Credit Relationships and Dynamic Credit Constraints *

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Abstract

This paper presents microeconomic evidence from the U.S. syndicated loan market showing that as a credit relationship between a lender and a borrower strengthens, borrowing is more likely to be linked to a firm's earnings through loan covenants rather than physical assets as collateral. I rationalize this in a model with limited commitment and information asymmetry, in which heterogeneity in relationship status leads to heterogeneous borrowing constraints. In a credit relationship, access to earnings-based credit increases over time because of a learning mechanism. The lender learns about the borrower's private information through repeated interactions and so updates its belief. This leads to a dynamic borrowing constraint for the firm, with a switch from collateral-based to earnings-based constraints as the relationship develops. Empirically, I find that the use of loan covenant, which is often linked to earnings and increases credit supply by more than collateral use, increases as the lender-borrower relationship matures. Moreover, covenants tend to replace collateral requirements in a relationship. This provides direct evidence of a dynamic credit constraint in relationship lending, and demonstrates a new channel through which relationships increase credit supply by expanding access to earnings-based contracts. Finally, the effect of relationships on access to earnings-based credits is larger for smaller, typically more informationally opaque firms, underscoring the importance of the learning mechanism.

Keywords: Credit constraint; relationship banking; information asymmetry; loan covenant; financial friction; debt collateral.

JEL Codes: D22, D82, D83, E22, G21, G32.

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1 Introduction

Credit constraints are an important determinant of firms' corporate investment decisions and the propagation of macroeconomic shocks.[1] When a firm faces a tight credit constraint, its ability to invest is restricted. This can amplify negative shocks, as tightening credit constraints lead to even lower levels of investment. A way to alleviate these constraints is through credit relationships, because repeated interactions between a borrower and lender can reduce contracting costs and relax distortions.[2] Given the wide variety of contractual devices that firms can use to attract funds, credit can be of differing nature and have differing implications for both firm performance and aggregate fluctuations. While the literature has explored how the terms of individual contractual devices evolve within a relationship and the resulting impact on credit availability, surprisingly little is known about how a relationship influences the ex-ante incidence of such contractual devices. This paper investigates the effect of credit relationships on access and availability of two distinct types of credit, collateral-based credit and earnings-based credit. The paper makes two main contributions. First, it presents new empirical and theoretical evidence that established credit relationships increase credit availability by improving access to earnings-based credit, which can substitute for collateral-based credit. Second, it demonstrates that in a credit relationship, a firm's credit constraint is dynamic in both credit availability and type of credit, i.e., collateral-based to earnings-based credits. Because collateral-based and earnings-based constraints have different implications for aggregate fluctuations,[3] the pervasiveness of credit relationships underscores the importance of dynamic credit constraints in macroeconomic modeling.

I find microeconomic evidence in the U.S. syndicated loan market that as the strength of a credit relationship increases, measured by both the frequency of interaction and the duration, covenants, which are often linked to the borrowers' earnings, are included in loan

[1] See, e.g., Bernanke & Gertler (1989) and Kiyotaki & Moore (1997).
[2] See, e.g., Petersen & Rajan (1994) and Berger & Udell (1995).
[3] See, e.g., Greenwald (2019), Lian & Ma (2021), and Drechsel (2023).

contracts more frequently, substituting for collateral requirements. To the best of my knowledge, this paper is the first to document this switch from collateral-based to earnings-based borrowing in credit relationships. To explain this new stylized fact, I develop a credit relationship model featuring a bank learning mechanism. Through repeated interactions, the bank learns about the firm's private information and updates its beliefs for subsequent loan contracting. In initial interactions, credit is predominantly collateral-based because covenant use is restricted by private information held solely by the borrower. As the relationship develops, information asymmetry is reduced, improving the firm's access to loans backed by covenants and thus increasing the firm's credit availability. As a credit relationship develops, a productive but constrained firm switches from loan contracts with collateral requirements to loan contracts with covenant requirements that provide higher credit availability, and the resulting credit switches from collateral-based to earnings based, representing a relationship-driven dynamic borrowing constraint. My model is relatively parsimonious and illustrates in a straightforward way the learning mechanism that drives the substitution of earnings-based credit for collateral-based credit, and the dynamic nature of credit constraints in a relationship. I also propose a mechanism through which credit relationship intensity can have a real effect on firms' investment responses to shocks in business cycles, which provides insights for future studies on both credit relationships and financial frictions. Informationally opaque firms may experience slow relationship formation, making them more likely to face collateral-based credit constraints and more susceptible to shocks leading to collateral price changes. Responses to the same shock can be heterogeneous across firms with different statuses of credit relationships.

The model provides several testable predictions, which are validated using a merged Compustat-DealScan database featuring detailed loan-level data and firm-level financial statement data. In particular, I find that covenant use in syndicated loan contracts increases with credit relationship strength, proxied by both the maximum number of interactions between the borrower and any of the lead lenders in a loan deal and the number of years since their earliest interaction, and that in a relationship, covenant use increases with the degree to which a firm is constrained by investable and pledgeable assets prior to origination of the loan deal. If a firm is credit-constrained, the increase in covenant use in loan contracting over the duration of a relationship replaces collateral requirements as a monitoring device, which provides direct evidence of the switch from collateral-based to earnings-based borrowing. With prior interactions, covenant use can also provide higher credit availability compared to collateral requirements. These findings confirm the channel through which credit relationships increase credit availability by improving access to earnings-based credit. Moreover, the effect of relationship on access to earnings-based credits is stronger for smaller, typically more informationally opaque firms, and this highlights the importance of the learning mechanism. Finally, in the syndicated loan market I examine, borrowers tend to be large corporations with many alternative means of external financing, including bond, commercial paper, and equity financing, and are less dependent on relationships in loan financing than other firms. The estimated positive effect of mature credit relationships on access to and availability of credit should be regarded as the lower bound of the true effect of such relationships for the wider population of firms, including small and medium-sized enterprises.

