Tests of Ex Ante versus Ex Post Theories of Collateral using Private and Public Information

Allen N. Berger
University of South Carolina
Wharton Financial Institutions Center
CentER, Tilburg University
aberger@moore.sc.edu

W. Scott Frame
Federal Reserve Bank of Atlanta
scott.frame@atl.frb.org

Vasso Ioannidou
CentER, Tilburg University
v.p.ioannidou@uvt.nl

Abstract

Collateral is a widely used, but not well understood, debt contracting feature. Two broad strands of theoretical literature explain collateral as arising from the existence of either *ex ante* private information or *ex post* incentive problems between borrowers and lenders. This paper attempts to empirically isolate each of these effects using a credit registry that is unique in that it allows the researcher to have access to (private) risk information about the borrower that is unobserved by the lender. The results suggest that the *ex post* theories are empirically dominant, although the *ex ante* theories are valid for customers with short borrower-lender relationships that are relatively unknown to the lender.

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I. Introduction

Collateral is a prominent feature of debt contracts. Residential and commercial mortgages, motor vehicle and equipment loans, and inter-bank repurchase agreements all rely heavily on readily marketable assets to secure funding. Interestingly, other debt contracts, like bank loans to small and medium-sized enterprises (SMEs), only sometimes require collateral, and the pledged assets tend to be quite heterogeneous.

The use of collateral in debt contracts can be costly for lenders, borrowers, and (in some cases) even society at-large. Lenders incur costs of screening and monitoring the pledged assets, as well as any enforcement and disposal expenses in the case of repossession. The use of collateral may impose opportunity costs on borrowers by tying up assets that might otherwise be put to more productive uses. Borrowers may also suffer fluctuations in their credit availability as the values of their securable assets vary. Collateral may also result in social costs (externalities) when changes in the value of widely pledged assets, like real estate, are correlated across borrowers and act to amplify the business cycle through procyclical changes in access to credit (e.g., Bernanke and Gertler 1989, 1990, Kiyatoki and Moore 1997). Recent research suggests that the significant decline in real estate collateral values in Japan in the early 1990s played an important role in reducing debt capacity and investment in that nation (Gan 2007). A similar procyclical effect is now occurring in U.S. mortgage markets and, by extension, global financial markets.

Given that collateral is costly and yet widely employed, it is natural to inquire as to the economic function of collateral pledges. Economic theory largely explains collateral as an attempt to compensate for *ex ante* asymmetric information problems or as a method of reducing *ex post* incentive problems. Specifically, one set of theoretical models explains collateral as arising from *ex ante* information gaps between borrowers and lenders that can otherwise lead to an equilibrium characterized by adverse selection and credit rationing in the spirit of Stiglitz and Weiss (1981). In this case, collateral allows lenders to sort observationally equivalent loan applicants through signaling. Lenders offer a menu of contract terms such that applicants with higher-quality projects choose secured debt with lower risk premiums, while those with lower-quality projects self-select into unsecured debt with higher risk premiums (e.g., Bester 1985, 1987, Besanko and Thakor 1987a, 1987b, Chan and Thakor 1987, Boot, Thakor and Udell 1991, Beaudry and Poitevin 1995, and Schmidt-Mohr 1997). A second set of theoretical models motivates collateral as being part of an optimal debt contract by invoking *ex post* frictions, including moral hazard concerns (e.g., Aghion and Bolton 1997, Holmstrom and Tirole 1997); difficulties in enforcing contracts (e.g., Banerjee and Newman 1993, Albuquerque and Hopenhayn 2004, Cooley, Marimon, and Quadrini 2004); and costly state verification (e.g., Townsend 1979, Gale and Hellwig 1985, Williamson 1986, Boyd and Smith 1994).

In this paper, we test the empirical predictions generated by both the *ex ante* private-information/signaling models and the *ex post* models where collateral is used to overcome borrower/lender incentive conflicts. Our first empirical model (Model 1) attempts to identify the effect of each of these theories by studying variation in the incidence of collateral pledges at loan origination. This model exploits differences in information that is available within a credit registry and known to us versus the information the registry discloses to lenders. This provides us with clean measures of "private information" (information known to borrowers, but not to lenders) and "public information" (information known to both borrowers and lenders) with which to test the relevance of the two broad collateral theories. Our second empirical model (Model 2) aims to uncover which of the two broad theories, the *ex ante* private information theory or the *ex post* incentive conflict models, empirically dominate by studying whether loan performance systematically varies for collateralized loans.

By way of preview, the results for Model 1 suggest that the data is consistent with both sets of theories, although the *ex ante* theories only hold for customers with short relationships with the lender (i.e., borrowers that are relatively unknown to the lender). The results for Model 2 are consistent with those of Model 1 insofar as the *ex post* theories empirically dominate for firms with longer relationships.

Our Models 1 and 2 are most closely related to prior research by Jiminez, Salas, and Saurina (2006) and Jiminez and Saurina (2004), respectively, who analyze Spanish credit registry data. However, we differ significantly in that we are able to identify and segment relevant risk information that is both observed and unobserved by the lender. Several other studies examine the empirical relationship between asymmetric information and the incidence of collateral (like Model 1) primarily using the strength of the lender-borrower relationship (i.e., relationship length, breadth, or exclusivity) as an inverse proxy for the degree of asymmetric information.[1] The findings are mixed, perhaps owing to the fact that observed banking relationships reflect more than just a measure of the degree of asymmetric information between borrowers and lenders.[2] However, one recent paper uses the adoption of small business credit scoring methods as a treatment to the information environment and find support for the *ex ante* private information hypothesis (Berger, Espinosa-Vega, Frame, and Miller 2008). Related to our Model 2, another set of studies examines the empirical association between observed borrower risk (broadly defined) and collateral as suggested by the *ex post* models. These studies consistently find a positive correlation between observable risk and the incidence of collateral, supporting the *ex post* theories.[3]

The remainder of the paper is structured as follows. Section II describes the Bolivian Credit Registry Data and Section III discusses the Bolivian macro-financial environment over the sample period. Section IV presents the empirical model and results. Additional robustness checks follow in Section V. Section VI concludes.

