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Credit Lines and Credit Utilization

While much is known about the characteristics of consumers or businesses that obtain credit lines, relatively little is known empirically about credit line utilization after origination. This study fills that gap by testing two interrelated hypotheses concerning borrower credit quality and credit line utilization. The empirical analysis confirms that borrowers with higher expectations of future credit quality deterioration originate credit lines to preserve financial flexibility. Furthermore, we estimate a competing risks model that confirms our predictions concerning changes in borrower credit line utilization in response to borrower credit quality shocks.

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THE LITERATURE ON BANK credit commitments (or lines of credit) to businesses is extensive, and the link between firm quality and credit lines is well documented.[1] For example, Qi and Shockley (2003) find that higher quality firms finance via loan commitments, while Shockley and Thakor (1997) find that loan commitment costs decline with credit quality. Furthermore, Klapper (2002) finds that higher risk firms are more likely to use secured lines of credit than unsecured lines. In addition, Berger and Udell (1995) discuss the use of credit

1. In this paper, we consider "formal" lines of credit as opposed to "informal" lines of credit. An informal line of credit does not contractually commit the lender to provide funds, whereas a formal credit line involves an explicit contractual commitment on the part of the lender to provide funds to the borrower.

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commitments by small firms and find support for theoretical models showing that relationship lending produces information about borrower quality. Berger and Udell (1995) document that those firms with longer bank relationships borrow at lower rates than firms with shorter relationships. They also note that their results are consistent with the theory that banks accumulate private information about borrower quality and utilize this information in setting loan contract terms.[2] In two early studies of credit commitments, Melnik and Plaut (1986b) examined the composition of the credit line commitment contract and document that the size of the commitment is positively related to the commitment cost as well as the quality of the borrowing firm, while Melnik and Plaut (1986a) examined the relationship between firm default risk and pricing in commitments and spot loans. These empirical findings are broadly consistent with the theoretical model developed by Dinç (2000), but are counter to the theoretical predictions of Sharpe (1990), who posits that less risky firms will have higher interest rates than higher risk firms.

In addition, a number of studies have examined the role of credit lines in overcoming information asymmetry problems between borrowers and lenders. For example, in a study of business credit lines Boot, Thakor, and Udell (1987, 1991) show that loan commitments eliminate welfare losses resulting from asymmetric information. In addition, Berkovitch and Greenbaum (1991) demonstrate that business credit lines (or loan commitments) solve the traditional underinvestment problem through the imposition of usage fees and maximum loan amounts, while Duan and Yoon (1993) determine that firms can utilize loan commitments as a credible signal of project quality.

As this brief review demonstrates, much is known about the implications of originating credit commitments, as well as the characteristics of firms that originate them. However, few studies have empirically tested the predictions concerning risk and credit commitment utilization. This study seeks to fill this gap in the literature using information on consumer credit lines. Although consumer and business credit lines are distinct, the contractual features of consumer and business credit lines are remarkably similar. Thus, consumer credit lines provide an interesting market to empirically test the theoretical predictions concerning credit utilization and risk that have been derived from studies of business credit.

We use objective measures of credit risk to estimate the impact of changes in risk on borrower credit utilization. Furthermore, we also examine the conditions that lead borrowers to payoff their lines of credit. Our results are consistent with theoretical predictions that are derived from models of business credit lines that suggest that credit utilization increases during periods of economic distress. As a result, this study provides additional evidence concerning the link between borrower credit quality and bank loan commitments by utilizing a unique panel data set of borrower-specific consumer loan commitment contracts containing independent objective measures of credit quality.

2. Thakor (1982) establishes that lines of credit effectively allow lenders to sort firms based on risk while Duan and Yoon (1993) show that firms can utilize credit lines as a signaling mechanism of future growth prospects. Furthermore, Houston and Venkataraman (1996) show that firms will have preferences for credit lines based on firm risk characteristics and uncertainty regarding future projects.

In Section 1, we outline the distinction between bank loans and lines of credit. We also discuss the differences between consumer and business credit lines and the implications of these differences in the subsequent empirical analysis. In Section 2, we outline the testable hypotheses and in Section 3 we discuss the data. Section 4 follows with the empirical results, robustness checks, and a brief discussion of policy implications. Section 5 concludes.

1. CREDIT LINES AND TERM LOANS

The differences between bank loans and lines of credit with respect to business credit are well documented. According to Strahan (1999), banks provide firms with lines of credit to meet short-term liquidity needs, while also providing "term loans" to finance long-term investments. In general, the distinction between a term loan and a line of credit centers on two aspects of the contract. First, credit lines are usually variable-rate debt in which the bank commits to provide a fixed amount to the borrower, while term loans carry fixed as well as variable interest rates. Second, the borrower pays interest only on funds drawn against the commitment.[3]

Strahan (1999) notes that credit lines expose banks to both liquidity risk and credit risk, while term loans only involve credit risk. Liquidity risk refers to the bank's commitment to provide funds to the borrower over the life of the contract, while credit risk refers to the risk that the borrower may default on the loan. Of course, both liquidity risk and credit risk are interrelated since borrower credit risk usually increases during periods when liquidity risk is greatest. In general, Strahan (1999) finds that banks structure the price and terms of commitments and loans to reflect these risks. That is, less risky firms have lower interest rates and longer terms than higher risk firms.[4]

In consumer lending, the distinction between bank loans and lines of credit is equivalent. Home equity credit is generally classified into home equity loans [i.e., "spot" loans] and home equity lines. A home equity spot loan is a closed-end note extended for a specified length of time that requires repayment of interest and principal in equal monthly installments. The interest rate on these loans is usually fixed at the time of origination. On the other hand, a home equity line is an open-end revolving credit agreement that permits the consumer to borrow up to the amount of the line. The interest rate on credit lines varies with an index (often the prime rate).[5] Furthermore, most lines are open for 5 years, and during this time period they require payment of interest only. After 5 years, the line is closed and converted to a fixed-term loan requiring payment of both interest and principal in equal monthly installments.

3. In addition, business credit line contracts often have a provision assessing a fee on the unutilized portion of the commitment (Melnik and Plaut, 1986b).

4. This is consistent with the findings of Berger and Udell (1995). Credit line pricing is the subject of an extensive literature (see James, 1981, and Melnik and Plaut, 1986a, 1986b, among others).

5. DeMong and Lindgren (1995) document that 90% of all credit lines are variable rate.

With respect to consumer bank spot loans and lines of credit, Canner, Durkin, and Luckett (1998) document that consumers with credit lines typically own relatively more expensive homes, have higher income, and have substantially greater equity in their homes than borrowers with bank loans. In fact, they show that median household income for line borrowers in their sample was $10,000 more than that for loan borrowers. Furthermore, the median home equity among the line borrowers in their sample was $76,000, as opposed to $35,000 for loan borrowers. Finally, Canner, Durkin, and Luckett (1998) note that 23% of the loan borrowers were below the age of 34, compared to only 6% of the line borrowers. Manchester and Poterba (1989) report similar findings regarding second mortgage borrower characteristics contained in the Survey of Income and Program Participation. The financial strength of the line borrowers is also reflected in the statistics on delinquency rates. For instance, according to the American Bankers Association statistics, less than 1% of the lines, as opposed to 1.25% of the loans, are delinquent.[6]

While consumer and business credit lines are relatively similar with respect to key contract features, a number of important differences exist. For example, unlike business credit lines, consumer credit lines do not contain material adverse change clauses that allow lenders to withdraw the line if credit quality declines after origination.[7] In addition, consumer credit lines do not have upfront commitment fees or overuse penalties, which are common in business credit lines.