1.1 Related literature

This paper contributes to four main strands of the literature. First, this paper contributes to the literature on financial frictions and their aggregate implications. This strand of the literature began with the seminal works of Bernanke & Gertler (1989) and Kiyotaki & Moore (1997). In particular, the present paper contributes to research on models of borrowing constraints arising from agency problems, as studied by Kehoe & Levine (1993) and Kiyotaki & Moore (1997), by introducing a dynamic setting in which limited enforcement and information asymmetry problems evolve over the duration of a credit relationship, thereby resulting in dynamic borrowing constraints.

Second, this paper is closely related to the literature on implications of bank-firm relationships. Early empirical work mainly focuses on the formation of relationships between banks and small-medium enterprises (Petersen & Rajan, 1994; Berger & Udell, 1995; Harhoff & Körting, 1998), whereas increased data availability allows later studies to evaluate the effects of credit relationships on large firms (D'Auria et al., 1999; Bharath et al., 2007, 2011). However, whereas the effects of relationships on price and availability of credit and on collateral requirements have been extensively studied, there is limited work on credit relationships and choices of monitoring devices. Prilmeier (2017), an exception, found in a sample of syndicated loans that contain covenants that covenant tightness reduces over the duration of a relationship and that relationship maturity has a non-linear effect on the number of covenants included in a loan deal. Although the literature documents how the terms of collateral or covenant requirements change in a relationship, taking the incidence of these requirements as given, little is known about how relationships affect the ex-ante incidence of collateral or covenant. This paper closes this gap and adds to the existing literature by documenting a positive effect of credit relationship maturity on covenant inclusion in loan contracting. To my knowledge, this paper is the first to identify substitution of covenant requirements for collateral requirements as a relationship develops.

Third, this paper relates to research on loan covenants and collateral-based versus earnings-based borrowing constraints.[4] The paper contributes to this strand of literature in two ways. First, I document that over the duration of a credit relationship, loan covenants are substituted for collateral requirements, challenging the conventional view that collateral and covenants are complementary in bank monitoring. Second, in light of this new evidence, I propose a mechanism whereby a firm's credit relationship affects its access to credit via bank learning. Under this mechanism, a firm's borrowing constraint can be dynamic: predominantly collateral-based at the start of a credit relationship, and gradually shifting to earnings-based as the credit relationship develops.

[4] For example, see Rajan & Winton (1995) and Park (2000) for why loans contain covenants, Chava & Roberts (2008), Nini et al. (2012), and Chodorow-Reich & Falato (2022) for consequences of covenant breaches and transmission of shocks, and Lian & Ma (2021) and Drechsel (2023) for pervasiveness and aggregate implications of earnings-based constraints.

Finally, this paper contributes to the growing literature on dynamic credit constraints. Amberg et al. (2023) shows that collateral constraints can be dynamic due to firms' precautionary behaviors in anticipation of future uncertainty. I contribute to this literature by showing that credit constraint dynamics can be driven by bank learning in credit relationships, and that credit constraints can move dynamically from collateral-based to earnings-based in a credit relationship.

1.2 Structure of the paper

Section 2 provides an institutional background of loan syndication. Section 3 provides microeconomic evidence on credit relationships and collateral versus covenant choice, motivating my further research. Section 4 develops a parsimonious model that shows bank learning in a credit relationship affects choices between collateral and covenants, and presents testable predictions. Section 5 tests for empirical relevance of these predictions. Section 6 concludes.

2 Institutional background of loan syndication

This section provides an institutional background on the syndicated loan market, drawing largely on insights from consultations with active syndicated lenders. Syndicated lending, a collaborative financing arrangement where multiple financial institutions jointly extend a loan to a single borrower, plays a critical role in financing large-scale corporate projects. This arrangement enables risk-sharing among lenders while providing borrowers with access to substantial capital resources beyond the capacity of a single lender.

2.1 The loan syndication process

A syndicated loan may be initiated either by a borrower seeking financing and approaching financial institutions or by a lead lender that identifies the borrower's financing needs and proposes a structured loan deal. Once preliminary terms are agreed upon, a Non-Disclosure Agreement (NDA) is signed between the borrower and the lead lenders, allowing the borrower to share confidential information necessary for further due diligence and deal structuring. Such confidential information can include detailed financial projections, specific operational metrics, risk management and compliance frameworks, and strategic plans, including prospective mergers or acquisitions. While these details support lenders in assessing creditworthiness, even publicly listed companies are not obligated to disclose them unless they meet respective regulatory body's materiality thresholds impacting investors' decisions.

Following negotiations between lead lenders and the borrower, a term sheet and an information memorandum are drafted, and are submitted for approval by the internal committees within each lead lender institution for risk and compliance purpose. When approvals are granted, lead lenders formally invite potential participants to join the syndicate. Commitments are obtained from participants and the loan deal is finalized, which legally binds all parties to the deal terms. Final agreement is signed and funds are credited to the borrower.

2.2 Post-origination of syndicated loans

Throughout the tenure of the syndicated loan, lead lenders actively monitor the borrower's financial and operational performance. This includes regular review of financial statements, compliance with loan terms, and ongoing assessment of any risk factors that may impact repayment. In some circumstances, lead lenders may receive limited observer rights or access to board-level information, primarily to stay informed on corporate decisions relevant to the loan's risk profile, without participating in governance or influencing decisions.

After the existing loan matures, the borrower and lead lenders continue to maintain their credit relationships. The borrower may choose to refinance the loan with the same lead lenders if there are ongoing financing needs. Alternatively, lead lenders may keep regular contact with the borrower, staying informed about the borrower's financial health and business developments, in order to promptly address any future financing need that the borrower may have, such as expansion, acquisition financing, or working capital lines. Lead lenders may also gain access to confidential and detailed information from the borrower when assisting in drafting financial statements or investor presentations. This proactive approach enables lead lenders to continuously acquire insights into the borrower's financial position and strategic initiatives, even outside of an active loan arrangement.

3 Microeconomic evidence on relationships and loan contracts

This section presents motivating microeconomic evidence on credit relationships and credit access in the U.S. syndicated loans market. Loan-level data show that one channel through which credit relationships affect firms' credit access is the inclusion of covenant and/or collateral requirements in loan contracting.