II. Bolivian Credit Registry Data: 1998-2003

Our analysis utilizes data from the Bolivian public credit registry provided by the Superintendent of Banks and Financial Entities (SBEF). The SBEF, which is principally responsible for regulating and supervising all financial institutions in Bolivia, also manages the credit registry. The data include monthly information from January 1998 through December 2003, although the first 14 months of data does not allow

[1] Papers in this vein include Berger and Udell (1995), Harhoff and Korting (1998), Machaer and Weber (1998), Degryse and van Cayseele (2000), Elsas and Krahnen (2000), Ono and Uesegi (2005), Chakraborty and Hu (2006), Jiminez, Salas, and Saurina (2006), Menkhoff, Neuberger, and Suwanaporn 2006, and Voordeckers and Steijvers (2006).

[2] According to Berger, Espinosa-Vega, Frame, and Miller (2008), the mixed empirical findings may reflect offsetting biases. On one hand, there could be a bias towards a positive association between collateral and relationships to the extent that lenders sort borrowers into different lending arrangements based on their opacity (e.g., lenders use relationships to evaluate more opaque small businesses). On the other hand, a bias toward a negative association could occur if collateral and relationships are substitute methods of dealing with opacity problems.

[3] See Leeth and Scott (1989), Berger and Udell (1990, 1995), Booth (1992), Degryse and Van Cayseele (2000), and Ono and Uesegi (2005).

us to distinguish between commercial and consumer loans. As a result, our primary sample is based on commercial loans observed between March 1999 and December 2003. We use the prior information from January 1998 through February 1999 to help fill in history on loans and relationships that existed as of March 1999.

While all financial institutions contribute information to the Bolivian credit registry, we use only data from commercial banks because they are the dominant source of commercial credit. Table 1 provides an overview of all commercial banks that were active in Bolivia during the sample period. There were 13 active institutions, seven of which were foreign owned – four branches and three subsidiaries.[4] One of the foreign branches, ABN Amro, left the Bolivian market in November 2000. As shown in Table 1, five banks dominate Bolivian banking – each with total assets of at least US$500 million and with more than 10 percent market share of deposits and loans. The HHI for deposits is 1292 and for loans it is 1236, suggesting moderate concentration.

Bolivia's corporate sector is composed of a few large firms and a large number of very small firms that are mostly informal.[5] Bolivian firms operating in the formal economy are required to register and provide annual financial statements to the Fundacion para el Desarrollo Empresarial (Fundaempresa), the Bolivian commerce registry that is made available to financial institutions in order to assess firm creditworthiness; subject to authorization by the firm.[6] Large firms (those with paid-in capital exceeding 600,000 Bolivian Pesos[7] or liabilities with financial entities of over 900,000 Bolivian Pesos) are required to present audited financial statements 120 days after their year-end (PriceWaterhouse 1998). Small firms, by contrast, often present unreliable or incomplete financial statements (or sometimes none at all). Such firms do not have access to commercial banks; they borrow from microcredit institutions.

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[4] Foreign-owned banks operating in Bolivia have similar rights and responsibilities as domestically-owned institutions.

[5] About 70% of Bolivia's firms are informal (i.e., operate outside of the legal system) presumably to avoid certain up-front legal costs associated with starting a business; as well corporate income taxation on an ongoing basis (Sirtaine, Skamelos, and Frank 2004).

[6] There are about 46,000 firms registered with the Fundaempresa and about 300,000 with the tax authorities. Many more firms are unregistered.

[7] At the end of February 1999, 600,000 Bolivian Pesos were equal to US$105,078.

There are several types of commercial credit contracts in the data, including credit cards, overdrafts, installment loans, discount loans, and used or unused credit lines. We focus exclusively on installment loans and discount loans and refer to these as "standard Bolivian debt contracts." These contracts account for 60% percent of the total number and 92 percent of the total value of commercial loans in the registry during the sample period. Of the standard Bolivian debt contracts, 98 percent are denominated in U.S. dollars and we use only these loans in our analysis.

Our initial sample encompasses 32,286 bank loans made to 2,676 different firms. This sample is used to estimate Model 1, which relates the incidence of collateral to observed and unobserved risk measures, relationship information, and a host of control variables. When we investigate the effect of collateral on ex-post performance (Model 2), we drop all loans that do not mature before the end of the sample (December 2003); thereby leaving 29,485 bank loans. Since this has the effect of reducing the average loan maturity in our sample, we also eliminate all loans originated during the last six months of the sample (July – December 2003) – further reducing the sample to 28,758 loans.

For each loan, we have information on the origination month, maturity date, contract terms, and ex post performance through the sample period. For each borrower, we have information about their industry, physical location, legal structure, total bank debt, banking relationships, and whether they have been delinquent or defaulted on a loan in the recent past.

Information sharing through the credit bureau allows us to construct our key independent variables for testing the two sets of collateral theories. The credit registry has data for each borrower's credit history, including all previous defaults and delinquencies. But some of this credit history is not known to the lender. The lender certainly knows if there have been prior defaults and delinquencies on its own loans, and the institution is able to observe all past defaults at other banks through the credit registry files. However, in terms of delinquencies (loans past due 30 days or more), the registry only reveals to the lender those that occurred with other banks during the prior two months. By having access to entire credit registry, we are able to also observe information that is not known to the lender. Specifically, we observe delinquencies with other banks prior to the two-month common information period before the loan origination.

Table 2 provides variable names, definitions, and summary statistics.[8] Collateral was pledged for 24.4 percent of the loans in the sample. The incidence of collateral is similar to the 26 percent found for Belgium (Degryse and Van Cayseele 2000), but lower than that the 82 percent for the United States (Berger, Espinosa-Vega, Frame, and Miller 2008); perhaps owing to legal difficulties and delays in seizing and disposing of pledged assets. In terms of performance, 6.5 percent of the loans became delinquent (i.e., had overdue payments for at least 30 days) or defaulted some time after origination. About 20 percent of the loans that became delinquent eventually defaulted (not shown in Table 2).

Table 2 next shows information on past performance problems that are both observed and unobserved by the lender, which we view as predictive of performance on newly issued loans to the same firms. That is, we assume that borrowers with past repayment problems are more likely to have delinquencies or defaults on their newly issued loans. The data indicate that only 0.3 percent of the sample loans were given to borrowers that had defaulted in the prior 12 months (*Default_AnyBank_[1,12]*). A total of 5.7 percent of the loans were issued to firms that had been delinquent with any bank in the two prior months (*Npl_AnyBank_[1,2]*). The data also show that 7.4 percent of the credits were issued to firms that had been delinquent with the same bank anytime from three to twelve months prior (*Npl_Bank_[3,12]*). Finally, 14.0 percent of loans were given to borrowers with delinquencies at other banks from three to twelve months prior to the loan origination (*Npl_OtherBank_[3,12]*). This last information item is not revealed to the lender through the credit registry, but as our empirical analysis below suggests, it might be revealed through lending relationships.

