. Our empirical work supports a negative association between the value of the collateral pledged by borrowers and the HELOC rate of interest charged by banks, as opposed to the positive association typically found in the empirical literature on commercial loans.

2. Data

The data set used in this study consists of a pooled sample from the 1995 and 1998 rounds of the *U.S. Surveys of Consumer Finances* (SCF).[1] We use data for the 5,995 households who have positive equity in their homes. There are two types of sample members:

[1] All variables were converted to 1998 dollars.

Type I: $D^H = r_H = 0$, where D^H and r_H are the observed HELOC debt and interest rate respectively.

Type II: $D^H > 0$ and $r_H > 0$.

The descriptive statistics for HELOC debtors and HELOC non-debtors in this data set are presented in Appendix A.

3. An Econometric Model

We will consider the following variables in our model:

Definitions of Variables

W – Wealth of the consumer	t – Income tax rate; $0 < t < 1$
C – Cost of collateralization[2]	δ –Discount factor; $0 < \delta < 1$
τ – Fixed cost[3] of HELOC; $\tau > 0$	α – Required rate of repayment; $0 < \alpha < 1$

Following Dey and Dunn (2004), the consumer's discounted expected lifetime utility from optimally carrying D_i^{H*} amount of HELOC debt is

$$V^{H*} = V^H(W, r_H, \delta, \alpha, t, \tau, c, D_i^{H*}).$$

Hence for household *i* we have, $D_i^{H*} = h\,(W_i, \tau_i, c_i, t_i, r_{Hi}, \alpha_i, \delta_i)$.

Counterparts from the Data

We will use the following empirical quantities to represent the variables of the model:

Wealth Factors W_i: equity in the home, liquid assets, other non-financial assets, and household size.

[2] These are perceived costs related to the risk of home-loss;, where $C = c\,(D^H)$, $1 > c > 0$.
[3] This involves upfront costs such as appraisal fees, closing costs, and annual fees.

Risk Factors R_i: a dummy variable based on the incidence of delinquency, dummies capturing household's attitude towards risk, and the repayment rate α_i.

Tax Factors T_i: a vector including a dummy variable which determines whether household *i* itemizes tax-deductions or not and household income.

Mortgage Factors M_i: a vector including incidence of mortgage debt, debt repayment frequency, and mortgage rate of interest.

Discount Factors S_i: a vector including age, income, household size, ethnicity, and education level.

Since the fixed costs of obtaining HELOCs (τ_i) have no variation across households, $\tau_i = \tau \ \forall \ i$. Therefore, the fixed costs go into the constant term of the HELOC debt equation. The marginal cost of collateralization c_i is considered to be a function of the individual's risk-type represented by R_i as given above. The discount factor δ_i is captured by the vector S_i. The vector T_i as defined above captures the income tax rates t_i. Hence we have

$$c_i = \alpha_0 + \alpha_1' R_i + \varepsilon_{1i},$$

$$t_i = \alpha_2 + \alpha_3' T_i + \varepsilon_{2i}$$

$$\delta_i = \varphi_i' S_i + \eta_i$$

Substituting for c_i, t_i, δ_i and τ_i into D_i^{H*}; using W_i and α_i, we have a quasi-reduced form equation for D_i^{H*},

$$D_i^{H*} = \gamma r_{Hi} + \beta_1' X_{1i} + v_{1i} \qquad (1)$$

where X_{1i} is a vector of exogenous variables influencing D_i^{H*}.

Using the amount of collateral pledged by household *i*, i.e. the home equity, R_i, and M_i, we have a reduced form equation for r_{Hi},

$$r_{Hi} = \beta_2' X_{2i} + v_{2i} \qquad (2)$$

where X_{2i} is a vector of exogenous variables influencing r_{Hi}.