2. HYPOTHESES DEVELOPMENT AND EMPIRICAL METHODOLOGY

One of the primary advantages of credit lines over term spot loans is that credit lines provide borrowers with financial flexibility. In studying bank commitments to businesses, Avery and Berger (1991) provide evidence that a primary motive for using credit commitments is to provide flexibility during adverse credit market conditions. Kanatas (1987) notes that credit commitments provide firms with a guarantee of credit, and thus can be viewed as hedging instruments. Furthermore, Hawkins (1982) notes that credit lines provide firms with a mechanism for managing fluctuations in working capital.

A second advantage of credit lines over spot term loans is that credit lines provide borrowers with access to funds in the event that deterioration in credit quality precludes future borrowing in the spot market. For example, Avery and Berger (1991) indicate that credit lines provide risk-averse firms with access to credit in the event of a future decline in credit quality.

Since the primary purpose of credit lines is to provide future financial flexibility, the majority of borrowing firms do not utilize the full credit line at origination. For

6. According the Survey of Consumers conducted from May to October 1997, other differences exist between line and loan borrowers. For instance, 49% of the households who prefer a loan are sensitive to interest rates, whereas 43% of households cite the "ease of use" for choosing lines, as opposed to 1% who select loans.

7. Lenders are able to convert the credit line into a fixed-term loan (effectively restricting further draw down of the line) if the borrower becomes delinquent on the line payments.

example, Martin and Santomero (1997) note that firms typically utilize only 65% of their credit line, implying that the average firm with a credit line has access to significant future credit.

While much is known about the characteristics of consumers or businesses that obtain lines of credit, relatively little is known empirically about line utilization (or takedown) after origination. Given that one of the primary reasons for originating a credit line is to provide flexibility in the event of future credit shocks, we hypothesize that initial credit utilization will be lower for borrowers with higher *a priori* expectations of a future credit deterioration. That is, in equilibrium, borrowers who value the flexibility afforded by ready access to credit will preserve the option for future credit by retaining the option to increase their credit line utilization. However, borrowers with low expectations of future credit demand should utilize a greater percentage of total credit availability, all else being equal.[8]

In addition to credit utilization at origination, Greenbaum and Venezia (1985) note that borrower credit line takedowns after origination are an increasing function of borrower risk. Thus, if borrowers originate credit lines in anticipation of future credit shocks, then we should observe an inverse relationship between changes in borrower credit quality after origination and credit utilization at origination. That is, borrowers who experience credit shocks are more likely to take down their credit line after origination.

Unlike business credit lines, consumer credit lines also have characteristics similar to mortgages, in that the credit line is collateralized by the borrower's principal residence. Traditional mortgage pricing models recognize two explicit options embedded in the mortgage contract, the right to prepay and the right to default. In addition, the now ubiquitous mortgage option pricing models recognize that the interaction of the explicit termination options create an additional implied option to substitute one method of termination with another.[9] Traditional mortgage pricing models recognize that the primary sources of uncertainty, interest rates, and house prices determine the option values. Given that consumer credit lines are secured by the underlying property and are prepayable at the borrower's option, we expect to find similar relationships between the termination options and volatility of interest rates and property values.

As with traditional mortgages, the options embedded in credit lines have significant interaction effects that create difficulties in empirically isolating the factors associated with line performance. As discussed above, a credit commitment gives the borrower an explicit right to draw down funds against the commitment over the term of the loan. However, the borrower also has the option to pay off the existing balance of the commitment at any time prior to the loan termination. Analyzing these options requires recognizing the implicit interactions embedded in the exercise of each

8. This is consistent with the theoretical models of credit lines as developed in Campbell (1978), Hawkins (1982), Melnik and Plaut (1986a, 1986b), and Sofianos, Wachtel, and Melnik (1990).

9. See Kau and Keenan (1995) for a review of the literature and issues associated with traditional mortgage pricing models.

option. For example, the incentive to prepay increases during periods of declining interest rates as borrowers seek to convert their variable-rate lines to fixed-rate loans, with the incentive to prepay being greater for borrowers with higher loan amounts, all else being equal. However, a decline in interest rate levels coupled with a downward sloping yield curve is usually correlated with overall weakness in the economy, indicative of declining credit quality. This suggests that the borrower's ability to refinance (and hence prepay the line) may decline at the same time as the borrower's credit commitment utilization increases. Furthermore, the subsequent probability of default and corresponding loss associated with default should also rise as credit utilization increases. This is embodied in the "credit risk" component of credit commitments, as discussed by Strahan (1999).

To summarize, we identify two interrelated testable hypotheses concerning the relationship between borrower credit risk and credit line utilization. First, initial credit utilization will be lower for borrowers with expectations of future credit quality deterioration. Second, credit line utilization (takedown) after origination will be correlated with changes in borrower credit quality.[10] The next section presents the data used in testing these hypotheses.

3. DATA

The data are from a large financial institution (proprietary in nature) that originates home equity lines. Our sample consists of 34,384 credit lines issued to owner-occupants and originated from January 1998 to May 2001. The loans are typical credit lines that are open for the first 5 years, during which time the borrower is only required to make interest payments on the utilized line balance. After the fifth year, the line is closed and converts to a fixed-rate term loan with a remaining term of 5 or 15 years. At this point, the borrower is required to make fixed monthly payments of principal and interest for the remaining period of the line. Consistent with other mortgage loans, the borrower may prepay the line at any time. We require that credit lines have at least 12 months of performance data to be included in the analysis, and we track the performance of each credit line from origination to May 2002.

The credit lines are originated in nine northeastern states, with the majority located in Massachusetts (64.1%), Connecticut (9.9%), and New York (9.8%). Table 1 reports the geographic distribution of the credit lines, and Table 2 reports the

10. A third interrelated hypothesis is that credit utilization will also vary inversely with borrower expectations of future liquidity needs. That is, borrowers with highly variable incomes (or consumption patterns) may originate credit lines in order to tap into their home equity during periods of low income. Unfortunately, our data set does not contain information on expectations of borrower liquidity (such as self-employment status or other assets), and thus we are unable to directly test this hypothesis. However, in Section 4.3, we examine the relationship between credit utilization and household wealth and income levels as a robustness check against our results concerning credit utilization and changes in credit quality.

TABLE 1

GEOGRAPHIC DISTRIBUTION OF CREDIT LINES

State	Percentage (%)
CT	10.0
MA	64.2
NH	5.7
NJ	5.2
NY	9.9
PA	0.6
RI	0.5

NOTE: This table reports the geographic distribution at the state level of the 34,384 credit lines issued to owner-occupants from January 1998 to May 2001.

descriptive statistics for the lines at origination. We note that the average loan-to-value (OLTV) ratio at origination (calculated as total debt (credit line plus first-mortgage debt) divided by house value) is 48% and the average borrower credit score at origination is 724.[11] The average interest rate spread at origination is 2.3%.[12]

4. EMPIRICAL TESTS

4.1 Initial Credit Utilization

The theoretical expectation is that borrowers take out credit lines in order to meet unexpected cash-flow shocks. Consistent with this expectation, we see that the average credit line was \$46,392, while the average amount utilized at origination (line balance) was \$24,459. Furthermore, we note that the average credit line utilization at origination was 61%. This indicates that many borrowers had significant potential credit available.