Turning to the control variables, the average banking relationship in the sample is 23.1 months. This is defined as the number of months since the first loan of this borrower from this bank in the registry since January 1998. Most of the sample firms are corporations (71.4 percent), while partnerships (14.0 percent) and sole proprietorships (12.5 percent) are much less common. Almost one-half of the sample is comprised of installment loans. Finally, the average loan amount is US$161,490 and the average loan maturity is about 12 months.

[8] For relationship length, loan amount, and maturity we report summary statistics for the level of these variables, but our empirical models (below) incorporate the natural logarithm of one plus the level.

III. Bolivian Macro-financial Environment: 1998 to 2003

The 1998 to 2003 period was generally volatile for Bolivia both economically and politically. As a result of the Russian/Asian financial crises in the late 1990s, currencies throughout Latin America depreciated – including the Bolivian Peso. While Bolivian bank assets and liabilities were largely denominated in U.S. dollars, wages and business income were largely paid in domestic currency. Hence, what began as a liquidity event became a solvency problem for local consumers, firms, and financial intermediaries. As shown in Figure 1, the growth rate of real GDP in Bolivia slowed considerably during the sample period (relative to the pre-1998 period), although the overall (official) growth rate never actually turned negative during this time period.[9]

During the period under study, there was a deterioration of companies' capacity to honor their debts in nearly all industries and regions of Bolivia. Especially troubled in terms of the proportion of loans in arrears were: agriculture (40%), construction (33%), manufacturing (26%), commerce (25%), and real estate (22%). The crisis led to a reduction in the quantity of credit, as well as more restrictive terms (more collateral, shorter maturities, etc.).

Figure 2 presents data on total deposits, total loans, and nonperforming loans in the Bolivian banking system between 1999 and 2003.[10] The data illustrate that after 1999 total deposits and loans declined considerably, while nonperforming loans increased from US$172 million in March 1999 to a peak of US$570 million in June 2003. This amounts to an increase of the ratio of nonperforming loans to total loans from 4.3 percent to 20.3 percent. The increase in nonperforming loans was due, in part, to the slowdown of economic growth.

[9] The average annual growth rate of real GDP in Bolivia during the sample period was 2.2 percent, ranging between 0.72 and 3.74 percent. There are several possible reasons for the growth rate never turning negative. First, the official figures may understate the actual changes since there is a large informal economy and many of the shocks affected the informal economy more forcefully. Second, investment was propped up by increased assistance from the international donor community. Finally, there were some bright spots during this time in terms of commodities like natural gas and soy.

[10] This information, along with all other bank-level information, is obtained from the bank balance sheet and income statements, which are made publicly available by the SBEF at http://www.sbef.gov.bo/boletin bancos.php.

As the Bolivian economy slowed during the late-1990s, the Bolivian government responded by increasing bank supervision and capital requirements. While successful at preserving bank solvency, this policy prescription led to a credit crunch. Importantly, Bolivian capital markets are quite underdeveloped and hence were largely unable to act as an alternative method of finance for larger firms.[11]

Despite the weakened macroeconomic and banking environment in Bolivia during our sample period, bank capital adequacy ratios (in aggregate) were well above minimum requirements and actually increased over time. During the period, the Bolivian government extended credit under favorable terms to banks in order to restructure bad loans and also purchased subordinated debt to increase their regulatory capital ratios.[12] Without these loans and purchases, banks' ratios of total capital to risk weighted assets would have fallen below the 10% minimum requirement. Figure 3 shows the median and the interquartile range of total capital to risk weighted assets. As a method to improve their (risk-weighted) capital adequacy ratios, banks started investing more heavily in government bonds that carry a zero risk weight instead of commercial loans that carry a 100 percent risk weight.

IV. Empirical Models & Results

We estimate two different empirical models in order to test the theoretical predictions of models explaining collateral as part of an optimal contract under conditions of asymmetric information.

A. Model 1

Our first empirical model relates the incidence of collateral to measures of observed and unobserved risk, the length of the banking relationship, loan- and firm-level control variables, and bank and time fixed effects. This model, which is estimated using Probit, can be summarized as:

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[11] Bolivian corporate bond issues peaked in 2001 with six issues that raised US$247 million. On the equity side, there are only 29 publicly listed firms and only one of them issued new shares during the sample period.

[12] In 2001, Bolivia's Program of Capital Enforcement (PROFOB) purchased subordinated debt of US$7 million, US$18 million, and US$23 million from Banco Ganadero, Banco National de Bolivia, and Banco Union, respectively (Sirtaine, Skamelos and Frank 2004).

$$P(Collateral_{ijt}) = f(\, Observed\_Risk_{ijt},\ Unobserved\_Risk_{ijt},\ Unobserved\_Risk_{ijt}{*}Rel\_Length_{ijt},$$
$$Rel\_Length_{ijt},\ Loan_{ijt},\ Firm_{ijt}\,,\ \alpha_j,\ \gamma_t\,) \qquad (1)$$

where $P(\bullet)$ indicates probability, $Collateral_{ijt}$ is a dummy variable that equals 1 if the loan is secured, and *i*, *j*, and *t* index loans, banks, and time, respectively. The key exogenous variables are those capturing observed and unobserved borrower risk as we define them based on information in the credit registry.

$Observed\_Risk_{ijt}$ is comprised of the three variables discussed above that indicate the observed riskiness of the borrower at loan origination, *Default_AnyBank_[1,12]*, *NPL_AnyBank_[1,2]*, and *NPL_Bank_[3,12]*. $Unobserved\_Risk_{ijt}$ is comprised of a single binary variable, *Npl_OtherBank_[3,12]*. As noted, this variable is in the registry and available to us, but not available to the lender.

A positive, statistically and economically significant coefficient for any of the three variables included in $Observed\_Risk_{ijt}$ would be evidence in favor of the *ex post* theories. That is, observably risky borrowers are more likely to be required by lenders to post collateral. By contrast, a negative, statistically and economically significant coefficient on $Unobserved\_Risk_{ijt}$ would be consistent with the *ex ante* theories. That is, according to models of signaling, firms with private information that they are "good" ("bad") are more (less) likely to pledge collateral.