3.1 Data description

Loan-level data are obtained from *Refinitiv LPC DealScan*, a database that contains detailed terms and conditions on more than 131,000 loan, high-yield bond and private placement transactions in the global commercial loan market. The unit of observation is a loan deal, and often consist of several loan tranches. A typical observation at the deal level provides rich information on contract details, including borrower identification and characteristics, lenders' identification and their respective roles in the syndication process, date of deal origination, deal purpose, deal amount, collateral requirements and detailed asset classes, and covenant requirements and detailed restrictions. A typical observation at tranche level contains additional information tranche amount, maturity, and all-in drawn spreads, the spread over LIBOR including fees and interest. Within a loan deal, while amounts, maturities, and spreads may differ across different tranches, lenders' roles, and any collateral or covenant requirement are the same across different tranches. Loan information is only collected at the time of origination.

This dataset covers about 75% of total U.S. commercial loans by volume, and is widely used in the corporate credit literature. Due to great data coverage in the U.S. economy, I focus on the sample of U.S. dollar denominated loans incurred by U.S. nonfinancial corporations. I start the sample from 1990, before which observations are sparse, and end the sample in 2019, the year which the current dataset covers up to. Table 1 summarizes key characteristics of the 60,322 individual deal-level observations included in the sample. Equal-weighted statistics are sample averages weighted by the number of observations, and value-weighted statistics are sample averages weighted by the real loan amount of each deal.[5]

The Loan Sample Overview panel provides a summary of key loan characteristics. The loan amount is deflated by NIPA's nonresidential fixed investment goods deflator and expressed as 2017 USD. Maturity and spread are averages among different tranches within the same loan deal, and weighted by the tranche amount. First, average real loan amount in the sample is 417.61 million USD, which is significantly larger than an average U.S. commercial loan. This results from the nature of syndicated loans, which often are taken by large corporations, financed by multiple lenders, and incur considerably large fees. Given the primary focus on relationship lending, this selection bias not only poses no threat but actually strengthens the external validity of the findings in this paper. The positive effects of credit relationships observed in this sample should be interpreted as a lower bound for the entire population, as larger borrowers typically have greater access to alternative sources of credit and are less dependent on relationships for financing. Average maturity of a loan deal in the sample is around 3.6 years, both equal- and volume-weighted. Equal- and volume-weighted means of all-in spread drawn, which is the spread over LIBOR including any fee and interest, are 193.43 and 165.39 basis points respectively.

[5] Summary of other characteristics are included in Appendix B.

Table 1: Summary of selective loan characteristics

Loan Characteristics	Equal-Weighted	Volume-Weighted
Loan Sample Overview		
Loan Amount (millions 2017 USD)	417.61	
Maturity (months)	42.37	43.11
Spread (drawn spread bps)	193.43	165.39
Relationship Characteristics		
Repeated Interaction (frequency)	37.47%	58.53%
Repeated in $\leq$ 4 years	31.36%	47.87%
Repeated in $\leq$ 8 years	34.59%	53.95%
No. of Previous Interactions	0.78	1.59
Duration (years)	1.36	3.09
Contract Features		
Collateral (frequency)	45.33%	36.66%
Covenant (frequency)	31.68%	36.55%
Financial Covenant	30.24%	35.31%
Max. Debt to EBITDA	21.04%	24.89%
Min. Interest Coverage	12.57%	16.96%
Min. Fixed Charge Coverage	10.83%	7.69%
Net Worth	10.65%	5.98%
Max. Leverage	4.92%	7.62%
Max. Debt to Tangible Net Worth	3.39%	1.20%
Min. Current Ratio	3.33%	1.37%
Min. Debt Service Coverage	2.82%	1.03%
Nonfinancial Covenant	19.97%	22.43%
Any Sweep Provision	17.70%	21.69%
Capital Expenditure Restriction	7.24%	5.25%
Observations	60322	60322

Notes: This table shows summary of selective loan characteristics from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. Equal-weighted statistics are the averages weighted by number of loan observations, and volume-weighted statistics are the averages weighted by loan volumes. *Loan Amount* is the total amount of a loan deal in millions, deflated by NIPA's nonresidential fixed investment goods deflator (base year = 2017). *Maturity* and *Spread* are the volume-weighted average maturity and yield spread over base reference rate (LIBOR) for each dollar drawn on the loan respectively. *Repeated Interaction* is a dummy variable that equals 1 if the borrower and any lender in a loan deal has interacted previously in other loan deals, and 0 otherwise. *Repeated in $\leq$ 4 years & $\leq$ 8 years* indicate if such repeated interaction was within 4 or 8 years respectively. *No. of Previous Interactions* is a measure of relationship intensity, captured by the number of past interactions between the borrower-lender pair in a loan deal that has interacted most since the start date of the dataset, and *Duration* is another measure, captured by the number of years since the earliest interaction between any borrower-lender pair in the loan deal. *Collateral* indicates if at least a tranche of a loan is secured, *Covenant*, either financial or nonfinancial, indicates if at least a tranche of a loan contains (financial) covenant, and the subclass below are dummies for each specific covenant.

3.2 The importance of credit relationships

Credit relationships are pervasive in the U.S. syndicated loan market, as borrowers consistently return to the same lender(s) for financing over time. The Relationship Characteristics panel of Table 1 shows summary statistics on relationship status of loans in the sample. I define that relationship formation in a loan deal takes place between the borrower, and any lender that takes a lead role in the syndication process and acquires most information on the borrower[6]. Overall, 37.47% of loans by number and 58.53% by total volume in the sample are issued to firms that have previously interacted with a lender leading the syndication process. In these deals, more than 80% involve past interactions within 4 years, and more than 90% occur within 8 years. Across all borrower-lender pairs in a loan deal, the equal- and volume-weighted averages of the maximum number of past interactions are 0.78 and 1.59, respectively, while the maximum number of years since their first interaction are 1.36 and 3.09 years, respectively.

Credit relationships are also an important determinant of firms' access to credits, and hence investment and aggregate economic activities. Table 2 [7] shows the summary statistics of loan characteristics across groups with different relationship strengths. I use two proxies for loan relationship strength: the number of past interactions and the years since the first interaction. Panel A and B sort the relationship groups based on these proxies respectively. Low relationship strength represents the subsample of deals that mark the first interaction between the borrower and any lender. Loans involving repeated interactions are classified as having medium or high relationship strength, depending on whether the relationship proxy is below or above the median. Both panels show that firms with higher relationship strength can access larger and cheaper credits compared to those with lower relationship strength, while the relationship strength appears to have little effect on loan maturity.