Borrower credit (FICO) scores provide lenders with an objective indicator of future borrower default propensity, with higher scores indicating lower risk of future default. To confirm the link between current and future credit quality, we examine the relationship between current borrower FICO score and future changes in FICO scores. In order to maintain a consistent analysis window, we track changes in borrower FICO scores at quarterly intervals over 12 and 24 months.[13] To measure the change in borrower credit quality, we calculate the percent change in the borrower's FICO score over the 12- or 24-month window. Thus, FICO_CHANGE is defined as ([FICO_NEW − FICO_OLD]/FICO_OLD), where FICO_OLD is the borrower's

11. Borrower credit scores are provided by Fair, Isaac and Company (FICO). Higher scores indicate higher credit quality.

12. The interest rate spread is defined as the line annual percentage rate at origination less the 10-year Treasury rate.

13. Since we require that all observations have at least 12 months of data, the 12-month analysis includes all borrowers. However, some borrowers will leave the sample during the second year after origination, and thus, the 24-month analysis will be biased towards borrowers with longer loan tenures. It is unclear what impact this selection bias will have on the 24-month credit change analysis.

TABLE 2

DESCRIPTIVE STATISTICS OF CREDIT LINES AT ORIGINATION

Variable	Mean	Standard deviation
Line amount	\$46,392	\$34,820
Line balance	\$24,459	\$23,944
Loan-to-value (OLTV) (%)	47.90	34.48
APR spread (%)	2.26	0.91
Utilization (U) (%)	60.99	37.77
FICO	724	79
Unemployment rate (%)	3.16	1.19

NOTES: This table describes the characteristics at origination of the 34,384 credit lines issued to owner-occupants from January 1998 to May 2001. Line amount is the maximum credit amount available under the credit line agreement. Line balance is the amount of credit accessed (taken down) at origination. Loan-to-value equals the total debt (credit line amount plus first-mortgage debt balance) at credit line origination divided by the collateral property value. APR spread is the credit line annual percentage rate at origination less the 10-year Treasury rate. Utilization is the line balance at origination divided by the line amount. FICO is the borrower's Fair, Isaac and Company credit score at origination. Unemployment rate is the unemployment rate for the borrower's county during the quarter when the credit line was originated.

FICO score at origination and FICO_NEW is the borrower's FICO score at either month 12 or 24. Since we are interested in the probability that credit scores will deteriorate over the subsequent period, we set positive changes in FICO to zero. Thus, FICO_CHANGE is a simple measure of credit deterioration. To test whether borrowers with lower FICO scores at line origination experience a higher credit quality decline, we estimate the following equation:

$$\text{FICO\_CHANGE}_i = f(\text{FICO}_i, \text{State}_i)\ , \tag{1}$$

where FICO_i is borrower i's credit quality score at origination and State_i is a series of dummy variables controlling for location. Equation (1) is estimated as a Tobit model, and our hypothesis is that credit decline (FICO_CHANGE) will be negatively related to borrower FICO score at line origination. Table 3 reports the results for both the 12- and 24-month analysis. The significantly negative coefficient for FICO indicates that borrowers with high initial FICO scores encounter smaller subsequent drops in their credit quality score than borrowers with lower initial credit quality scores.[14] To put these results into perspective, the estimated coefficient for FICO for the 24-month window indicates that the probability of credit deteriorating for a borrower with a FICO score of 800 at origination is 6.2% while the probability of credit deterioration for a borrower with a FICO score of 650 at origination is 17.3%.

14. We conducted two robustness tests to validate our finding that future credit risk is a function of current credit risk. First, we create a dummy variable denoting borrowers whose FICO scores at the end of the analysis window are lower than at origination. This specification is a simple test for the probability of a decline in credit quality. Estimation results (based on a logit model) confirm that borrowers with higher initial credit scores have a lower probability of a decline in credit quality. Second, we constructed a dummy variable that equals one if the borrower experienced any decline in FICO score over the analysis window. This specification tests for any reduction in credit quality. Results from all specifications show that the relationship is robust. The results are reported in the Appendix.

TABLE 3

Tobit Regression of Change in Credit Quality

	12-month window			24-month window		
Variable	Coefficient value	Standard error	p-value	Coefficient value	Standard error	p-value
Intercept	−0.070	0.046	0.133	−0.316	0.037	<0.0001
FICO at origination	−2.0E−04	1.0E−04	0.012	−0.001	0.000	<0.0001
State Dummy CT	−0.010	0.013	0.411	−0.019	0.012	0.110
State Dummy MA	−0.010	0.013	0.431	−0.008	0.012	0.507
State Dummy NH	−0.004	0.016	0.811	−0.010	0.014	0.455
State Dummy NJ	0.010	0.013	0.437	0.009	0.012	0.482
State Dummy NY	0.009	0.013	0.466	0.009	0.011	0.458
State Dummy PA	0.103	0.153	0.583	0.014	0.026	0.586
Likelihood ratio	81.1			90.2		
Number of observations	34,384			32,948		

Notes: This table presents the Tobit regression analysis of change in borrower credit quality to test the hypothesis that borrowers with lower credit scores at credit line origination experience a greater subsequent decline in credit quality. The dependent variable is defined as ([FICO_NEW − FICO_OLD]/FICO_OLD) if less than zero and is set to zero otherwise. FICO is the borrower's credit quality score.

Based on the results reported in Table 3, in equilibrium, borrowers with low *a priori* expectations of future credit quality deterioration (i.e., borrowers with high initial FICO scores) should value the flexibility of credit lines less than borrowers with higher risk (borrowers with lower FICO scores). Thus, to test the hypothesis that borrowers with high *a priori* expectations of future credit quality decline request credit lines in excess of current consumption requirements, we examine the distribution of credit utilization based on credit quality. Table 4 reports the mean credit utilization and loan-to-value ratios at origination for the sample segmented by FICO score. We segment the sample into quartiles based on FICO scores. The average initial credit utilization ratio for borrowers in the top quartile of the FICO distribution is 81%, while the initial credit utilization for the borrowers in the bottom quartile of the FICO distribution is 35%. This is consistent with our hypothesis that borrowers with higher *a priori* expectations of future credit needs (lower FICO scores) conserve their credit resources by utilizing lower amounts of their credit line at origination. In addition, we see that the average origination loan-to-value ratios for the bottom and top quartiles are 25% and 66%, respectively. Based on the F-test of differences in sample means, we can reject the null hypothesis that average utilization rates are equal across borrower FICO quartiles.

In addition to the simple means test, we also test the initial credit utilization hypothesis by estimating the following regression:

$$U_i = \beta_0 + \beta_1 \mathrm{OLTV}_i + \beta_2 r_i + \beta_3 \mathrm{FICO}_i + \sum_{k=1}^{6} \delta_k \mathrm{State}_{ki} + \varepsilon_i\,, \tag{2}$$

where U_i is borrower i's credit line utilization at origination, OLTV_i is the original loan-to-value, r_i is the current mortgage interest rate, FICO_i is the borrower's credit signal at origination, and State_i is a series of dummy variables controlling for the borrower's location. The relationships between FICO score, loan-to-value ratio, and

TABLE 4

Distribution of Credit Utilization and LTV Ratios at Origination by FICO Score

FICO scores	Credit utilization	Loan-to-value
FICO quartile (range: 449–698)	35.26 (35.03)	25.12 (29.30)
FICO quartile (range: 699–735)	55.84 (36.87)	42.28 (32.75)
FICO quartile (range: 736–766)	71.29 (33.42)	57.36 (31.50)
FICO quartile (range: 767–831)	80.8 (28.70)	66.55 (29.15)
F-test	30.23	19.2

Notes: This table reports the means and standard deviations of the borrower's credit line utilization at origination and loan-to-value ratio at origination by FICO quartile range. Credit utilization is the line balance at origination divided by the line amount and loan-to-value equals the total debt (credit line amount plus first-mortgage debt balance) at credit line origination divided by the collateral property value.

initial credit line utilization identified in Equation (2) may result from a form of sample selection bias present in the data due to the underwriting process governing credit line originations. That is, low FICO score borrowers may have compensating factors (such as significant equity) that would lead to a finding that low credit score borrowers have lower utilization rates.