To account for the theoretical prediction that a firm's private information declines in the length of the bank-firm relationship, we also include the interaction term $Unobserved\_Risk_{ijt}{*}Rel\_Length_{ijt}$. We expect that the empirical relevance of the *ex ante* theories diminishes as the length of a bank-firm relationship increases, suggesting a negative coefficient for $Unobserved\_Risk_{ijt}$ and a positive coefficient for $Unobserved\_Risk_{ijt}{*}Rel\_Length_{ijt}$. In other words, good borrowers choose to pledge collateral to signal their quality only when relationships are short and the bank does not know their quality. Finally, if relationships mitigate informational asymmetries, the coefficient of Rel_Length_{ijt} should be negative.

The vector $FIRM_{ijt}$ accounts for differences in firm characteristics such as legal structure, industry, and region. We use a set of dummy variables indicating the legal structure of the firm: *Partnership*, *Corporation*, and *Other* (*Sole_Proprietorship* is the omitted group). *Industry* is a set of 18 dummy variables controlling for the firm's industry classification (like SIC or NAICS codes). *Region* is a set of dummy variables that indicate the location from which the bank originated the loan. This includes nine regions in Bolivia as well as Argentina, Paraguay, Panama, and the United States.

The vector $LOAN_{ijt}$ accounts for differences in the individual loan contract terms. However, since each of these variables is potentially endogenous, we estimate our empirical models both with and without these variables. *Installment* is a dummy variable equal to one if the contract is an installment loan rather than a discount loan. *Loan_Amount* is measured as the natural logarithm of one plus the amount of the loan proceeds at origination in U.S. dollars. *Maturity* is the natural logarithm of one plus the number of months between loan origination and maturity. We explicitly exclude the interest rate since it is jointly determined with collateral under the *ex ante* theories.

Bank and time (month) fixed effects are also included in the model, represented by the scalars α_j and γ_t, respectively. Bank fixed effects should capture any systematic differences in bank propensities to require collateral for their commercial loans. The time fixed effects are intended to account for temporal differences in required collateral related to the business or credit cycle. Accounting for such variation may be important given the volatile macro-financial environment in Bolivia during the period under study.

Estimation results are presented in Table 3. In Column I, we report a benchmark specification without interaction terms and loan characteristics. In Column II, we include the interaction term between the length of a bank-firm relationship and unobserved risk, and in Column III, we also add loan characteristics. Under the heading *Probit Coefficients,* we report the estimated coefficients of the three Probit specifications. Under the heading *Marginal Effects,* we report the change in probability of pledging collateral for each one of the independent variables, holding all other independent variables at their sample means. For continuous variables, we report the effect for an infinitesimal change in the variable; and for dummy variables we report the estimated effect of a change from 0 to 1.

In all three specifications, our three indicators of observed risk are positively associated with the incidence of collateral. These findings are consistent with the *ex post* theories under which observably riskier borrowers are asked to pledge collateral to mitigate frictions associated with moral hazard, limited contract enforceability, and/or costly monitoring. Each of these indicators of previous delinquencies or defaults is estimated to be associated with a 3.9 to 12.8 percentage point estimated increase in the probability of collateral being pledged. These findings are economically significant, given that the predicted probability of collateral at the mean of all independent variables (P0) is only about 20%.

The estimated coefficient of *Unobserved Risk* is neither statistically neither economically significant in Column I. However, when we include the interaction term between unobserved risk and relationship length, the measured effect of unobserved risk becomes both statistically and economically significant. For "new" borrowers, for whom relationship length is zero, unobserved risk is associated with 13.7 to 17.0 percentage point decrease in the probability of collateral, consistent with the *ex ante* theories. Combining the marginal effects of *Unobserved Risk* and the interaction term suggests that the effect is negative for relationships under approximately seven months.[13] This is consistent with a reduction in private information with longer relationships. Thus, the data suggest that the *ex ante* theories only hold for relatively short relationships when asymmetric information problems are more likely to be present. Relationship length itself is significantly negatively related to the incidence of collateral. This is also consistent with the literature that banking relationships assist in resolving asymmetric information problems.

The incidence of collateral is lower for loans to partnerships or corporations than for those to sole proprietorships (the omitted category), consistent with collateral being more likely for opaque firms. Installment loans are less likely to have collateral pledged, but larger loans and those with longer maturities are more likely to be associated with collateral pledges.

Related to both sets of collateral theories (*ex ante* and *ex post*) is the analysis of Jiminez, Salas, and Saurina (2006). These authors show that the incidence of collateral is negatively related to *ex post* defaults on debt issued to young firms and argue that this finding reflects high unobserved risk at origination and hence *ex ante* private information. However, because collateral may raise the cost of default, one might expect to find that secured debt is less likely to default, irrespective of whether *ex ante* asymmetric

[13] In Column II, the effect of unobserved risk equals zero for relationship length x when $-0.17+0.082*\ln(1+x)=0$, which is solved for x equal to 6.9. For the estimates in Column III, the corresponding x equals 6.7.

information is important. Moreover, defaults may reflect moral hazard or other frictions, and thus may not isolate the effects of *ex ante* private information.

B. Model 2

Our second empirical model investigates the relative importance of *ex ante* and *ex post* theories of collateral by examining the relationship between collateral and ex post loan performance. We estimate the following Probit regression model:

$$P(ExPost\_Nonperformance_{ijt}) = g(Collateral_{ijt}, Collateral_{ijt}*Rel\_Length_{ijt}, Rel\_Length_{ijt}, Loan_{ijt}, Firm_{ij}, \alpha_j, \gamma_t), \quad (2)$$

The endogenous variable is the probability of *ex post* nonperformance (delinquency or default). The key exogenous variables are those indicating that the loan is collateralized ($Collateral_{ijt}$), the length of the bank-firm relationship (Rel_Length_{ijt}), and the interaction of these two variables ($Collateral_{ijt}*Rel\_Length_{ijt}$). All other variables were included in equation (1) and defined above.

In Model 2, we try to see which of the theories may dominate empirically. The measured effect of collateral on the probability of *ex post* nonperformance is ambiguous. First, under the *ex post* theories, collateral is required of observably riskier borrowers who are more likely to have performance problems, although this effect could be offset to the extent that collateral mitigates or eliminates the *ex post* frictions. Under the *ex ante* private information theories, the measured effect of collateral is expected to be negative since it is actually the unobservably safer borrowers who pledge collateral more often and are hence less likely to have performance problems. Thus, a positive measured effect of collateral on nonperformance problems would suggest the net empirical dominance of the *ex post* theories. By contrast, a negative measured effect would suggest either a net empirical dominance of the *ex ante* private information theories, a mitigating effect of collateral under the *ex post* theories, or both.