[6] A detailed explanation of the method used to identify relationship lender and relationship formation is shown in Appendix B

[7] This table shows equal-weighted means of loan characteristics. A volume-weighted version is included in Appendix B, and findings are consistent.

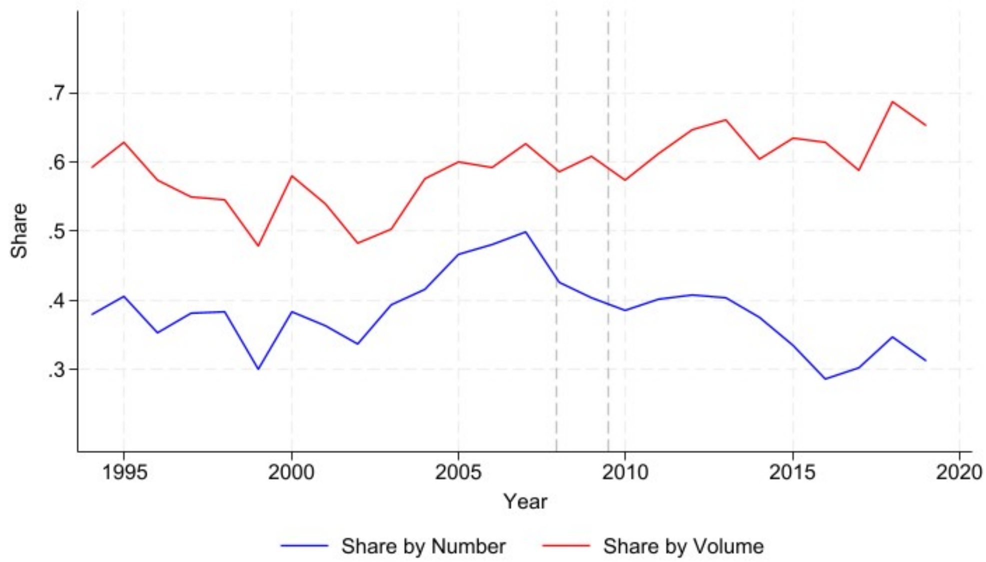
Table 2: Summary of loan characteristics by relationship strength (equal-weighted)

Panel A: Interaction Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Loan Amount (millions 2017 USD)	417.61	277.07	485.62	834.05
Maturity (months)	42.37	42.43	42.58	41.96
Spread (drawn spread bps)	193.43	205.68	188.07	156.51
Collateral (frequency)	45.33%	47.73%	45.58%	36.67%
Covenant (frequency)	31.68%	29.18%	34.09%	37.82%
No. of Prev. Interactions	0.78	0	1	3.26
Observations	60322	37741	11767	10814

Panel B: Duration Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Loan Amount (millions 2017 USD)	417.61	280.79	473.61	867.59
Maturity (months)	42.37	42.45	40.85	43.82
Spread (drawn spread bps)	193.43	206.33	171.39	169.78
Collateral (frequency)	45.33%	47.93%	43.68%	37.40%
Covenant (frequency)	31.68%	29.25%	33.97%	38.25%
Duration (years)	1.36	0	1.46	6.36
Observations	60322	38525	11518	10279

Notes: This table shows summary of selective loan characteristics from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. All statistics are sample averages weighted by number of loan observations. Two relationship strength proxies are used: *No. of Previous Interactions*, and *Duration*. Relationship strengths are sorted into three subgroups: Low, Medium, and High Relationship groups. The Low group includes all observations where the relationship proxy equals zero. The Medium group includes all observations where the relationship proxy is greater than zero but below the median of observations with a positive relationship proxy. The High group includes all observations where the relationship proxy is greater than zero and above the median of observations with a positive relationship proxy. Panel A and B present the summaries with relationship group sorted by *No. of Previous Interactions* and *Duration* respectively.

Figure 1: Share of loans incurred by firms in credit relationships



Notes: This figure shows shares of loans issed to firms that have previously interacted with a lead lender by both number and volume over time for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. Area between two grey lines indicates the period of the Great Recession.

The prevalence of credit relationships is not solely driven by time or the length of firms' continued operations. Figure 1 illustrates the annual share of total loans, both by number and volume, extended to firms with previous interactions with any lead lender. These shares remain relatively stable over time. The two grey lines mark the beginning and end of the Great Recession. During this period, while the share of loans by number for relationship borrowers declines, possibly driven by firm exit and relationship separation, the volume share remains fairly stable, suggesting that surviving firms with prior relationships experienced smaller reductions in credit supply compared to those without such relationships. This further underscores the importance of credit relationships during times of crisis.

3.3 Covenant vs. collateral

Collateral and covenants can both reduce risks and provide protections to creditors rights, but their mechanisms and implications are different. When collateral is pledged, the loan is secured. In the event of the borrower's default, the lender has the legal right to seize and liquidate the collateral to recover the loan amount. Common types of collateral include real estate, property, plant and equipment (PP&E), inventories, and accounts receivable. As a result, loans with collateral are typically classified as collateral-based credits.

Loan covenants are legally binding agreements between the borrower and lender that the borrower must adhere to throughout the life of the loan. These covenants are typically tied to specific financial indicators, often found in the borrower's financial statements, and establish maximum or minimum thresholds for these indicators. For instance, a covenant might require that 'the borrower's debt-to-earnings ratio must not exceed 4'. Breaches of loan covenants lead to technical default, which entitles the creditor to rights such as accelerating repayment, or more often, re-negotiation of loan terms (Aghion & Bolton, 1987; Chava & Roberts, 2008).