In order to control for this potential bias, we estimate the two-stage "treatment effects" model (see Greene 1997). This procedure involves estimating the following credit line origination accept/reject equation

$$\mathrm{ACCEPT}_i = \gamma Z_i + \xi_i \,, \tag{3}$$

where Z_i is a vector of underwriting characteristics utilized by the lender in determining whether to accept or reject the credit line application and ξ_i is an error term. In order to estimate this model, we supplemented the credit line data set with underwriting data on 14,923 credit line applications that were rejected over the same origination window (January 1998 to May 2001). The underwriting characteristics include the borrower's FICO score, loan-to-value ratio, debt-to-income ratio, an indicator variable denoting prior borrower fraud, an indicator variable denoting prior borrower bankruptcy, an indicator variable denoting prior borrower delinquency, an indicator variable denoting whether the borrower has a prior foreclosure, and finally an indicator denoting the presence of prior liens on the property (other than the senior mortgage). We estimate Equation (3) as a probit model with the following form:

$$\Pr(\mathrm{ACCEPT}_i = 1) = \frac{\phi(-\gamma Z_i)}{1 - \Phi(-\gamma Z_i)} \tag{4}$$

and

$$\Pr(\mathrm{ACCEPT}_i = 0) = [1 - \Pr(\mathrm{ACCEPT}_i = 1)] \,. \tag{5}$$

ϕ is the standard normal probability density function (pdf) and Φ is the standard normal cumulative distribution function (cdf). We compute the inverse Mills ratio (λ_i) as

$$\lambda_i = \frac{\phi(\hat{\gamma}Z_i)}{\Phi(\hat{\gamma}Z_i)} \,. \tag{6}$$

Flannery and Houston (1999) note that if ε_i and ξ_i are jointly normally distributed, then

$$E(\varepsilon_i \,|\, \text{ACCEPT}_i) = \rho\sigma_\xi E(\xi_i \,|\, \text{ACCEPT}_i) \,, \tag{7}$$

where ρ is the correlation between ε_i and ξ_i, and σ_ξ is the standard deviation of ξ_i. Thus, in the second step, we estimate Equation (2) via least squares with λ_i included as an explanatory variable:

$$U_i = \beta_0 + \beta_1 \text{OLTV}_i + \beta_2 r_i + \beta_3 \text{FICO}_i + \sum_{k=1}^{6} \delta_k \text{State}_{ki} + \alpha\lambda_i + \varepsilon_i \,, \tag{8}$$

The inverse Mills ratio coefficient (α) is a measure of ($\rho\sigma_\xi$) in Equation (7) and an insignificant parameter estimate for λ indicates that sample selection bias is not present. However, Willis and Rosen (1979) show that including λ corrects for selectivity bias in the sample observations.

Table 5 presents the estimated coefficients for the line acceptance Equation (3) and the utilization Equation (8). Panel A shows the estimates for the underwriting model. Given that we include all the factors utilized by the lending institution in determining borrower acceptability, it is not surprising that all the coefficients are highly significant with the appropriate sign. For example, the probability of acceptance increases with borrower credit quality and decreases with the loan-to-value ratio, the debt-to-income ratio, and the indicators of past credit problems (delinquency, foreclosure, bankruptcy, fraud, and other liens).

Table 5, Panel B, reports the second-stage results with asymptotically corrected standard errors for the utilization model including the inverse Mills ratio to control

TABLE 5

Sample Selection Correction

Panel A. Probit Model				
Variable	Coefficient value	Standard error	*t*-statistic	*p*-value
Intercept	−1.744	0.142	−151.0	<0.0001
FICO score	0.004	0.000	609.6	<0.0001
OLTV	−0.010	0.000	−690.6	<0.0001
Debt to income	−0.015	0.001	−877.8	<0.0001
Fraud indicator	−3.102	0.288	−115.8	<0.0001
Prior delinquency	−1.266	0.041	−954.7	<0.0001
Prior bankruptcy	−2.352	0.123	−363.8	<0.0001
Prior foreclosure	−2.318	0.269	−74.3	<0.0001
Liens	−0.790	0.081	−94.6	<0.0001
Log likelihood	−9594			
Number of accounts accept/decline	34,384/14,923			

Notes: This table reports the maximum-likelihood parameter estimates for the first-stage probit model of whether the credit line application is accepted or rejected. The dependent variable is a dummy variable equal to 1 if the application is accepted and 0 otherwise. The independent variables are as follows: FICO score is the borrower's credit quality score at application; OLTV is the proposed loan-to-value ratio; debt-to-income is the borrower's proposed total debt to income; fraud, delinquency, bankruptcy, and foreclosure are indicator variables of prior borrower credit problems; and liens indicates whether the borrower has additional outstanding debt.

TABLE 5

SAMPLE SELECTION CORRECTION

Panel B. Second-stage OLS Regression with Consistent Asymptotic Standard Errors

Variable	Coefficient value	Standard error	t-statistic	p-value
Intercept	56.077	3.119	17.980	<0.0001
OLTV	0.183	0.006	29.154	<0.0001
APR	−1.262	0.226	−5.584	<0.0001
FICO	0.008	0.002	3.411	0.001
State Dummy CT	2.999	1.089	2.752	0.006
State Dummy MA	−5.700	0.931	−6.123	<0.0001
State Dummy NH	−0.091	1.210	−0.075	0.940
State Dummy NJ	2.390	0.130	18.364	<0.0001
State Dummy NY	2.367	0.117	20.162	<0.0001
State Dummy PA	2.509	0.230	10.926	<0.0001
λ	11.152	1.332	8.372	<0.0001
R^2	0.121			
Number of observations	34,384			

NOTES: This table reports the OLS regression estimates of the following equation:

$$U_i = \beta_0 + \beta_1 \mathrm{OLTV}_i + \beta_2 r_i + \beta_3 \mathrm{FICO}_i + \sum_{k=1}^{6} \delta_k \mathrm{State}_{ki} + \alpha\lambda_i + \varepsilon_i \,.$$

The dependent variable is credit line utilization at origination. OLTV_i is the original loan-to-value (total debt divided by property value), r_i is the current mortgage interest rate, FICO_i is the borrower's credit signal at origination, and State_i is a series of dummy variables controlling for the borrower's location. The inverse Mills ratio (λ) is defined as $\lambda_i = \phi(\hat{\gamma}Z_i)/\Phi(\hat{\gamma}Z_i)$, where γ are the parameter coefficients of the first-stage probit model reported in Panel A.

for sample selection bias. The positive and significant parameter estimate for FICO confirms our hypothesis that borrowers with higher credit quality signals have higher initial credit utilization rates. This is consistent with our expectation that borrowers with lower credit signals (low FICO scores)—and thus a higher probability of encountering a future liquidity shock (and are less likely to be able to handle such a shock)—preserve flexibility by utilizing a lower amount of credit at origination relative to borrowers with higher credit quality signals. For example, the parameter estimates indicate that a borrower with an FICO score of 650 would utilize 34.8% less credit at line origination than a borrower with an FICO score of 800. We also note that initial utilization decreases with increases in mortgage interest rates (r). Furthermore, initial utilization also increases with loan-to-value. The significantly positive coefficient for λ indicates that a simple OLS model of credit line utilization without including λ would suffer from omitted variables bias.[15] In addition, since the coefficient for λ is positive, this suggests that credit line utilization is larger than that estimated under a simple OLS regression.

