
# Estimating the Relationship Between Collateral and Interest Rate: A Comparison of Methods

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# Estimating the Relationship Between Collateral and Interest Rate: A Comparison of Methods

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**Abstract**

This paper uses a variety of estimation methods to explore the empirical relationship between interest rate and collateral requirements in bank loan contracts. Methods that do not allow for endogenous contract terms detect a positive reciprocal association between interest rate and collateral. Methods that allow for endogenous contract terms point to a strong positive effect of interest rate on collateral but the effect of collateral on interest rate is much weaker. This highlights the importance of incorporating the endogenous nature of contract terms in empirical work.

*JEL Classification:* G21, G32, L11
*Keywords:* Bank lending, Collateral, Interest rate

## 1. Introduction

Extant theoretical work in the area of loan contracting usually models interest rate and collateral as interrelated components of the same contract. Despite theoretical postulates, early empirical research that studies the relationship between collateral requirements and interest rate estimates single-equation models that either treat one of the contract terms (usually collateral) as exogenous or predetermined, or impose implicit constraints on the estimated models (e.g., Berger and Udell, 1990; Harhoff and Körting, 1998; Degryse and Van Cayseele, 2000). Building upon this reduced-form method, some studies approach the analysis by endogenizing the probability of collateral being pledged and including it as an explanatory variable in models for interest rate (e.g., Dennis et al., 2000; Bharath et al., 2011; Calcagnini et al., 2014), or by testing for exogeneity of the interest rate (e.g., Ono and Uesugi, 2009).

In this paper, we adopt a more comprehensive approach and explore several methods for the estimation of the empirical relationship between interest rate and collateral in bank loan contracts. We ultimately specify a system of equations without imposing any directional constraints on the relationship between the contract terms. Our approach is similar to the one followed by Brick and Palia (2007) but we improve the analysis along two key dimensions. First, our analysis, conducted at the loan contract level, is based on a proprietary dataset of credit lines extended to a large number of small and medium-sized enterprises (SMEs) that includes specific information on interest rate and collateral requirements. This overcomes limitations stemming from the use of survey data with self-reported information and allows us to unambiguously match collateral and interest rate within specific credit lines. Second, we consider the amount of collateral pledged by a borrower, i.e. the degree of collateralization, and its joint determination with interest rate. Hence, in line with theory, which also models degree or magnitude of collateral use, we investigate the relationship between interest rate and collateral intensity.

## 2. Empirical Models and Data

We estimate several alternative econometric models of the following general set of equations:

$$Rate_{i,t} = \alpha_R + \beta_R Collateral_{i,t} + \gamma_R W_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$Collateral_{i,t} = \alpha_C + \beta_C Rate_{i,t} + \gamma_C Z_{i,t} + u_{i,t} \quad (2)$$

where *i* denotes borrower and *t* time period. Each contract term depends on the other term, as well as a vector of control variables, *W* for interest rate and *Z* for collateral. Coefficients with a subscript *R* (*C*) refer to the interest rate (collateral) equation, respectively.

We begin our analysis by using ordinary least squares (OLS) regressions. Then, we estimate a model of seemingly unrelated regressions (SUR) to allow the errors to be cross-correlated across equations. We next proceed by allowing for endogenous loan contract terms. We first implement equation-by-equation instrumental variable (IV) analysis by estimating 2-stage least squares (2-SLS) models. Last, we model the simultaneity present in the determination of the loan contract terms by jointly estimating the system of equations (1) and (2) using 3-SLS method (Zellner and Theil, 1962).

### *2.1. Data and Outcome Variables*

We estimate the models of collateral and interest rate using a dataset of credit lines extended to a large number of Italian SMEs by a major Italian bank as of September of 2004 and 2006. Our dataset provides a wide array of borrower characteristics and information on contract terms.

We focus on two outcome variables. *Rate* is the annualized interest rate charged by the bank and measured in percentage terms. *Collateral* is the amount of collateral pledged by the borrower, expressed as a percentage of the limit on the credit line.[1] Table 1 reports summary statistics for the variables and Appendix A provides descriptions and construction.

Insert Table 1 Here

### *2.2. Determinants of Contract Terms*

We control for firm size using indicator variables *D(Sales i)* for each of the seven classes in which the bank classifies its borrowers on the basis of their annual sales (where $i = 1 \ldots 7$, from smaller to larger classes).[2] Our regressions also include three characteristics of the lending relationship. *Relationship Length* reflects the time since the firm has first borrowed from our bank. *Multiple Lending* takes value of 1 if a firm borrows from multiple banks and 0 if it has

[1] For robustness, we also use a dummy variable for the incidence of collateral. The results are available upon request.