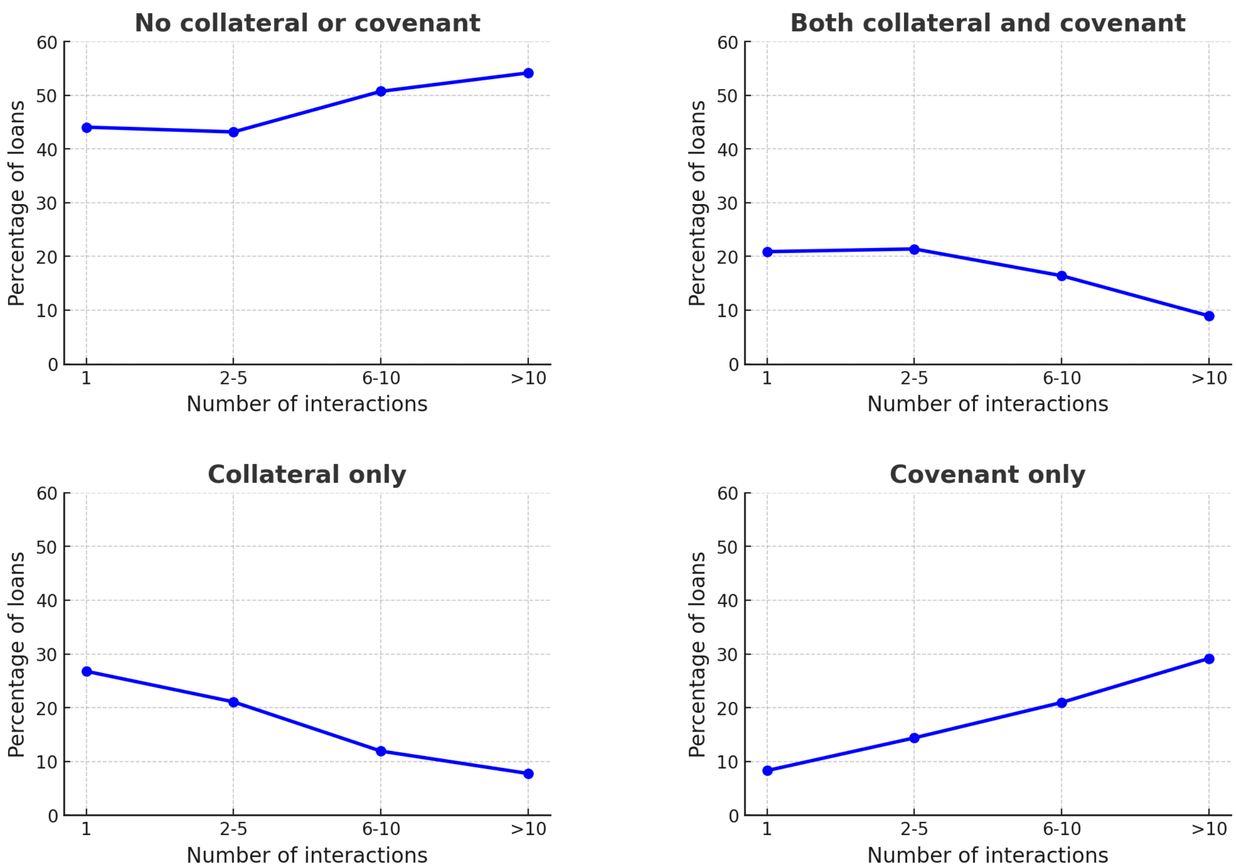
The Contract Features panel in Table 1 shows that both forms of creditor rights protections are utilized in loan contracts within the DealScan sample, based on both the number of observations and loan volume. Among loans with covenants, more than 95% loans include restrictions tied to financial variables. Earnings before interest, taxes, depreciation, and amortization (EBITDA) is a particularly key financial metric, with more than 60% of loans with covenants imposing maximum limits on borrowers' debt-to-EBITDA ratios. Additionally, around 40% of these loans have restrictions on borrower's interest coverage ratio (EBITDA-to-interest expense). When covenants are present, borrowers' maximum borrowing capacities are highly likely to be linked to their earnings, classifying these loans as earnings-based credits.

While both covenants and collateral serve the same purpose of creditor protection, they function through different mechanisms, and I find that credit relationships are a key driver of dynamics in collateral-based and earnings-based credits substitutions. Table 2 shows that relationship strength increases, collateral requirement decreases while covenant use rises. This pattern holds when relationship strength is measured by both the number of interactions and the duration of the relationship. These findings suggest that, over time, a firm's access to credit can shift from collateral-based to earnings-based. I also show in Appendix B that the differences in covenant and collateral use across varying relationship strengths documented in Table 2 are statistically significant.

The patterns documenting a switch from collateral-based to earnings-based borrowing within a credit relationship are illustrated by the following examples. WLR Foods Inc, previously the largest poultry producer in Virginia, United States, borrowed 135 million USD in 1995 from the First Union National Bank of Virginia for general purpose, with a loan contract that was secured by physical assets. In 1997, the same firm borrowed from the same lender for the same purpose, but with a slightly larger loan amount of 160 million USD, and with a loan contract that required no collateral, but with covenants including a minimum fixed charge coverage ratio of 1.25. This also applies to US Xpress, a leading truckload carrier in the United States, who borrowed 10 million USD from Wachovia Bank with a secured loan for general purpose in 1997. In the subsequent year, US Xpress borrowed again from Wachovia Bank, who led the syndicate and contributed 15% to the overall loan amount of 200 million USD, and with a loan contract that required no collateral, but with two covenants that were both linked to the firm's earnings: a maximum debt to cashflow ratio of 3.00, and a minimum fixed charge coverage ratio of 1.25.

I classify loan contracts by mechanisms for creditor protection, and proxy loan relationship status by the maximum number of interactions at time of loan origination between a borrower and lead lender pair since 1990. Figure 2 shows the intensities of different types of contract in different relationship subgroups. For instance, among loans that are first-time interactions between the borrower and all lead lenders, just under 10% have only covenant requirements, compared to just under 30% for the subgroup of loans with the highest credit relationship level. First, in line with a trend that is well-documented in the literature, use of collateral requirements decreases as credit relationships strengthen. Second, I note that the substantial increase in contracts with covenants, as interactions increase, cannot be fully explained by the slight decrease in contracts with both collateral and covenants (see the top right and bottom right sub-figures in Figure 2). This challenges the view that collateral and covenants are complimentary monitoring incentive devices (see Rajan & Winton, 1995; Park, 2000). This evidence indicates that as a credit relationship matures, covenants can be used to substitute for collateral in loan contracting, and collateral requirements may be switched to covenant requirements as monitoring device. In the next section, I propose a model with information asymmetry, in which bank learning influences the choice of monitoring device, to explain this new empirical finding.