4.2 Changes in Borrower Credit Quality and Credit Line Performance

To test the "credit risk" hypothesis—that subsequent credit utilization and credit line performance are related to changes in borrower credit—we compare the ex-post origination performance of credit commitments to determine whether higher

15. See Flannery and Houston (1999) for a discussion of the interpretation of the inverse Mills ratio in the context of the impact of bank examinations on market value.

risk borrowers do indeed take advantage of the flexibility afforded by credit lines. Thus, we estimate a competing risks model of borrower actions, recognizing that the borrower has the ability to draw additional funds from the commitment (increase utilization), partially prepay the line, fully pay off the line, default, or maintain the current level of utilization. In estimating the competing risks model, we denote credit commitments that are still current at the end of the observation period as censored. Thus, we define T_j ($j = 1,\ldots,5$) as the latent duration for each commitment to end by partially prepaying, fully prepaying, defaulting, increasing credit utilization, or being censored, and the observed duration, τ, is the minimum of the T_j.

Conditional on a set of explanatory variables, x_j, that include personal characteristics as well as market conditions at the time of origination, the pdf and cdf for T_j are

$$f_j(T_j \mid x_j;\theta_j) = h_j(T_j \mid x_j;\theta_j)\exp(-I_j(r_j \mid x_j;\theta_j)) , \tag{9}$$

$$F_j(T_j \mid x_j;\theta_j) = 1 - \exp(-I_j(r_j \mid x_j;\theta_j)) , \tag{10}$$

where I_j is the integrated hazard for outcome j:

$$I_j(T_j \mid x_j;\theta) = \int_0^{T_j} h_j(s \mid x_j;\theta_j)\, \mathrm{d}s \tag{11}$$

and h_j is the hazard function.

The joint distribution of the duration and outcome is

$$f(\tau,j \mid x;\theta) = h_j(\tau \mid x_j;\theta_j)\exp(-I_0(\tau \mid x;\theta)) , \tag{12}$$

where $x = (x_1, x_2, x_3, x_4, x_5)$, $\theta = (\theta_1, \theta_2, \theta_3, \theta_4, \theta_5)$, and $I_0 = \Sigma\, I_j$ is the aggregated integrated hazard. Thus, the conditional probability of an outcome is

$$\Pr(j \mid \tau,x;\theta) = \frac{h_j(\tau \mid x_j;\theta)}{\sum_{j=1}^{5} h_j(\tau \mid x;\theta)} . \tag{13}$$

In order to simplify estimation, we specify a separate exponential hazard function for each mortgage outcome

$$h_j(\tau_j \mid x_j;\theta_j) = \exp(x_j'\beta_j) \tag{14}$$

and estimate Equation (14) in a multinomial logit framework.

In estimating Equation (14), we recognize that we initially observe each credit line as being current. In subsequent quarters, we observe whether the borrower continues the current credit utilization, increases the utilization, partially prepays the line (decreases utilization), fully prepays the line, or defaults on the line. We classify borrowers as increasing their credit utilization if the credit line amount increased more than 20% in any given quarter, and we classify a partial prepayment if the credit line amount declined by more than 20% but less than 100% in any given quarter. Although arbitrary, we chose the 20% cutoff criteria in order to focus on substantial changes in borrower credit line utilization rather than *de minimus* changes in credit utilization.[16] Obviously, full prepayment occurs if the credit line is closed and the full amount paid off. Over the sample period, very few borrowers defaulted, and thus, we are unable to estimate the default hazard. However, we include a dummy variable for a positive quarterly change in the loan-to-value (LTV_DIFF_Dummy) to capture the changes in default option values. Quarterly current loan-to-value (CLTV) ratios were estimated by multiplying the loan-to-value at origination (OLTV) by the change in local house prices since origination. We use the zip code level Case-Shiller Home Price Index as a proxy for changes in local house prices. Furthermore, we observe the quarterly change in borrower credit quality (FICO score), the change in market interest rates, and the change in the county unemployment rates. Our proxy for the market interest rate is the average interest rate charged by lenders on new first mortgages. We also include the county unemployment rate as a proxy for local economic risk factors and state dummy variables to control for unobserved differences in local economic risk factors.

We use the credit score level and a dummy variable for a change in borrower credit score as a proxy for credit quality shocks. According to our theoretical predictions, a decline in a borrower's credit score (indicating a credit shock) should be associated with a higher probability of credit utilization and a lower probability of prepayment. Furthermore, we anticipate that increases in interest rates and declines in estimated house values will be associated with lower probabilities of prepayment. Finally, assuming that local unemployment rates also serve as a proxy for borrower credit shocks, we should see lower prepayment probabilities and higher credit utilization probabilities for borrowers in areas with rising unemployment rates. Table 6 presents the estimated coefficients for Equation (14), and Table 7 presents the marginal effects, showing the impact of a change in a variable (holding all else constant) on the outcome probabilities at month 48.

Full prepayment. Looking first at the probability of prepayment, we see that, with the exception of the dummy variables for a positive change in LTV and unemployment over the previous quarter (LTV_DIFF_Dummy and Unemp_DIFF_Dummy), all the borrower and economic risk factors are statistically significant. The marginal effects table provides a better indication of the economic significance. For example, we see that a 10% decline in borrower credit quality results in a 7.2% decline in the probability of prepayment, and a 10% increase in the LTV (reflecting a decrease in the house value) corresponds to a 12.9% decrease in the probability of prepayment at month 48. Consistent with theoretical expectations about the impact of changes in market interest rates, a 1 percentage point decline in the average mortgage interest rate is associated with a 10% increase in the probability of prepayment. This indicates that borrowers do take advantage of dips in interest rates to convert variable-rate lines into fixed-rate loans. Finally, we note that a 1 percentage point increase in the unemployment rate corresponds to a 5.9% drop in the probability of prepayment. Overall, the results follow expectations concerning the importance of borrower

16. We also tried alternate specifications, and the results were qualitatively similar. Results are available from the authors upon request.