We include the interaction term between collateral and relationship length,

$Collateral_{ijt}$*Rel_Length_{ijt}, because (as demonstrated by Model 1) the *ex ante* theories are less likely to hold when the relationship is long and the bank has had time to discover more of the private information about the firm. Thus, we expect a positive sign on the interaction term as the *ex post* theories are more likely to empirically dominate when relationships are longer.

Table 4 presents the results for *ExPost_Nonperformance,* both in terms of the probit coefficients and marginal effects. Similar to above, Column I reports a benchmark specification without the collateral-relationship length interaction term or loan characteristics. Column II introduces the interaction term, and Column III also includes the potentially endogenous loan characteristics.

In Column I, collateral is positively associated with *ex post* delinquencies or defaults, consistent with net empirical dominance of the *ex post* theories. The estimated marginal effect suggests a 4.1 percentage point increase in the probability of *ex post* nonperformance for secured loans. This effect is economically significant, since the predicted probability of ex post nonperformance at the mean of all independent variables (P0) is 4.7 percent. This suggests that secured loans are almost twice as likely to have repayment problems as unsecured loans. However, when the interaction term is introduced in Column II, the results change substantially. The coefficient on collateral becomes zero implying that there is no net effect of collateral when the customer is new to the bank (i.e., when relationship length is zero). However, the positive coefficient of the interaction term implies that for longer relationships, the measured effect of collateral is positive, consistent with the net empirical dominance of the *ex post* theories for seasoned customers. The marginal effect of 0.015 for the interaction between collateral and relationship length implies that collateral is associated with an increase in the probability of ex post nonperformance of 4.2 percentage points when relationship length is equal to 12 months ($-0.004 + 0.015*\ln(1+12)$). This implies approximately a 92 percent increase in the incidence of ex post nonperformance relative to predicted value of at the mean of all regressors. The results in Column III are qualitatively similar (72 percent increase).

The independent effect of relationship length is essentially zero in Column I when no interaction term is included. The negative coefficient for relationship length in Columns II and III implies that when no collateral is pledged, firms with longer relationships are less likely to have nonperformance problems, consistent with expectations that such borrowers are less risky.

With respect to the other control variables, we find that partnerships and corporations are more likely to have loan performance problems than sole proprietorships. This is consistent with the possibility that banks may be more willing to make risky loans to partnerships and corporations than to sole proprietorships that are generally more opaque. In addition, partnerships and corporations might be more likely to go past due or default on their loans because of limited liability. Regarding contract terms, it appears that installment loans and loans with longer maturities are associated with a higher incidence of repayment problems. Larger loans, by contrast, are negatively associated with the ex post nonperformance.

Model 2 is quite similar to that presented in Jiminez and Saurina (2004), who focus on the probability of loan default using data from the Spanish credit registry. The results of that study are consistent with our baseline estimates (Table 4; Column I) insofar as those authors find that collateral is positively related to the probability of default. Two important differences between these studies exist. First, the (inverse) proxy for relationship strength used by Jiminez and Saurina is the number of banking relationships, which they find is negatively related to the probability of loan default. Second, Jiminez and Saurina did not include an interaction term between collateral and relationship strength, which can be particularly useful in helping to distinguishing the empirical importance of the *ex ante* and *ex post* theories.

V. Additional Robustness Checks

We conduct a number of additional robustness checks. First, we include a number of additional relationship characteristics to the specifications reported in Columns II of Tables 3 and 4, our main specification. Specifically, we include a dummy variable for multiple banking, a dummy variable for when the bank is the firm's primary lender (i.e., more than 50 percent of outstanding loan balances are from that bank), and a dummy variable for the existence of other lending products such as other loans, credit cards, credit lines, and overdrafts in the current account. The empirical results of both Model 1 and Model 2 are materially unchanged by this addition.

Second, we estimated Models 1 and 2 using loan type and size subsamples and including additional loan characteristics. When we estimate the models separately for installment and discount loans, the results are very similar to those reported in Columns II of Table 3 and 4. One difference is that the estimated coefficients of *Default_AnyBank_[1,12]* and *NPL_Bank_[3,12]* in the discount loans equations are not statistically significant. However, the estimated coefficient of the third indicator of observed borrower risk, *NPL_AnyBank_[1,2]*, remains positive and statistically significant, supporting the *ex post* theories. We also estimate our two models separately for loans with contract amounts above and below the median amount ($43,175). The results are very similar to those reported earlier, with the exception of the coefficients of *Default_AnyBank_[1,12]* and *NPL_Bank_[3,12]* that are not statistically significant in the sample of loans with a contract amount below the sample median. Like above, the coefficient of *NPL_AnyBank_[1,2]* remains positive and statistically significant. Finally, adding the loan interest rate among the loan characteristics to the specifications reported in Columns III of Tables 3 and 4 has no material affect on our results.

Finally, we estimate Model 2 using the probability of default as the dependent variable in place of the probability of delinquency or default (i.e., we adopt a more conservative definition of nonperformance). Again, the signs and significance of the results are virtually unchanged.

VI. Conclusions

The theoretical literature offers two broad classes of theories about why borrowers pledge collateral. The first set of theories motivates collateral as a way for good borrowers to signal their quality under conditions of *ex ante* private information. Another set of theories explains collateral as an optimal response to *ex post* frictions such as moral hazard, limited contract enforceability, and costly state verification. A growing body of literature empirically testing these models and the ongoing financial crisis has raised significant academic and policy interest in understanding the role of collateral in debt contracts.

This paper improves upon the empirical literature by using newly available data from the Bolivian public credit registry that provides us with important risk information about the borrower that is not known to the lender. Thus, we have both "private" and "public" information about the firm. Using this information structure, we are able to construct measures of both observed and unobserved risk and hence more effectively test the two sets of collateral theories. The data also allows us to explore the role of banking relationships and how information gleaned from relationships reduces private information.

We present results suggesting a role for both sets of theories, although the *ex ante* private information theories appear to hold only for customers with short relationships that are relatively unknown to the lender. The data also suggest that the *ex post* theories tend to empirically dominate for firms with long relationships and where private information is less important.