We consider the following econometric model:

$$\left.\begin{aligned} D_i^H &= D_i^{H*} = \gamma r_{Hi} + \beta_1' X_{1i} + v_{1i} \\ r_{Hi} &= \beta_2' X_{2i} + v_{2i} \end{aligned}\right\} \quad \text{if } D_i^{H*} > 0$$

$$\left.\begin{aligned} r_{Hi} &= 0 \\ D_i^H &= 0 \end{aligned}\right\} \quad \text{otherwise}$$

where v_{1i} and v_{2i} follow bivariate normal with zero means, variances σ_1^2 and σ_2^2 respectively, and with covariance σ_{12}. If X_{2i} contains at least one variable that is not included in X_{1i}, then all the parameters of the model are identified. The vector M_i contains information about the incidence of mortgage debt among households, mortgage rates of interest they face, and their debt repayment frequency. Since all banks use the same credit bureau information to assess the risks of all loan applicants, the HELOC rate of interest should be correlated with the mortgage rate of interest. However, after controlling for the HELOC rate of interest, the amount borrowed on the HELOC can reasonably be assumed not to depend on the mortgage rate of interest. Hence we can logically include at least one variable in vector X_{2i}, namely the mortgage interest rate, which is not included in vector X_{1i}. In order to correct for the endogeneity present in the HELOC debt equation, our two-stage estimation procedure uses an estimate of the HELOC rate of interest $\hat{r}_{Hi}$ as an instrument.

We use a maximum likelihood procedure to estimate the econometric model. A consumer is observed to carry debt on HELOC if

$$D_i^{H*} > 0.$$

Substituting the HELOC interest rate equation into the HELOC debt function, the HELOC debt-holding decision can be written as

$\beta_1{}'X_{1i} + \gamma\beta_2{}'X_{2i} > -(v_{1i} + \gamma v_{2i})$

or, $I_i > v_i$

where, $v_i \sim N(0, \sigma_1{}^2 + \gamma^2\sigma_2{}^2 + 2\gamma\sigma_{12}) \equiv N(0, \sigma_v{}^2)$.

The likelihood of observing a HELOC non-debtor is

$$\Pr ob(I_i < v_i) = \int_{I_i/\sigma_v}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{\varpi^2}{2}} d\varpi = 1 - \Phi(\frac{I_i}{\sigma_v}) = \Phi(-\frac{I_i}{\sigma_v})$$

where Φ is the standard normal cumulative density function. Hence the likelihood of the data consisting of N observations, with N_1 HELOC non-debtors is

$$L = \prod_{i=1}^{N_1} \Phi(-\frac{I_i}{\sigma_v}) \prod_{i=N_1+1}^{N} b(v_{1i}, v_{2i}) = \prod_{i=1}^{N_1} \Phi(-\frac{I_i}{\sigma_v}) \prod_{i=N_1+1}^{N} n(v_{2i}) n(v_{1i}|v_{2i})$$

where b (.) is the bivariate normal density function, n (.) is the normal density function and

$v_{1i} = D_i^H - \beta_1{}'X_{1i} - \gamma r_{Hi}$

$v_{2i} = r_{Hi} - \beta_2{}'X_{2i}$.

We know that $v_{2i} \sim N(0, \sigma_2{}^2)$

$$v_{1i}|v_{2i} \sim N\left(\frac{\rho\sigma_1 v_{2i}}{\sigma_2}, \sigma_1^2(1-\rho^2)\right), \text{ where } \rho = \frac{\sigma_{12}}{\sigma_1\sigma_2}.$$

Let, $\sigma_c^2 = \sigma_1^2(1-\rho^2)$ and

$$F_i = \frac{v_{1i} - \frac{\rho\sigma_1 v_{2i}}{\sigma_2}}{\sigma_c}.$$

The corresponding log-likelihood function can be written as

$$\log L = \sum_{i=1}^{N_1} \log[\Phi(-\frac{I_i}{\sigma_v})] + \sum_{i=N_1+1}^{N} \frac{\phi\left(\frac{v_{2i}}{\sigma_2}\right)}{\sigma_2} + \sum_{i=N_1+1}^{N} \frac{\phi(F_i)}{\sigma_c}$$

where $\phi(.)$ is the standard normal density function.