[2] We note that our dataset provides only sales classes used by the bank and not the actual sales figures of the borrowers.

exclusive relationship with our bank. *Other Services* takes value of 1 if a borrower uses additional services by the bank and 0 otherwise. Finally, we control for borrower risk by using the internal credit rating assigned by the bank, which categorizes borrowers into 9 classes in order of increasing risk. We use a separate indicator *D(Rating i)* for each rating class *i*. As we do not have a rating for all borrowers, we adopt a modified zero order regression approach following Hollander and Verriest (2016). To this end, we re-code the rating as 0 for borrowers without a rating, create an indictor *D(Rated)* that takes value of 1 for rated borrowers, and interact it with *D(Rating i)*. Last, we note all estimations include industry, branch, and year fixed effects.

### *2.3. Instruments*

To instrument the interest rate (*Rate*), and identify the interest rate equation (1) in the system, we rely on the contractual nature of the credit lines, as well as the industrial organization of the local credit markets where the bank operates.[3] Our first instrument is *Overdraw*, a variable that takes the value of 0 if a borrower uses funds not exceeding the contractual limit of the credit line, and the logarithm of the actual amount of excess funds if the borrower exceeds the limit and overdraws. This is based on a contract clause that borrowers pay a fixed interest rate if they use funds within a pre-specified limit, but pay a penalty fee, increasing in the amount of withdrawn excess funds, if they exceed the limit. Hence, the interest rate depends on whether a borrower exceeds the credit limit and by how much. By contrast, the contract does not condition the collateral requirements on overdrawn funds. Our second instrument for interest rate is *Branch HHI* constructed as the branch-based Herfindahl-Hirschman Index (HHI) to capture market competition in the local credit market. In concentrated markets, banks can use explicit loan rates as a strategic tool to establish long-term relationships and secure rents on future business (e.g., Petersen and Rajan, 1995; Brick and Palia, 2007; Bellucci et al., 2013).

To instrument the collateral requirements (*Collateral*), and identify the collateral equation (2), we develop three instruments. The first, *Real Estate Prices*, is equal to the logarithm of the average price per meter for industrial and commercial real estate during the period 2003-2004 in the local credit market of the borrower. The underlying rationale is that fluctuations in these

[3] We identify as a separate local market each municipality within the provinces covered by our sample where the bank has at least one branch.

values affect the liquidation values of properties in the market and can thus change the incentives of the bank to secure the loans granted to borrowers in this market.

Our second instrument for collateral is *Bankruptcy Costs*, measured as the average cost of bankruptcy procedures as of 2003 and 2005 for the judicial district of each borrower. The rationale is that collateral becomes relevant if a borrower cannot meet repayment obligations, but the actual realization of bankruptcy and seizure of collateral by the bank, vis-à-vis other outcomes such as out-of-court renegotiation depends on the cost of the procedures: Higher bankruptcy costs could lead to higher probability of renegotiation and lower collateral relevance (Degryse et al., 2019).

The third instrument *Individual Firm* is an indicator that takes value of 1 if a borrower has sole proprietorship as an organizational form and 0 otherwise. Sole proprietorships are not covered by limited liability and this could affect the asset base recoverable by banks in a bankruptcy, and thus the importance of collateral requirements. In addition, sole proprietorships are informationally less transparent and are expected to face differential collateral requirements (Berger and Udell, 1998).

## 3. Empirical Results

We begin by estimating models that do not allow for endogenous contract terms. The OLS results in Table 2 show that the contract terms exhibit positive empirical association. The point estimate of the coefficient on *Collateral* (*Rate*) is positive and statistically significant at the 1% level in column (1) (column (2)) of the table. We estimate that an increase in *Collateral* of a standard deviation is associated with an increase in the interest rate of about 9 basis points (bps). Compared to unsecured loans, a fully collateralized loan has 27 bps higher interest rate. Similarly, an increase in *Rate* of a standard deviation is associated with an increase in degree of collateralization of about 1%. This represents a meaningful economic effect given that the mean value of *Collateral* is 19%.

Insert Table 2 Here

Table 3 shows the SUR estimates. In columns (1) and (2) we use as explanatory variables the variables that are in the set of common controls as well as the contract features. We augment the

models by adding the instruments for each contract term in columns (3) and (4). Our insights about the positive empirical relationship between interest rate and collateral continue to hold.