TABLE 6

COMPETING RISKS MODEL COEFFICIENT ESTIMATES OF CREDIT LINE OUTCOMES

	Prepay			Decrease utilization			Increase utilization		
	Coefficient value	Standard error	p-value	Coefficient value	Standard error	p-value	Coefficient value	Standard error	p-value
Intercept	9.814	3.214	0.002	−6.268	0.468	<0.0001	−3.968	0.500	<0.0001
State Dummy CT	0.934	0.688	0.175	−0.237	0.085	0.005	−0.130	0.080	0.104
State Dummy MA	1.491	0.663	0.024	−0.239	0.078	0.002	−0.124	0.072	0.087
State Dummy NH	1.302	0.815	0.110	−0.537	0.099	<0.0001	−0.010	0.099	0.920
State Dummy NJ	−6.852	460.900	0.988	−0.489	0.742	0.510	−8.799	58.790	0.881
State Dummy NY	−1.369	1.172	0.243	−0.188	0.321	0.558	−0.187	0.330	0.572
State Dummy PA	−7.413	280.100	0.979	−1.049	0.730	0.151	−0.128	0.750	0.865
Age	0.069	0.062	0.267	−0.017	0.009	0.046	0.013	0.009	0.144
Age (square)	0.001	0.001	0.537	1.1E−04	1.4E−04	0.424	−1.5E−04	1.5E−04	0.317
CLTV_Diff_Dummy	−0.061	0.176	0.727	−2.001	0.039	<0.0001	−1.591	0.028	<0.0001
CLTV	−0.025	0.003	<0.0001	−0.004	4.9E−04	<0.0001	−0.057	0.001	<0.0001
FICO_Diff_Dummy	0.320	0.137	0.031	0.033	0.025	0.186	−0.049	0.021	0.031
FICO (lagged 4 months)	0.001	1.8E−04	0.013	0.003	3.1E−04	<0.0001	−0.001	3.0E−04	0.014
APR_Diff_Dummy	−1.907	0.694	0.006	0.257	0.094	0.006	0.159	0.050	0.021
APR	−1.456	0.709	0.040	0.250	0.096	0.010	0.167	0.040	0.031
Unemp_Diff_Dummy	−0.679	0.701	0.332	−0.127	0.092	0.169	−0.086	0.094	0.356
Unemployment	−0.456	0.134	0.001	−0.175	0.019	<0.0001	−0.005	0.019	0.795

NOTES: This table shows results of a proportional hazard model of prepayment, increasing utilization, and decreasing utilization using monthly date for home equity lines of credit from January 1998 to May 2002. Increased utilization is defined as increasing the credit line amount more than 20% in any given quarter. Decreased utilization is defined as decreasing the credit line amount by more than 20% but less than 100% in any given quarter. Although arbitrary, we chose the 20% cutoff criteria in order to focus on substantial changes in borrower credit line utilization. The independent variables control for calendar time, credit risk, current loan-to-value ratio, interest rates, and county unemployment rates both at the level and differences. The competing risks model is estimated as a multinomial logit via maximum likelihood.

TABLE 7

IMPACT OF CHANGES IN VARIABLE VALUES ON PREDICTED OUTCOME PROBABILITIES

Marginal effects	Age 48 months
Prepayment	
FICO 10% drop	−7.23%
CLTV 10% increase	−12.91%
APR 1% point drop	10.03%
Unemployment 1% point increase	−5.93%
Increase utilization	
FICO 10% drop	15.57%
CLTV 10% increase	−23.89%
APR 1% point drop	−2.71%
Unemployment 1% point increase	−3.13%
Decrease utilization	
FICO 10% drop	−7.81%
CLTV 10% increase	−3.28%
APR 1% point drop	−0.49%
Unemployment 1% point increase	−0.48%

NOTES: This table reports the impact of a change in the indicated variable on the probabilities of prepayment and credit utilization holding all other variables constant that their sample mean.

characteristics on the exercise of financial options. For example, the decline in prepayment following a reduction in credit quality is consistent with borrowers preserving current credit given the lower likelihood of qualifying for future credit.

Partial prepayment. Turning to the probability of a decrease in utilization (or partial prepayment), we again find that a decline in borrower quality is associated with a decline in the probability of a partial prepayment. A 10% decline in borrower FICO scores results in a 7.8% drop in the probability of decreasing the credit line by month 48. Interestingly, however, the risk factor associated with changes in property value is negatively associated with partial prepayment. The marginal effects indicate that a decline in house values (proxied by a 10% increase in LTV) results in a 3% decline in the probability of paying down part of the credit line. Again, this is consistent with the theory that the ability to refinance is reduced during periods of declining property value. Furthermore, our model indicates that changes in interest rates and unemployment rates, while statistically significant, have very small economic impacts on partial prepayment.

Increased utilization. Finally, turning to the probability of an increase in utilization, we see that a 10% decline in borrower credit quality corresponds to a 15% increase in the probability that the borrower will draw against the credit line. This is consistent with our hypothesis that borrowers experiencing a credit shock (proxied by a decline in credit quality) are more likely to increase their credit line utilization. However, the estimated coefficients imply that a 10% decline in property value results in a 23.9% decline in the probability of increased utilization. This is not consistent with the hypothesis that borrowers facing credit shocks (or asset value deterioration) will increase their credit line utilization. On the other hand, this finding is consistent with the theory that borrowers rationally manage their overall debt exposure in the face of changes in asset value. That is, borrowers do not actively increase their debt burden and thus increase the probability of optimal default when property values fall. We also see that a decline in market interest rates and an increase in the local unemployment rate each result in a lower probability of an increase in utilization. The marginal effects indicate that a 1 percentage point decrease in the interest rate results in a 2.7% drop in the probability of the borrower increasing the credit line utilization. Although it implies that borrowers respond to changes in price, an interesting question is why credit utilization increases rather than declines as the cost of credit increases. In the meantime, contrary to our expectations, borrowers in areas experiencing an adverse economic shock (increasing unemployment rates) have a lower probability of increasing their credit utilization.

4.3 Robustness Checks

We conduct several robustness checks. Specifically, we are concerned that an increase in utilization might just be a reflection of the permanent income hypothesis and not necessarily a response to credit shocks.[17] Hence, we control for both financial and demographic characteristics of the borrower. Specifically, we control for household wealth and income at account origination. Since both income and wealth can be endogenous to changes in utilization, we control for them at account origination. We construct three control variables denoting low, medium, and high income and wealth. Table 8 reports the distributions of the various segments, with 62% of households having a net worth between \$50,000 and \$70,000, while 59% of households have a gross income between \$40,000 and \$80,000. We define both of these categories as medium wealth. Wealth for the low and high categories is evenly distributed at 18%, while the low-income and high-income categories represent 12% and 27% of the households, respectively.[18]

Table 9 provides results for the determinants of net worth and income on prepayment, partial prepayment, and increased utilization. High income and wealth categories are the control segments. We also interact the credit score with both income and wealth. Income, wealth, and their interaction with credit scores are statistically insignificant for prepayment. Income variables are also insignificant for increased utilization. The results show that low- and medium-wealth households tend to increase utilization in comparison to high-wealth individuals. Moreover, the interaction of low- and medium-wealth households with credit score shows that an increase in credit constraints within each wealth category also increases utilization. Finally, even after controlling for both wealth and income, we show that households change their credit line utilization in response to credit shocks.[19]

17. The permanent income hypothesis suggests that borrowers originate lines or loans depending upon their income or wealth level.

18. We chose the wealth and income cutoff levels based on examination of the distribution of borrower wealth and income for the sample. Furthermore, these variables were originally coded in discrete \$10,000 increments, limiting our ability to construct continuous variables.

19. In other specifications we also control for education, marital status, and other demographics. Though these variables are not populated for 100% of the sample, the results show that credit constraints, as measured by a drop in credit scores, are a significant determinant of increases in utilization of the credit line.

TABLE 8

DISTRIBUTION OF INCOME AND NET WORTH AT ORIGINATION

Variable	Range	Percentage (%)
Low income	$40,000−	12.56
Medium income	$40,001–$80,000	59.71
High income	$80,001+	27.72
Low net worth	$50,000−	18.59
Medium net worth	$50,001–$70,000	62.56
High net worth	$70,001+	18.85

NOTE: This table reports the distribution of borrower income and net worth at credit line origination.