Figure 2: Collateral and covenant intensity in credit relationships



Notes: This figure shows intensities of different types of loan contracts for different subgroups of credit relationships for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. Loans are classified into four sub-types by covenant and collateral requirements: loans with no collateral or covenant ($N = 26,524$), with both collateral and covenant ($N = 12,610$), with collateral only ($N = 14,689$), and with covenant only ($N = 6,504$). Credit relationships of loans are classified into four subgroups by maximum number of interactions between a borrower and a lead lender pair in a loan deal since 1990: 1 as first-time interaction (no prior relationship, $N = 37,725$), $2-5$ as some prior interactions (low-level prior relationship, $N = 20,788$), $6-10$ as considerable prior interactions (medium-level prior relationship, $N = 1,646$), and 10 as extensive prior interactions (high-level prior relationship, $N = 168$).

4 A model on bank learning in credit relationships

I consider a discrete-time model with three periods, $t \in \{0, 1, 2\}$. There are two types of agents, firm F and a representative bank B, and both are risk-neutral. The firm borrows one-period loans from the bank in periods 0 & 1 and repays in periods 1 & 2, respectively. The firm cannot fully commit to repayment so the bank requires either collateral or covenants to protect its creditor rights. Information asymmetry exists when there is no prior interaction between the firm and the bank, and the bank can only observe the firm's productivity during a loan deal. The bank's decision on whether to require collateral or covenants at loan origination is influenced by its information on the firm's productivity. Capital and consumption goods can be exchanged one-for-one, and I set capital as the numeraire.

The main mechanism in this model is bank learning, which is motivated by empirical evidence that lenders accumulate valuable information about borrowers through credit relationships (see e.g. Berger et al., 2005; Garmaise & Natividad, 2010; Even-Tov et al., 2023). In practice, lenders often sign Non-Disclosure Agreements to have exclusive access to borrowers' confidential information. Accumulation of such information allows lenders to detect any misrepresentation in financial health or earnings by borrowers and to better predict future default risk. In my model, I assume in the model that the bank learns about firm's productivity over time, a process analogous to how lenders gain insights into operational efficiency in practice. In period 0, the bank and firm have no prior relationship, and information asymmetry is present while the bank cannot observe the firm's productivity. In period 1, if there is an ongoing relationship between both agents, the bank will be able to observe the firm's productivity, and will be able offer loan contracts based on its updated beliefs if the relationship continues into period 2.

4.1 Agents

Bank: The representative bank acts as a financial intermediary that borrows from depositors at an exogenous rate $r_t \equiv r \ \forall t$. I assume that the banking sector is competitive and there is no barrier to entry, and the representative bank is price-taking and breaks even. In order to focus on non-price terms of a loan contract, I further assume for simplicity that the bank charges no spread and lends to the firm at rate $R_t = r_t \equiv r \ \forall t$. In Appendix A.5, I present an extension that relaxes this assumption and allows for endogenous spread choice, and show that main results and findings do not change qualitatively[8].

In periods $t \in \{0, 1\}$, the bank offers a loan b_{t+1} with either collateral or covenant required, and receives repayments $(1 + r)b_{t+1}$ in $t + 1$. The bank is endowed with a technology that enables it to observe the firm's private information on productivity during an ongoing loan deal. The bank's objective in each period is to offer a loan contract such that: 1) the firm is willing to borrow (firm's participation constraint); 2) the firm will not voluntarily default (firm's incentive compatibility constraint); and 3) the bank breaks even (bank's participation constraint).

Firm: A firm is born in period 0 with initial net worth n_0, and draws productivity a from distribution $\Phi(a)$ with cumulative distribution function Φ and probability density function ϕ. The firm also owns a production technology that can produce output $y_t = af(k_t)$ with capital k_t in period $t \in \{1, 2\}$, subject to capital depreciation rate δ. The cost of production is assumed to be zero, because it is equivalent to re-scaling n_0 and will not qualitatively affect the results, and hence profits (earnings) from production $\pi_t = y_t$. The production technology is finite and fully exhausts its productive capacity by the end of period 2. In period $t \in \{0, 1\}$, the firm can borrow a one-period loan b_{t+1} in order to finance its investment in capital stock k_{t+1} for next-period production. The firm owner only derives utility from consuming dividends d_2 paid out at the end of period 2, and their objective is to maximize

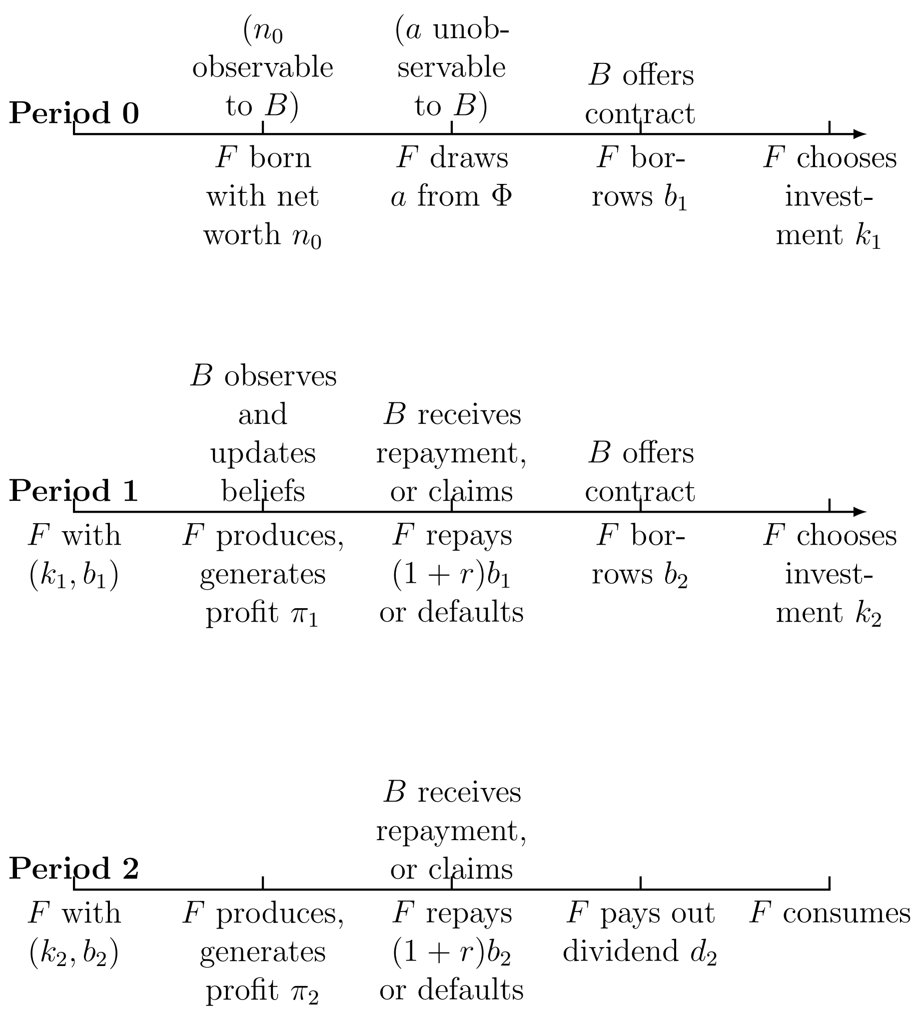
[8] The extension also finds that spread decreases in a relationship, consistent empirical findings on relationship and loan spreads (see Duqi et al., 2018)