Insert Table 3 Here

We next focus on estimation procedures that account for the endogeneity of interest rate and collateral. We first adopt equation-by-equation IV models based on two-stage estimation process, where we predict each endogenous variable in the first stage using the relevant instruments and all other explanatory variables, and then use the predicted value as explanatory variable in the second stage, along with the controls. Columns (1) and (2) of Table 4 show the results of the first stages for the estimation of the endogenous *Collateral* and *Rate*, respectively. Columns (3) and (4) show the second stages of the estimation.

Insert Table 4 Here

The instruments are significant determinants of the contract terms. In column (1), we note that if real estate prices increase, degree of collateralization increases. If bankruptcy costs increase, making formal court procedures more expensive, and less likely, collateralization decreases. Last, the coefficient on *Individual Firm* is positive and statistically significant. This is consistent with the idea that individual firms, which are considered as less transparent, are more likely to be asked for collateral. In column (2), we observe that the amount of overdrawing by a borrower increases interest rates. The effect of *Branch HHI* is not statistically significant.

Both first stages produce sufficiently high F-statistics of 29.43 for *Collateral* and 36.93 for *Rate*, respectively, thus reducing concerns about weak instruments. The *p-values* of the over-identifying restrictions tests, reported in the last row of the Table, show that we cannot reject the null hypothesis that the instruments are uncorrelated with the error terms and correctly excluded.

The IV analysis of *Rate* in column (3) reveals that after endogenizing the loan contract terms, the effect of collateral on interest rate is weaker and not robust as indicated by the coefficient on the predicted value of collateral, or *Collateral (predicted)*, which is positive but not significant. By contrast, interest rate continues to have a robust effect on collateral requirements as indicated

by the positive and statistically significant coefficient on the predicted value of interest rate, *Rate (predicted)* in column (4).

Last, we approach equations (1) and (2) as a system of simultaneous equations using 3-SLS estimation method. For identification purposes we rely on the instruments used in IV analysis. The results of our analysis, presented in columns (5) and (6) of Table 4, are consistent with our insights generated through the IV analysis that interest rate is a robust determinant of collateral, while collateral is not, even though the sign of the estimated coefficient on *Collateral* is negative.

Hence, we conclude that loan contract features such as interest rate and collateral requirements exhibit a largely positive empirical association even after we allow for endogenous contract terms. However, the link between the two contract terms is unidirectional: Firms that pay higher interest rates also pledge more collateral, but pledging more collateral is not associated with higher rates. This underscores the importance of using methods that endogenize the contract terms, as predicted by theory, and suggests that the use of collateral might be driven by a variety of mechanisms based on its role as an enforcing, incentive, or screening device.

## 4. Conclusion

We use a variety of methods to explore the empirical relationship between collateral requirements and interest rates in bank loan contracts. Consistent with extant research, our estimations generally document a positive link between these two contract terms. However, our analysis highlights the importance of incorporating the endogenous nature of contract terms in empirical work.

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## Appendix A Description of Variables

| *Variable* | *Definition* |
|---|---|
| Collateral | Degree of collateralization, i.e. fraction of the credit line secured with collateral, measured as amount of collateral expressed as percentage of the credit line limit. |
| Rate | Interest rate charged by the bank, expressed as percentage. |
| D(Sales i) | Indicator that takes value of 1 if the sales of a borrower fall in the *i*-th category (1 through 7) and 0 otherwise. The categories are as follows: 1 for sales below €.25M; 2 for sales between €.25M and €.5M; 3 for sales between €.5M and €1.5M; 4 for sales between €1.5M and €5M; 5 for sales between €5M and €25M; 6 for sales between €25M and €50M; and 7 for sales that exceed €50M. |
| Multiple Lending | Indicator that takes value of 1 if a borrower has lending relationship with multiple banks and 0 if it is exclusive relationship with the bank. |
| Other Services | Indicator that takes value of 1 if the bank provides other services (in addition to credit line) to a borrower and 0 otherwise. |
| Relationship Length | Length of bank-borrower relationship. Logarithmic transformation, in months. |
| D(Rated) | Indicator that takes value of 1 if a borrower has rating and 0 otherwise. |
| D(Rating i) | Indicator that takes value of 1 if a rating falls in the *i*-th category (1 through 9) and 0 otherwise. The rating assigned by the bank is from 1 to 9 with lower scores indicating lower risk. |
| Overdraw | Variable that takes value of 0 if borrower uses funds within the credit limit and natural logarithm of the amount of excess funds if borrower exceeds the limit in the contract. |
| Branch HHI | Branch-based measure of concentration of the credit market, where the market for each branch is determined by the postal area code where the branch is located. |
| Individual Firm | Indicator that takes value of 1 if the organizational form of a borrower is sole proprietorship and 0 otherwise. |
| Bankruptcy Costs | Average costs incurred in bankruptcy proceedings in the judicial district of each borrower for 2003 and 2005. The costs are computed annually by Italian National Institute of Statistics (ISTAT) using data for each district and include legal fees, administrative and procedural costs, trustee fees, etc. |
| Real Estate Prices | Natural logarithm of the average price of industrial and commercial real estate in the local market of a borrower for 2003-2004. Prices are computed semi-annually by Real Estate Market Observatory (OMI) of Italian Revenue Agency (Agenzia del Territorio, now part of Agenzia delle Entrate). The price data are from market transactions and appraiser valuations. OMI splits the area of each municipality into homogenous zones and records min and max price for each property category within the zone. For each zone we compute the mean of these prices. |