4.4 Potential Policy Implications

We identify two interesting relationships between borrower credit risk and credit line utilization. First, initial credit utilization is lower for borrowers with higher *a priori* expectations of a future credit deterioration. Second, there exists an inverse relationship between changes in borrower credit quality after origination and credit utilization. These results have direct implications for the treatment of credit line exposure at default (EAD) under the Basel II Capital Accord.[20] Specifically, our results show that a decrease in credit quality (increase in risk) results in a significant increase in credit line utilization. Consequently, the results indicate that EAD may be significantly higher in the event of credit line default. In other words, without considering the correlation between the borrower's probability of default (credit quality) and corresponding EAD (credit utilization), economic capital models may underestimate the impact of credit loss severity. Furthermore, due to the analogous treatment of EAD in consumer and commercial lines of credit, and since the new Basel II Capital Accord regulations require lenders to set aside capital based on risk, the results should provide some guidance to bank regulators concerning the need to evaluate credit line portfolios during periods when borrower credit quality is deteriorating.

The results also have potential implications on the effectiveness of monetary policy. Credit lines have the potential to provide borrowers with insurance against unexpected changes in monetary policy that might adversely impact either the pricing or availability of future credit. For example, central banks often act to curtail credit availability in an effort to slow economic growth in the face of inflation concerns. Yet, our results indicate that borrowers respond to rising interest rates by increasing credit line utilization. This implies that growth in credit line borrowing may limit the ability of the monetary authority to execute changes in policy that attempt to

20. 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.

TABLE 9

COMPETING RISKS MODEL COEFFICIENT ESTIMATES OF CREDIT LINE OUTCOMES CONTROLLING FOR INCOME AND WEALTH

	Prepay			Decrease utilization			Increase utilization		
	Coefficient value	Standard error	*p*-value	Coefficient value	Standard error	*p*-value	Coefficient value	Standard error	*p*-value
Intercept	4.740	3.829	0.216	−3.267	0.675	<0.0001	−2.192	0.780	0.005
State Dummy CT	0.801	0.691	0.247	−0.221	0.085	0.009	−0.110	0.081	0.171
State Dummy MA	1.487	0.663	0.025	−0.250	0.078	0.001	−0.170	0.073	0.019
State Dummy NH	1.400	0.816	0.086	−0.565	0.099	<0.0001	−0.124	0.099	0.212
State Dummy NJ	−7.012	454.700	0.988	−0.440	0.742	0.553	−8.789	57.879	0.879
State Dummy NY	−1.399	1.172	0.233	−0.183	0.321	0.570	−0.279	0.331	0.399
State Dummy PA	−7.419	291.900	0.980	−1.059	0.730	0.147	−0.119	0.748	0.873
Age	−0.068	0.062	0.275	−0.018	0.009	0.041	0.014	0.009	0.130
Age (square)	0.001	0.001	0.557	1.2E−04	1.4E−04	0.389	−1.6E−04	1.5E−04	0.278
CLTV_Diff_Dummy	−0.049	0.176	0.779	−2.003	0.039	<0.0001	−1.600	0.029	<0.0001
CLTV	−0.026	0.003	<0.0001	−0.004	0.000	<0.0001	−0.057	0.001	<0.0001
FICO_Diff_Dummy	0.317	0.177	0.074	0.033	0.015	0.045	−0.051	0.016	0.002
FICO (lagged 4 months)	0.008	0.004	0.028	0.001	2.3E−04	0.021	−0.001	2.6E−04	0.001
APR_Diff_Dummy	−1.908	0.694	0.006	0.258	0.094	0.006	0.161	0.080	0.035
APR	−1.493	0.710	0.036	0.250	0.097	0.009	0.149	0.051	0.021
Unemp_Diff_Dummy	−0.686	0.701	0.328	−0.131	0.092	0.155	−0.083	0.094	0.374
Unemployment	−0.459	0.134	0.001	−0.175	0.019	<0.0001	−0.004	0.002	0.013
Net worth low	4.487	3.570	0.209	2.463	0.684	0.000	−0.321	0.104	0.017
Net worth medium	5.092	3.009	0.091	2.510	0.584	<0.0001	−0.818	0.383	0.023
Income low	−0.222	3.160	0.944	−1.197	0.557	0.032	−3.147	0.649	<0.0001
Income medium	5.175	3.057	0.091	1.395	0.487	0.004	−0.969	0.563	0.085
FICO × net worth low	0.006	0.005	0.256	0.004	0.001	0.000	−1.1E−04	1.1E−04	0.009
FICO × net worth medium	0.006	0.004	0.147	0.003	0.001	<0.0001	−0.001	4.0E−04	0.012
FICO × income low	−4.5E−04	0.004	0.918	0.002	0.001	0.040	−0.004	0.001	<0.0001
FICO × income medium	0.007	0.004	0.104	0.002	0.001	0.006	−0.001	0.001	0.121

NOTES: This table shows results of a proportional hazard model of prepayment, increasing utilization, and decreasing utilization using monthly date for home equity lines of credit from January 1998 to May 2002. Increased utilization is defined as increasing the credit line amount more than 20% in any given quarter. Decreased utilization is defined as decreasing the credit line amount by more than 20% but less than 100% in any given quarter. Although arbitrary, we chose the 20% cutoff criteria in order to focus on substantial changes in borrower credit line utilization. The independent variables control for calendar time, credit risk, current loan-to-value ratio, interest rates, county unemployment rates both at the level and differences, as well as borrower wealth and income. The competing risks model is estimated as a multinomial logit via maximum likelihood.

slow consumer spending. However, since credit lines are usually variable-rate debt, it is hard to quantify whether the effectiveness of monetary policy will be constrained. Further research is necessary to determine the impact of monetary policy on borrowers who have credit lines.[21]

5. CONCLUSIONS

The literature on credit lines provides two interrelated hypotheses concerning borrower credit risk and credit line utilization. First, initial credit utilization will be lower for borrowers with higher expectations of future credit quality shocks. Second, credit line utilization will be correlated with changes in borrower credit quality. Using an objective measure of credit risk, the borrower's credit score, we are able to estimate the impact of changes in risk on credit utilization. We also examine the conditions that lead borrowers to prepay or pay down their credit lines.

Our analysis confirms that borrowers with greater expectations of a decline in future credit quality originate credit lines to preserve financial flexibility. Furthermore, our results indicate that borrowers with lower credit scores at origination utilize a lower percentage of their credit line than borrowers with higher credit scores. Since we also document that borrowers with lower credit scores are more likely to experience a subsequent decline in credit quality, we interpret the results as suggesting that borrowers with lower credit quality scores recognize the benefits of maintaining financial flexibility by retaining unused credit line utilization. In contrast, borrowers with low expectations of a need for additional future credit utilize a higher proportion of their credit lines at origination.

Our results show that borrowers who experience a decline of 10% in their FICO score (credit quality) after origination increase their credit line utilization by 15.5%. Furthermore, we also show that a 10% decline in borrower credit quality lowers the probability of prepayment by 7.2%. These findings are consistent with the theoretical "credit risk" prediction discussed by Strahan (1999).