Our analysis represents an important contribution to the literature seeking to understand the motivation for collateral in debt contracts. First, the issue has clearly been on the minds of market participants and policymakers in places like Japan and the United States owing to significant shocks to collateral values. Second, we use credit registry data that allows us to produce clean measures of private and public information, as well as providing a rich set of controls at the loan and bank level and bank and time fixed effects to account for unobserved bank heterogeneity and changes in the lending environment, respectively. Moreover, the availability of lending relationship information in our data allows us to tie back our work to much of the extant literature. Our approach might also be relevant to World Bank efforts to encourage the establishment of the development of credit registries in the developing world. Our findings suggest that the information provided by such registries might be useful in eliminating the need for costly collateral.

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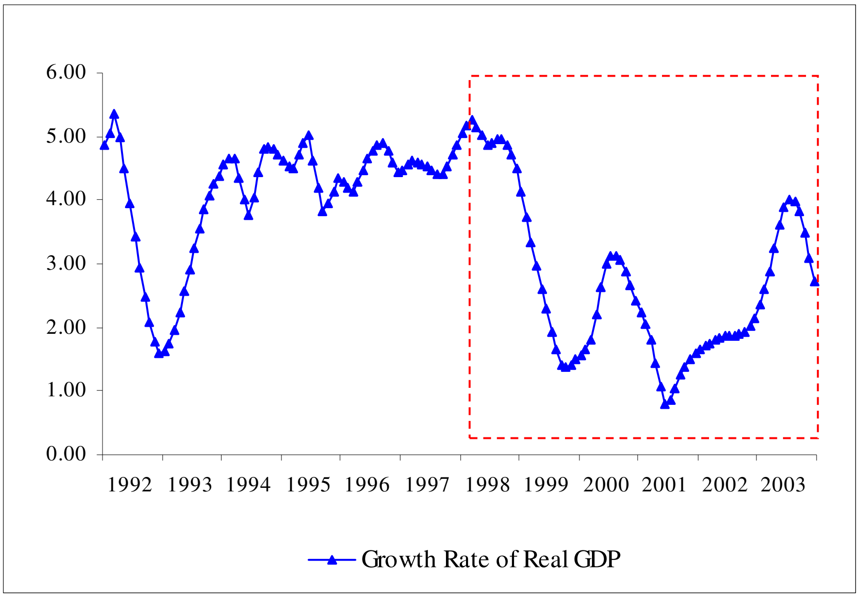
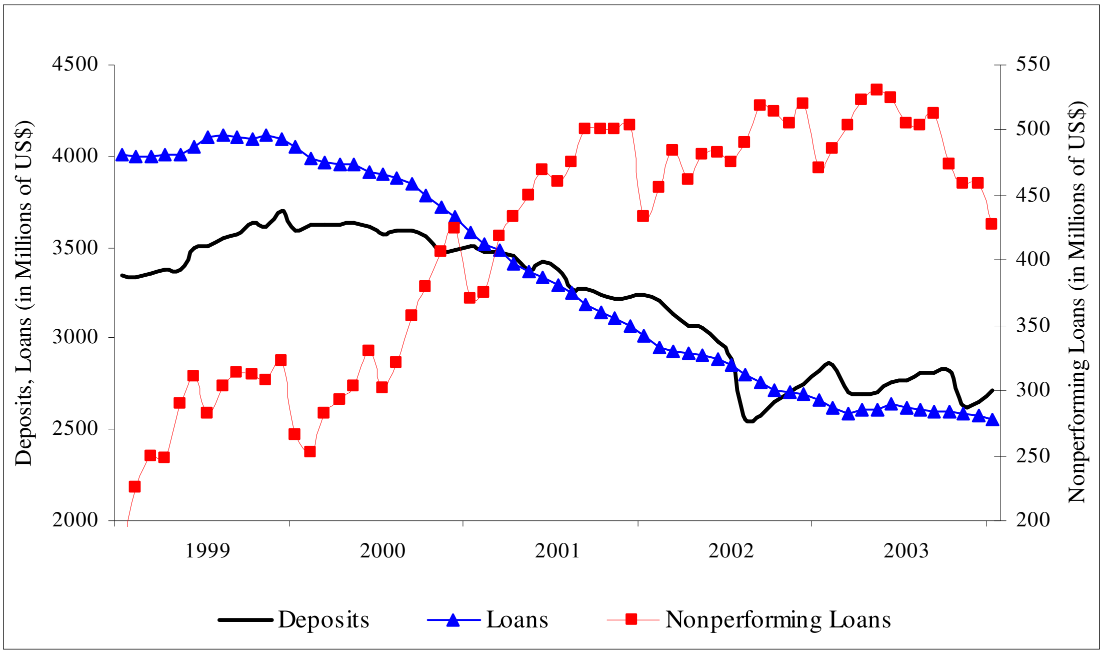
Figure 1
The Growth Rate of Real GDP in Bolivia
Monthly Data; 1992:01 to 2003:12



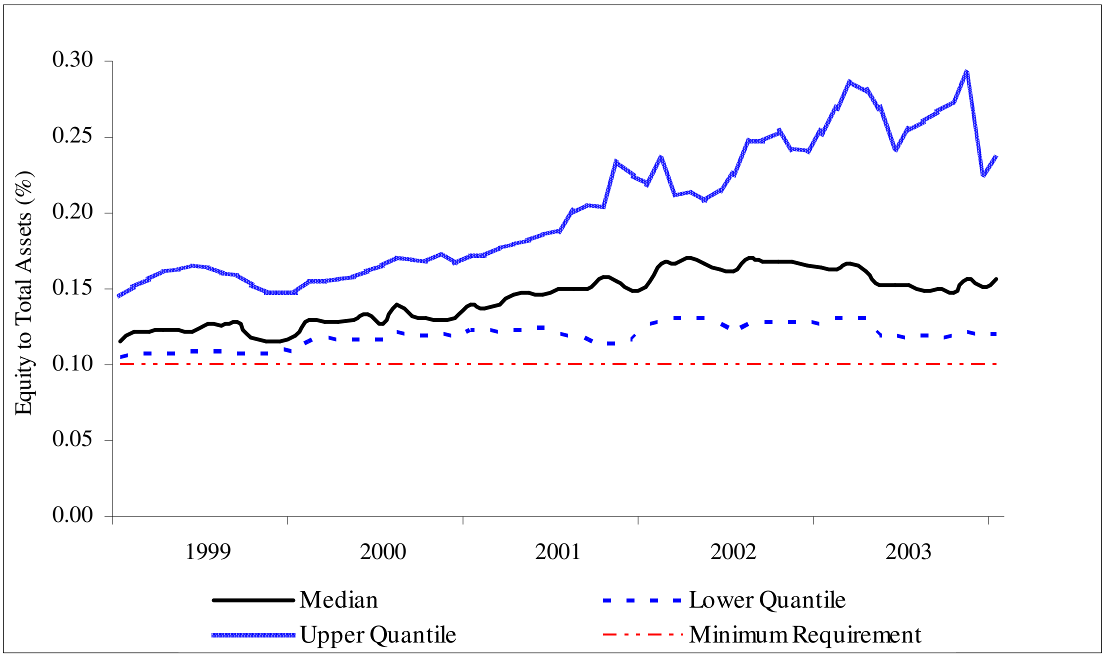
Source: Bolivian Superintendent of Banks and Financial Entities (SBEF).