A multi-step procedure was used to estimate the parameters of the model, first using the two-stage probit method as described in Lee *et al*. (1980). This two-step procedure yields consistent estimates of all parameters, and these estimates were used as initial values for the final maximization of the log-likelihood function.

4. Empirical Results

The variables used in the empirical analysis are found in Table 1 below. This is followed by Table 2 where the results for the maximum likelihood estimation for the HELOC rate of interest are presented. The value of collateral (HOMEQUITY) has a significant negative influence on the HELOC rate of interest charged by banks. Therefore our maximum likelihood estimation provides empirical support for the *sorting-by-private-information paradigm*. Borrowers who pledged higher amounts of collateral signal their superior risk-types and therefore are rewarded with lower interest rates by the banks. Among HELOC debtors, those who carry mortgage debt (MORTGAGE = 1) get lower HELOC interest rates from banks. The mortgage rate of interest (MORTGAGERATE) has a positive effect on HELOC interest rates, as expected from the discussion above. Finally, we find empirical evidence of a positive association between the variable capturing repayment frequency (REPAYMENTFREQ) and the HELOC rate of interest.

Table 1: Definitions of Variables

Variables	Explanation
HELOCDEBT	HELOC debt
HELOCRATE	HELOC rate of interest[a]
HOMEQUITY	Equity in home
LIQUIDASSETS	Liquid assets
OTHERASSETS	Other non-financial assets
TAX	1 – Itemize income tax deductions 0 – Otherwise
DELINQUENCY	1 –Behind in payments by two months or more 0 – Otherwise
INCOME	Income
REPAYMENTRATE	The required rate of repayment[b]
MORTGAGE	1 – Household has some kind of mortgage debt 0 – Otherwise
HIGH-RISKTAKER[c]	1 – Above average risk-taker 0 – Otherwise
AVERAGE-RISKTAKER	1 – Average risk-taker 0 – Otherwise
NOT-RISKTAKER	1 – Not a risk-taker 0 – Otherwise
MORTGAGERATE	Mortgage rate of interest[d]
AGE	Age of the household head
EDUCATION	Years of schooling of the household head
ETHNICITY	1 – Non-white 0 – Otherwise
HOUSEHOLDSIZE	Size of household
REPAYMENTFREQ[e]	0 – No or flexible repayment required 1 – Less frequent than monthly repayment required 2 – Monthly repayment required 3 – More frequent than monthly repayment required

[a] Maximum interest rate charged among the different HELOCs taken out by the household.
[b] Fraction of HELOC and mortgage debt repaid.
[c] Household's risk-tolerance on a 1 to 4 scale.
[d] Maximum interest rate charged among the different mortgage loans taken out by the household.
[e] Maximum of the repayment frequency on HELOC and mortgage debt.

Table 2: Full Information Maximum Likelihood Estimates of the HELOC Rates of Interest

Variables	Maximum Likelihood	
	Coefficient	S.E.
CONSTANT	3.486***	0.718
HOMEQUITY	-0.0003**	0.0001
NOT-RISKERTAKER	-0.014	0.316
HIGH-RISKTAKER	-0.537	0.532
DELINQUENCY	0.505	1.581
REPAYMENTRATE	3.788	2.852
MORTGAGE	-3.271***	0.885
MORTGAGERATE	0.46***	0.084
REPAYMENTFREQ	2.672***	0.329

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 3 presents the results of the maximum likelihood estimation for HELOC debt. The variables INCOME, OTHERASSETS, HOUSEHOLDSIZE, and HOMEQUITY are all significant with signs as expected. Households with high tolerance for risk are found to hold greater amounts of HELOC debt, as are those who itemize their taxes, since this debt is tax-deductible. The endogenous variable, the HELOC rate of interest, is found to depress HELOC debt-holding. The only significant socioeconomic variable is AGE, with advancing age decreasing the amount of HELOC debt held. The maximum likelihood estimates of the error variances (σ_1 and σ_2) are both significant. Finally, the estimate for ρ is found to be positive and significant.