Finally, we note that our results have two policy implications. First, for bank regulators implementing the Basel II Capital Accord, our results suggest that capital regulations for credit lines should reflect the possible changes in default exposure as borrowers alter their credit utilization in response to changes in credit profiles. Second, our results imply that the increasing prevalence of credit line borrowing has implications for the ability of central banks to affect changes in consumer behavior via monetary policy.

21. We thank the referee for providing the insight concerning policy implications of our results research.

APPENDIX

TABLE A1

ALTERNATE SPECIFICATIONS OF CREDIT QUALITY CHANGES

	12-month window			24-month window		
	Coefficient value	Standard error	*p*-value	Coefficient value	Standard error	*p*-value
Logit model estimation of the probability that borrower FICO score at the end of the observation window is less than the FICO score at origination						
Intercept	−8.424	2.098	<0.0001	−8.388	0.995	<0.0001
FICO at origination	−0.010	0.003	0.001	−0.010	0.001	<0.0001
State Dummy CT	−0.121	0.527	0.819	−0.071	0.260	0.785
State Dummy MA	−0.289	0.532	0.588	−0.136	0.248	0.583
State Dummy NH	−0.213	0.602	0.723	−0.256	0.301	0.394
State Dummy NJ	0.374	0.538	0.487	0.187	0.260	0.471
State Dummy NY	0.593	0.512	0.246	0.128	0.243	0.599
State Dummy PA	0.723	0.513	0.168	0.258	0.352	0.969
Likelihood ratio	74			129		
Number of observations	34,384			32,948		
Logit model estimation of the probability that quarterly FICO score during the observation window is less than the FICO score at origination						
Intercept	−6.100	1.664	2.00E−04	−8.356	0.831	<0.0001
FICO at origination	−0.008	0.002	2.00E−04	−0.012	0.001	<0.0001
State Dummy CT	−0.031	0.422	0.942	−0.254	0.234	0.278
State Dummy MA	−0.092	0.414	0.824	−0.169	0.222	0.447
State Dummy NH	−0.258	0.497	0.604	−0.364	0.264	0.167
State Dummy NJ	0.429	0.442	0.331	0.289	0.232	0.212
State Dummy NY	0.083	0.417	0.843	0.185	0.219	0.398
State Dummy PA	0.645	0.624	0.923	0.437	0.561	0.436
Likelihood ratio	92			147		
Number of observations	34,384			32,948		

LITERATURE CITED

Avery, Robert B., and Alan N. Berger (1991). “Loan Commitments and Bank Risk Exposure.” *Journal of Banking and Finance* 15, 173–192.

Berger, Alan N., and Gregory Udell (1995). “Relationship Lending and Lines of Credit in Small Firm Finance.” *Journal of Business* 68, 351–381.

Berkovitch, Elazar, and Stuart I. Greenbaum (1991). “The Loan Commitment as an Optimal Financing Contract.” *Journal of Financial and Quantitative Analysis* 26, 83–95.

Boot, Arnoud, Anjan V. Thakor, and Gregory F. Udell (1987). “Competition, Risk Neutrality and Loan Commitments.” *Journal of Banking and Finance* 11, 449–471.

Boot, Arnoud, Anjan V. Thakor, and Gregory F. Udell (1991). “Credible Commitments, Contract Enforcement Problems and Banks: Intermediation as Credibility Assurance.” *Journal of Banking and Finance* 15, 605–632.

Campbell, Tim S. (1978). “A Model of the Market for Lines of Credit.” *Journal of Finance* 23, 231–244.

Canner, Glenn B., Thomas A. Durkin, and Charles A. Luckett (1998). “Recent Developments in Home Equity Lending.” *Federal Reserve Bulletin* (April 1998), 241–251.

DeMong, Richard F., and John H. Lindgren (1995). "Home Equity Lending: Results Reveal a Bright Picture." *Journal of Retail Banking* 17, 37–48.

Dinç, I. Serdar (2000). "Bank Reputation, Bank Commitment, and the Effects of Competition in Credit Markets." *Review of Financial Studies* 13, 781–812.

Duan, Jin-Chuan, and Suk H. Yoon (1993). "Loan Commitments, Investment Decisions and the Signaling Equilibrium." *Journal of Banking and Finance* 17, 645–661.

Flannery, Mark J., and Joel F. Houston (1999). "The Value of a Government Monitor for US Banking Firms." *Journal of Money, Credit, and Banking* 31, 14–34.

Greenbaum, Stuart I., and Itzhak Venezia (1985). "Partial Exercise of Loan Commitments under Adaptive Pricing." *Journal of Financial Research* 8, 251–263.

Greene, William H. (1997). *Econometric Analysis,* 3rd edition. Upper Saddle River, NJ: Prentice Hall.

Hawkins, Gregory D. (1982). "An Analysis of Revolving Credit Arrangements." *Journal of Financial Economics* 10, 59–81.

Houston, Joel F., and Subramanyam Venkataraman (1996). "Liquidation under Moral Hazard: Optimal Debt Maturity and Loan Commitments." *Journal of Banking and Finance* 20, 115–133.

James, Chris (1981). "Self-Selection and the Pricing of Bank Services: An Analysis of the Market for Loan Commitments and the Role of Compensating Balance Requirements." *Journal of Financial and Quantitative Analysis* 16, 725–746.

Kanatas, George (1987). "Commercial Paper, Bank Reserve Requirements, and the Informational Role of Loan Commitments." *Journal of Banking and Finance* 11, 425–448.

Kau, James B., and Donald C. Keenan (1995). "An Overview of the Option-Theoretic Pricing of Mortgages." *Journal of Housing Research* 6, 217–244.

Klapper, Leora (2002). "The Uniqueness of Short-term Collateralization." The World Bank, Development Research Group, Working Paper.

Manchester, Joyce M., and James M. Poterba (1989). "Second Mortgages and Household Saving." *Regional Science and Urban Economics* 19, 325–346.

Martin, J. Spencer, and Anthony M. Santomero (1997). "Investment Opportunities and Corporate Demand for Lines of Credit." *Journal of Banking and Finance* 21, 1331–1350.

Melnik, Arie, and Steven E. Plaut (1986a). "The Economics of Loan Commitment Contracts: Credit Pricing and Utilization." *Journal of Banking and Finance* 10, 267–280.

Melnik, Arie, and Steven E. Plaut (1986b). "Loan Commitment Contracts, Terms of Lending, and Credit Allocation." *Journal of Finance* 41, 425–435.

Qi, Jianping, and Richard Shockley (2003). "Distinguishing between Spot and Commitment-Based Bank Financing." University of South Florida, Working Paper.

Sharpe, Steven A. (1990). "Asymmetric Information, Bank Lending, and Implicit Contracts, a Stylized Model of Customer Relationships." *Journal of Finance* 45, 1069–1087.

Shockley, Richard, and Anjan V. Thakor (1997). "Bank Loan Commitment Contracts: Data, Theory, and Tests." *Journal of Money, Credit, and Banking* 29, 517–534.

Sofianos, George, Paul Wachtel, and Arie Melnik (1990). "Loan Commitments and Monetary Policy." *Journal of Banking and Finance* 14, 677–689.

Strahan, Philip E. (1999). "Borrower Risk and the Price and Nonprice Terms of Bank Loans." Federal Reserve Bank of New York Working Paper.

Thakor, Anjan V. (1982). "Toward a Theory of Bank Loan Commitments." *Journal of Banking and Finance* 6, 55–83.

Willis, Robert, and Sherwin Rosen (1979). "Education and Self-Selection." *Journal of Political Economy* 87, 507–536.