Figure 2
Deposits, Loans, and Nonperforming Loans of the Banking System
Monthly Data; 1999:01 to 2003:12



Source: Bolivian Superintendent of Banks and Financial Entities (SBEF).

Figure 3
Total Capital to Total Risk-Weighted Assets of the Bolivian Banking Sector
Monthly Data; 1999:01 to 2003:12



Source: Bolivian Superintendent of Banks and Financial Entities (SBEF).

Table 1

Summary Statistics for Commercial Banks Operating in Bolivia

This table provides summary statistics on all commercial banks that were active in Bolivia between March 1999 and December 2003. *Assets* is equal to the average value of total assets in millions of US$ during the sample period. *Deposits Share* is equal to average ratio of bank deposits to the total deposits in the banking system. Similarly, *Loans Share* is equal to the average ratio total bank loans to the total loans in the banking system. The *Capital Ratio* reports the average ratio of total capital (Tier 1+Tier 2) to total risk-weighted assets. The *NPL Ratio* is equal to each bank's average ratio of nonperforming loans (delinquent of at least 30 days) to total loans. *Ownership* indicates whether a bank is foreign- or domestically-owned and for foreign-owned whether it is a branch or subsidiary (B or S). Banks for which at least 50 percent of their equity is foreign owned are defined as Foreign.

Bank Name	Assets	Deposits Share	Loans Share	Capital Ratio	NPL Ratio	Ownership
Banco Santa Cruz	859.138	0.183	0.161	18.276	0.168	Foreign (S)
Banco Industrial	677.694	0.127	0.151	12.504	0.097	Domestic
Banco Nacional de Bolivia	621.061	0.149	0.139	11.343	0.110	Domestic
Banco Mercantil	598.541	0.142	0.125	12.076	0.091	Domestic
Banco de Crédito de Bolivia	591.024	0.134	0.126	13.985	0.130	Foreign (S)
Banco de la Unión	450.655	0.088	0.104	12.479	0.166	Domestic
Banco Económico	287.374	0.062	0.067	15.074	0.099	Domestic
Citibank	265.291	0.044	0.047	18.835	0.312	Foreign (B)
Banco Ganadero	205.477	0.042	0.046	11.888	0.105	Domestic
Banco Solidario	95.932	0.019	0.024	18.346	0.103	Foreign (S)
Banco do Brasil	31.771	0.005	0.003	54.374	0.071	Foreign (B)
Banco de la Nación Argentina	28.649	0.004	0.006	36.476	0.290	Foreign (B)
ABN Amro	22.341	0.003	0.003	42.520	0.050	Foreign (B)

Table 2
Variables and Summary Statistics

The table reports the notation, definition/possible values of variables used in the analysis, and summary statistics.

VARIABLES	DESCRIPTION	Obs	Mean	Std Dev	Median
	A. DEPENDENT VARIABLES				
Collateral	= 1 if collateral was pledged at loan origination, and = 0 otherwise.	32,286	0.244	0.429	0
ExPost_Nonperformance	= 1 if a loan is 30+ days overdue anytime after origination or if it is downgraded. to the default status (i.e. given a rating of 5), and = 0 otherwise.	28,729	0.065	0.246	0
	B. INDEPENDENT VARIABLES				
Firm's Credit History					
Observed Risk					
Default_AnyBank_[1,12]	= 1 if the borrower had defaulted on a loan anytime in the previous 12 months with any lender, and = 0 otherwise.	32,286	0.003	0.052	0
Npl_Bank_[3,12]	= 1 if the borrower had overdue payments of at least 30 days with the current bank anytime from t-3 to t-12, and = 0 otherwise.	32,286	0.074	0.261	0
Npl_AnyBank_[1,2]	= 1 if the borrower had overdue payments of at least 30 days with any bank anytime from t-1 to t-2, and = 0 otherwise.	32,286	0.057	0.231	0
Unobserved Risk					
Npl_OtherBank_[3,12]	= 1 if the borrower had overdue payments of at least 30 days with another bank anytime from t-3 to t-12, and = 0 otherwise.	32,286	0.140	0.347	0
Relationship Characteristic					
Rel_Length	Length of bank-firm relationship in months.	32,286	23.102	16.046	19
Firm Characteristics					
Sole Proprietorship	= 1 if the firm is a sole proprietorship, and = 0 otherwise.	32,286	0.125	0.331	0
Partnership	= 1 if the firm is a partnership (i.e., all or some partners have unlimited liability), and is = 0 otherwise.	32,286	0.140	0.347	0
Corporation	= 1 if the firms is a corporation (i.e., all or some partners have limited liability), and is = 0 otherwise.	32,286	0.714	0.452	1
Other	= 1 if the firm is a public company, a municipality, or a cultural, sport, religious associations, and is = 0 otherwise.	32,286	0.020	0.142	0
Loan Characteristics					
Installment	= 1 if an installment loan and = 0 if a discount loan.	32,286	0.471	0.499	0
Loan Amount	Loan amount at loan origination in US Dollars.	32,286	161,490	467,960	43,175
Maturity	Number of months between loan origination and maturity.	32,286	11.880	16.308	6.9
Fixed Effects					
Industry	Set of dummy variables controlling for the firm's industry. There are 18 industry categories: Agriculture and cattle farming; Forestry and fishery; Extraction of oil and gas; Minerals; Manufacturing; Electricity, gas, and water; Construction; Wholesale and retail trade; Hotels and restaurants; Transport, storage, and communications; Financial intermediation; Real estate activities; Public administration defense, and compulsory social security; Education; Communal and personal social services; Activities of households as employees of domestic personnel; Activities of extraterritorial organizations and bodies; Other Activities.				
Region	Set of dummy variables controlling for region of loan origination (Chuquisaca, La Paz, Cochabamba, Oruro, Potosi, Tarija, Santa Cruz, Beni, Pando, U.S., Argentina, Paraguay, Panama).				
Bank	Set of dummy variables controlling for the bank that originated the loan. There are 13 banks.				
Time	Set of dummy variables controlling for the time of loan orignation. There are 57 months from 1999:03 to 2003:12.				