$U^F(d_2) = d_2$.

4.2 Timeline

Figure 3 summarizes the timing of actions taken by both agents in each period. Note that in period 0, information asymmetry exists when the bank and firm have no prior credit relationship, and the bank cannot observe the firm's productivity draw. In period 1, if there is an ongoing relationship between both agents, the bank will be able to observe the firm's productivity, and will be able offer loan contracts based on its updated beliefs if the relationship continues into period 2.

Figure 3: Timelines of each period



4.3 Collateral versus covenants in a loan contract

A loan contract can require either capital as collateral or covenants in order to protect creditor rights. Both collateral requirements and covenant requirements arise from a limited commitment issue in which the firm is not fully committed to repay the loan, but they can result in different borrowing constraints for the firm. Further, different sets of information are required when contracting with collateral and with covenants. For instance, collateral requirements necessitate verifiability of capital stock, whereas covenant requirements often necessitate verifiability of the firm's earnings.

If a loan contract involves collateral requirements, then the bank can seize capital pledged by the firm when it defaults, and use it to repay its depositors. Seizure and liquidation of capital incur legal and administrative costs of a fraction $(1-\theta^k)$ of the seized capital, where $\theta^k \in (0,1)$. Because the bank breaks even, even if the firm does not default, the bank's participation constraint implies that the bank will only lend up to the recovery value of depreciated collateral, with a collateral-based limit: $\bar{b_t^k} = (\frac{1}{1+r})\theta^k(1-\delta)k_t$.

If a loan contract involves covenant requirements, following existing literature (see e.g. Greenwald, 2019), I assume that the firm's borrowing constraint is linked to its future cash flows. I follow empirical findings in Table 1 that covenants often link borrowing capacity to earnings, and assume that covenant restriction is a maximum debt-to-EBITDA ratio. Because a loan only lasts for one period, the maximum ratio is non-negative during the loan and zero at maturity, when repayment is required.

This ratio can be microfounded from the re-negotiation process when covenant is breached and technical default is triggered. During this process, some control rights of the firm are shifted to the bank. The outcome of bargaining and exercising control rights by the bank result in η proportion of the firm's cash flow being 'paid out as dividends' to the bank to service debt, because seizure and liquidation of capital is costly and less efficient. This is equivalent to the firm pledging control rights of η proportion of its earnings at loan origination. The bank's participation constraint implies that the bank will only lend up to the expected amount it will receive from bargaining and exercising control rights, with an earnings-based limit $\bar{b_t^{\pi}} = (\frac{1}{1+r})\eta\mathbb{E}_{t-1}(\pi_t \mid \text{default})$, where $\mathbb{E}_{t-1}(\pi_t \mid \text{default})$ denotes the bank's expectation in $t-1$ of the firm's profit in t in the event of default, given firm productivity distribution Φ.

4.4 The bank's problem

In period $t \in \{0, 1\}$, the bank offers two types of contract, one based on collateral and the other one based on covenants. The bank's problem is to set terms for both types of contracts such that 1) the firm borrows; 2) the firm will not voluntarily default; and 3) the bank breaks even in the repayment period. The conditions under which the firm chooses not to default on loan contracts, either with collateral or covenant, are that the repayments do not exceed the costs of default. Specifically, in $t \in \{1, 2\}$ the no-default conditions are given by:

$$(1+r)b_t \leq (1-\delta)k_t; \tag{1}$$

$$(1+r)b_t \leq \eta a f(k_t). \tag{2}$$

The bank's break-even conditions imply that the firm's maximum borrowing capacities when borrowing with collateral and covenants, respectively, are:

$$\bar{b_t^k} = (\frac{1}{1+r})\theta^k(1-\delta)k_t, \tag{3}$$

and

$$\bar{b_t^{\pi}} = (\frac{1}{1+r})\eta\mathbb{E}_{t-1}(\pi_t \mid \text{default}). \tag{4}$$

The assumption that a loan contract can only contain collateral requirements or covenant requirements is relaxed to allow for both in Appendix A. It does not qualitatively affect the finding that inclusion of covenants is more likely as the credit relationship develops.

Intuitively, the two requirements link borrowing to stock and flow variables respectively, and allowing for both will merely entail addition of the two constraints.