Table 3: Full Information Maximum Likelihood Estimates of HELOC Debt

Variables	Maximum Likelihood Coefficient	S.E.
CONSTANT	-52.916	32.524
HOMEQUITY	0.028***	0.002
LIQUIDASSETS	0.003	0.003
OTHERASSETS	-0.003***	0.0003
HOUSEHOLDSIZE	4.722*	2.631
HIGH-RISKTAKER	19.988***	6.823
NOT-RISKTAKER	-5.592	9.789
DELINQUENCY	8.033	24.055
INCOME	-0.02***	0.005
TAX	16.013*	8.957
REPAYMENTRATE	-37.318	40.908
AGE	-1.93***	0.282
EDUCATION	0.868	1.602
ETHNICITY	3.611	10.746
HELOCRATE	-3.2*	1.8
σ_1	112.404***	1.494
σ_2	2.476***	0.072
ρ	0.182***	0.062
	-Log-L = -3751.253	

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

5. Summary and Conclusions

This paper has addressed the use of collateral in HELOCs. We have explored the role that collateral plays in sorting borrowers by their risk-types, thereby explaining the observed spread of HELOC rates of interest. The framework used here distinguishes between a line of credit and a loan. While the full amount of a traditional loan is actually borrowed, with a line of credit, the amount of actual borrowing may be different from the amount of credit extended. Therefore we proceed under the assumption that the actual or estimated borrowing amount is the relevant measure of the lender's exposure to risk for a line of credit. We thus make a distinction between the Loan-to-Value ratio (LTV), which has traditionally been used as a measure of risk, and the Borrowing-to-Value ratio (BTV), which should be estimated when considering secured lines of credit such as HELOCs. Our econometric analysis has utilized an estimate of the HELOC borrowing, along with the value of the collateral pledged and the HELOC interest rate, in a simultaneous equations model which assumes a pricing scheme reflecting the concept of BTV.

Using the *Survey of Consumer Finances, 1995, 1998* data with a maximum likelihood procedure, we have estimated the level of HELOC debt as a function of relevant variables. This includes the endogenous variable, the HELOC rate of interest, which is found to have a significant negative influence on HELCO debt. We have also estimated the HELOC rate of interest as a function of home equity pledged as collateral and other exogenous variables. Previous research has found the *sorting-by-observed-risk paradigm* to be empirically dominant in the secured *commercial* loan market. However, in the market for HELOC loans, we find that relatively low-risk borrowers signal their risk type by pledging larger amounts of collateral and thereby receive lower interest rates, thus supporting the *sorting-by-private-information paradigm*.

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APPENDIX A

Means of Variables for HELOC Debtors and HELOC Non-Debtors *

Variables	HELOC Debtors	HELOC Non-Debtors
	Mean	**Mean**
HOMEQUITY	264.9 (742.7)	331.9 (899.2)
LIQUIDASSETS	48.0 (195.2)	216.8 (1612)
OTHERASSETS	1489.2 (7262.9)	4279.3 (21389.9)
INCOME	200.8 (492.7)	553.8 (3905)
TAX	0.8 (0.4)	0.7 (0.5)
REPAYMENTRATE	0.03 (0.07)	0.01 (0.2)
HOUSEHOLDSIZE	3.1 (1.3)	2.7 (1.4)
MORTGAGE	0.8 (0.4)	0.6 (0.5)
MORTGAGERATE	6.3 (3.5)	4.8 (4.3)
DELINQUENCY	0.02 (0.1)	0.03 (0.2)
AGE	50.8 (11.4)	53.8 (15.2)
EDUCATION	14.9 (2.1)	14.1 (2.8)
REPAYMENTFREQ	2.0 (0.3)	1.1 (1)
HIGH-RISKTAKER	0.4 (0.5)	0.3 (0.5)
NOT-RISKTAKER	0.1 (0.4)	0.3 (0.4)
ETHNICITY	0.1 (0.3)	0.1 (0.3)

* All monetary variables are in thousands of dollars.