**Table 1 Summary Statistics**

The sample size is 14,672. Appendix A provides a detailed description of each variable.

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| *Outcome Variables* | | | | | |
| Rate | 7.04 | 2.43 | 0 | 6.34 | 13.5 |
| Collateral | 0.19 | 0.34 | 0 | 0 | 1 |
| | | | | | |
| *Control Variables* | | | | | |
| Multiple Lending | 0.97 | 0.18 | 0 | 1 | 1 |
| Other Services | 0.91 | 0.28 | 0 | 1 | 1 |
| Relationship Length | 113.33 | 90.75 | 0.03 | 83.63 | 387.9 |
| D(Sales 1) | 0.54 | 0.5 | 0 | 1 | 1 |
| D(Sales 2) | 0.1 | 0.3 | 0 | 0 | 1 |
| D(Sales 3) | 0.14 | 0.35 | 0 | 0 | 1 |
| D(Sales 4) | 0.11 | 0.31 | 0 | 0 | 1 |
| D(Sales 5) | 0.08 | 0.27 | 0 | 0 | 1 |
| D(Sales 6) | 0.02 | 0.14 | 0 | 0 | 1 |
| D(Sales 7) | 0.01 | 0.09 | 0 | 0 | 1 |
| D(Rating 1) | 0 | 0.02 | 0 | 0 | 1 |
| D(Rating 2) | 0 | 0.05 | 0 | 0 | 1 |
| D(Rating 3) | 0 | 0.06 | 0 | 0 | 1 |
| D(Rating 4) | 0.01 | 0.11 | 0 | 0 | 1 |
| D(Rating 5) | 0.02 | 0.15 | 0 | 0 | 1 |
| D(Rating 6) | 0.03 | 0.16 | 0 | 0 | 1 |
| D(Rating 7) | 0.01 | 0.11 | 0 | 0 | 1 |
| D(Rating 8) | 0.01 | 0.12 | 0 | 0 | 1 |
| D(Rating 9) | 0 | 0.01 | 0 | 0 | 1 |
| | | | | | |
| *Instruments* | | | | | |
| Branch HHI | 0.21 | 0.15 | 0.07 | 0.15 | 1 |
| Overdraw | 0.27 | 0.63 | 0 | 0 | 22.1 |
| Individual Firm | 0.43 | 0.5 | 0 | 0 | 1 |
| Bankruptcy Costs | 38.3 | 9.85 | 21.48 | 35.68 | 51.45 |
| Real Estate Prices | 6.92 | 0.22 | 6.29 | 7.03 | 7.22 |