Table 3
Determinants of Collateral

This table reports Probit regressions for *Collateral,* a dummy variable that equals one if the loan is secured and is equal to zero otherwise. Under *Probit Coefficients* we report the estimated coefficients of the three Probit specifications. Standard errors, corrected for heteroskedasticity, are reported between brackets. Under *Marginal Effects* we report the change in probability of pledging collateral for each one of the independent variables. For continuous variables we report the effect for an infinitesimal change in each independent variable and for dummy variables we report the estimated effect of a change from 0 to 1. P0 is the predicted probability that collateral is pledged evaluated at the mean of all independent variables. ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

	Probit Coefficients			Marginal Effects		
	I	II	III	I	II	III
Observed Risk						
Default_AnyBank_[1,12]	0.388 **	0.369 **	0.335 **	0.128 **	0.12 **	0.104 **
	[0.160]	[0.161]	[0.161]	[0.058]	[0.058]	[0.056]
Npl_Bank_[3,12]	0.163 ***	0.144 ***	0.136 ***	0.05 ***	0.043 ***	0.039 ***
	[0.035]	[0.036]	[0.037]	[0.011]	[0.011]	[0.011]
Npl_AnyBank_[1,2]	0.222 ***	0.219 ***	0.262 ***	0.069 ***	0.068 ***	0.079 ***
	[0.040]	[0.040]	[0.040]	[0.013]	[0.013]	[0.013]
Unobserved Risk						
Npl_OtherBank_[3,12]	0.043	-0.765 ***	-0.622 ***	0.012	-0.17 ***	-0.137 ***
	[0.027]	[0.094]	[0.094]	[0.008]	[0.015]	[0.016]
NPL_OtherBank_[3,12]*Rel_Length		0.287 ***	0.243 ***		0.082 ***	0.067 ***
		[0.031]	[0.031]		[0.009]	[0.009]
Relationship Characteristic						
Rel_Length	-0.148 ***	-0.164 ***	-0.131 ***	-0.043 ***	-0.047 ***	-0.036 ***
	[0.010]	[0.010]	[0.010]	[0.003]	[0.003]	[0.003]
Firm Characteristics						
Partnerships	-0.211 ***	-0.214 ***	-0.267 ***	-0.057 ***	-0.057 ***	-0.067 ***
	[0.037]	[0.037]	[0.038]	[0.009]	[0.009]	[0.009]
Corporations	-0.074 ***	-0.078 ***	-0.153 ***	-0.022 ***	-0.023 ***	-0.043 ***
	[0.027]	[0.027]	[0.028]	[0.008]	[0.008]	[0.008]
Other	0.164 **	0.154 **	-0.021	0.05 **	0.047 **	-0.006
	[0.065]	[0.065]	[0.068]	[0.021]	[0.021]	[0.018]
Loan Characteristics						
Installment Loan			-0.14 ***			-0.038 ***
			[0.025]			[0.007]
Loan Amount			0.141 ***			0.039 ***
			[0.007]			[0.002]
Maturity			0.372 ***			0.102 ***
			[0.015]			[0.004]
Industry, Region, Bank, and Time dummy variables included	YES	YES	YES	YES	YES	YES
P0				0.209	0.208	0.193
Pseudo R-square	0.213	0.215	0.264	0.213	0.209	0.264
Observations	32,286	32,286	32,286	32,286	32,286	32,286

Table 4
Determinants of Ex Post Nonperformance

This table reports Probit regressions for *Ex Post Nonperformance,* a dummy variable that equals one if a loan is 30+ days overdue anytime after its origination or if it is downgraded to the default status (i.e., given a rating of 5). Under *Probit Coefficients* we report the estimated coefficients of the three Probit specifications. Standard errors, corrected for heteroskedasticity, are reported between brackets. Under *Marginal Effects* we report the change in probability of pledging collateral for each one of the independent variables. For continuous variables we report the effect for an infinitesimal change in each independent variable and for dummy variables we report the estimated effect of a change from 0 to 1. P0 is the predicted probability of *ex post* nonperformance, evaluated at the mean of all independent variables. ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

	Probit Coefficients			Marginal Effects		
	I	II	III	I	II	III
Loan Characteristics						
Collateral	0.362 ***	-0.04	-0.069	0.041 ***	-0.004	-0.006
	[0.031]	[0.080]	[0.082]	[0.004]	[0.007]	[0.007]
Collateral* Rel_Length		0.153 ***	0.154 ***		0.015 ***	0.015 ***
		[0.028]	[0.028]		[0.003]	[0.003]
Relationship Characteristic						
Rel_Length	0.01	-0.05 ***	-0.041 **	0.001	-0.005 ***	-0.004 **
	[0.016]	[0.019]	[0.019]	[0.002]	[0.002]	[0.002]
Firm Characteristics						
Partnerships	0.249 ***	0.25 ***	0.263 ***	0.028 ***	0.028 ***	0.029 ***
	[0.052]	[0.052]	[0.053]	[0.007]	[0.007]	[0.007]
Corporations	0.127 ***	0.126 ***	0.16 ***	0.012 ***	0.012 ***	0.014 ***
	[0.043]	[0.043]	[0.044]	[0.004]	[0.004]	[0.004]
Other	-0.086	-0.08	-0.009	-0.008	-0.007	-0.001
	[0.107]	[0.107]	[0.107]	[0.009]	[0.009]	[0.010]
Other Loan Characteristics						
Installment Loan			0.188 ***			0.018 ***
			[0.035]			[0.003]
Loan Amount			-0.054 ***			-0.005 ***
			[0.009]			[0.001]
Maturity			0.076 ***			0.007 ***
			[0.021]			[0.002]
Industry, Region, Bank, and Time dummy variables included	YES	YES	YES	YES	YES	YES
P0				0.047	0.046	0.045
Pseudo R-square	0.11	0.11	0.12	0.11	0.11	0.12
Observations	28,729	28,729	28,729	28,729	28,729	28,729