**Table 2 OLS Estimation**

The table reports coefficient estimates, followed by standard errors in parentheses, of OLS analysis of equations (1) and (2). Appendix A provides a detailed description of each variable. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | (1)<br>Rate | (2)<br>Collateral |
|---|---|---|
| Collateral | 0.272*** | |
| | (0.070) | |
| Rate | | 0.005*** |
| | | (0.001) |
| Multiple Lending | 0.111 | -0.123*** |
| | (0.105) | (0.017) |
| Other Services | -0.315*** | -0.177*** |
| | (0.085) | (0.013) |
| Relationship Length | -0.001*** | -0.000*** |
| | (0.000) | (0.000) |
| Portfolio | -0.470*** | -0.037*** |
| | (0.089) | (0.011) |
| D(Sales 2) | -0.196*** | 0.014 |
| | (0.067) | (0.009) |
| D(Sales 3) | -0.213*** | -0.020*** |
| | (0.057) | (0.008) |
| D(Sales 4) | 0.042 | -0.060*** |
| | (0.068) | (0.008) |
| D(Sales 5) | -0.143 | -0.054*** |
| | (0.094) | (0.012) |
| D(Sales 6) | -0.432*** | -0.079*** |
| | (0.138) | (0.017) |
| D(Sales 7) | -0.976*** | -0.051** |
| | (0.175) | (0.024) |
| D(Rated)×D(Rating 1) | -0.403 | -0.097** |
| | (0.478) | (0.040) |
| D(Rated)×D(Rating 2) | -0.543** | -0.104*** |
| | (0.249) | (0.024) |
| D(Rated)×D(Rating 3) | -0.031 | -0.083*** |
| | (0.246) | (0.021) |
| D(Rated)×D(Rating 4) | -0.238* | -0.097*** |
| | (0.134) | (0.016) |
| D(Rated)×D(Rating 5) | -0.441*** | -0.100*** |
| | (0.108) | (0.015) |
| D(Rated)×D(Rating 6) | -0.233** | -0.080*** |
| | (0.104) | (0.015) |
| D(Rated)×D(Rating 7) | -0.297** | -0.084*** |
| | (0.126) | (0.020) |
| D(Rated)×D(Rating 8) | -0.011 | -0.045** |
| | (0.137) | (0.021) |
| D(Rated)×D(Rating 9) | -1.737 | -0.068 |
| | (1.340) | (0.232) |

| | | |
|---|---|---|
| Industry FE | Yes | Yes |
| Branch FE | Yes | Yes |
| Year FE | Yes | Yes |
| Observations | 14,672 | 14,672 |
| Adj. R-squared | 0.076 | 0.168 |

**Table 3 SUR Estimation**

The table reports coefficient estimates, followed by standard errors in parentheses, of SUR analysis of equations (1) and (2). Appendix A provides a detailed description of each variable. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | (1) Rate | (2) Collateral | (3) Rate | (4) Collateral |
|---|---|---|---|---|
| Collateral | 0.543*** | | 0.499*** | |
| | (0.063) | | (0.063) | |
| Rate | | 0.009*** | | 0.009*** |
| | | (0.001) | | (0.001) |
| Branch HHI | | | 0.231 | |
| | | | (0.313) | |
| Overdraw | | | 0.260*** | |
| | | | (0.031) | |
| Individual Firm | | | | 0.052*** |
| | | | | (0.006) |
| Bankruptcy Costs | | | | -0.004*** |
| | | | | (0.001) |
| Real Estate Prices | | | | 0.062*** |
| | | | | (0.023) |
| Controls | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Branch FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Observations | 14,672 | 14,672 | 14,672 | 14,672 |

**Table 4 IV Estimation**

The table reports coefficient estimates, followed by standard errors in parentheses, of IV analysis of equations (1) and (2) using 2-SLS (columns 1 to 4) and 3-SLS (columns 5 and 6). Appendix A provides a detailed description of each variable. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | First Stage | | Second Stage | | 3-SLS | |
| | Collateral | Rate | Rate | Collateral | Rate | Collateral |
| Rate (predicted) | | | | 0.140*** | | 0.132*** |
| | | | | (0.024) | | (0.021) |
| Collateral (predicted) | | | 0.084 | | -0.358 | |
| | | | (0.842) | | (0.865) | |
| Individual Firm | 0.052*** | | | | | 0.051*** |
| | (0.006) | | | | | (0.008) |
| Bankruptcy Costs | -0.004*** | | | | | -0.005*** |
| | (0.001) | | | | | (0.002) |
| Real Estate Prices | 0.060*** | | | | | 0.066*** |
| | (0.022) | | | | | (0.025) |
| Branch HHI | | 0.212 | | | -0.039 | |
| | | (0.320) | | | (0.240) | |
| Overdraw | | 0.270*** | | | 0.286*** | |
| | | (0.039) | | | (0.046) | |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Branch FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 14,672 | 14,672 | 14,672 | 14,672 | 14,672 | 14,672 |
| First Stage F-statistic | 29.43 | 36.93 | | | | |
| Sargan test (p-value) | | | .157 | .123 | | |