4.5 The firm's problem

The firm's decisions include borrowing and investment decisions in periods 0 and 1, repayment decisions in periods 1 and 2, and a dividend payout and consumption decision at the end of period 2. The firm's borrowing decisions in $t \in \{0, 1\}$ involve choosing its optimal level of leverage, and choosing a loan contract with a collateral or covenant requirement, if it is credit-constrained under at least one type of contract under (3) and (4):

$$b_{t+1} \leq \max\{b^{\bar{k}}_{t+1}, b^{\bar{\pi}}_{t+1}\} = \frac{1}{1+r} \max\{\theta^k (1-\delta) k_{t+1}, \eta \mathbb{E}_t(\pi_{t+1} \mid \text{default})\}. \tag{5}$$

In each period, conditioning on repaying existing loan, the firm's budget constraints are given by:

$$k_1 = b_1 + n_0; \tag{6}$$

$$k_2 + (1+r)b_1 = b_2 + af(k_1) + (1-\delta)k_1; \tag{7}$$

$$d_2 + (1+r)b_2 = af(k_2) + (1-\delta)k_{.} \tag{8}$$

The firm's optimization problem is characterized by:

$$\max_{b_1, k_1, b_2, k_2, d_2} \quad U^F(d_2) = d_2 \tag{9}$$

subject to borrowing constraint (5) and budget constraints (6), (7), and (8).

Firm's contractual device choice depends on its borrowing constraint (5), i.e. whether collateral-based or covenant-based contract yields larger borrowing capacity. Specifically, firm's borrowing capacity under collateral-based contract is dependent on the firm's net worth, and that under covenant-based contract is dependent on the bank's belief of the firm's productivity and the firm's net worth. Thus, firm's contractual device choice is a function of 1) firm's initial net worth; 2) firm's productivity; and 3) bank's information on firm's productivity.

4.6 Equilibrium characteristics

I first compare loan contracting problems in periods 0 and 1. Period-0 contracting is analogous to a bank-firm interaction with no prior relationship where the bank relies entirely on public information. Period-1 contracting simulates a continuous relationship, in which the bank has acquired information that is privately held by the firm, and this information is exclusive to the bank. The bank can take advantage of this information by updating its beliefs for setting future loan contracts in a continuing credit relationship.

Lemma 1. $\bar{b_t^k} > 0 \quad \forall t \in \{1, 2\}$.

Lemma 1 states that if a firm chooses collateral-based borrowing, the supply of collateral-based credit is always positive, whether in or out of a relationship. In both periods, the firm's net worth and investments are perfectly observable to the bank. With firm's budget constraint, the limit of collateral-based credit supply in equation (3) becomes:

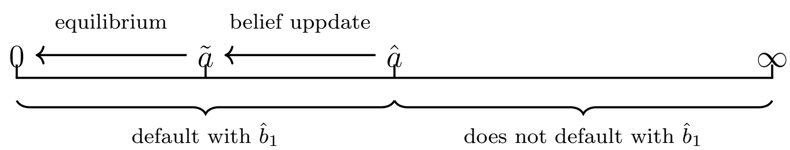
$$\bar{b_t^k} = (\frac{1}{1+r})\theta^k(1-\delta)k_t = (\frac{1}{1+r})\theta^k(1-\delta)(b_t + n_{t-1}),$$

and since borrowing $b_t \geq 0$ and net worth $n_{t-1} > 0$, we have the result in Lemma 1. Intuitively, since all firms have positive net worth as a form of down payment, the bank's participation constraint ensures that they always have access to positive collateral-based credit. A higher level of net worth serves as more down payment and hence the limit of collateral-based credit supply is higher.

Lemma 2. *The limit of earnings-based credit supply is $\bar{b_1^\pi} = 0$ in period 0, and $\bar{b_2^\pi} \geq 0$ in period 1.*

Lemma 2 indicates that if a firm chooses earnings-based borrowing, the resulting credit availability is zero in period 0 when there is no prior relationship. The key to Lemma 2 is $\mathbb{E}_0(a \mid \text{default}) = 0$ in equilibrium, i.e. the bank's period-0 optimal contracting choice involves the belief that only firms with the lowest productivity, specifically $a = 0$, will default. The proof is detailed in Appendix A, and a brief sketch is provided below in Figure 4. Suppose instead that bank's belief is one such that $\hat{\mathbb{E}}_0(a \mid \text{default}) = \hat{a} > 0$, and offers earnings-based credit $\hat{b}_1 = (\frac{1}{1+r})\eta \hat{a} k_1^\alpha$. Firms with $a < \hat{a}$ will default since no default condition (4) is not satisfied. This leads to $\mathbb{E}_0(a \mid \text{default}) = \mathbb{E}_0(a \mid a < \hat{a}) = \tilde{a} \neq \hat{a}$, implying that the contracting based on the initial belief is not optimal. Thus, in equilibrium, bank's period-0 optimal contracting choice has to satisfy Lemma 2. The resulting limit on the period-0 supply of earnings-based credit is $\bar{b_1^\pi} = 0$, and is not dependent on n_0.

Figure 4: Sketch proof of Lemma 2



The intuition of Lemma 2 is the following: in the absence of a prior credit relationship, the bank is unable to learn about the firm's productivity, and information asymmetry is present in period-0 contracting. The interplay between information asymmetry and limited commitment gives rise to adverse selection: a low-productivity firm can exploit private information about its productivity and adversely selects into a loan contract with covenant requirements. Anticipating this, the bank updates its belief, and in equilibrium, no loan with covenant requirements is offered to the firm. It can also be interpreted that the bank imposes very strict covenants on informationally opaque borrowers, offering minimal credit. These borrowers will not choose such contracts in equilibrium, as they can access more credit through pledging collateral.

Bank learning in a credit relationship, which reduces information asymmetry, can help mitigate this problem. In period 1 there is a continuing relationship, and as the bank learns about the firm's productivity, information asymmetry is eliminated and $\mathbb{E}_1(a \mid \text{default}) = a$. A loan contract with covenant requirements is hence only offered in a continuing relationship, with a limit on the supply of earnings-based credit $\bar{b_2^\pi} \geq 0$. A higher net worth allows the firm to choose a higher level of investment, and according to equation (4), the limit of earnings-based credit supply is higher.

Let n_1^* be the firm's investable/pledgeable net worth prior to loan contracting in period 1 in a continuing relationship, where $n_1^* \equiv af(k_1^*) + (1-\delta)k_1^* - (1+r)b_1^*$, and k_1^* and b_1^* are the firm's optimal choices of capital and debt in period 0.

Lemma 3. *In period* 1*, for each level of net worth* n_1^**, there exists a productivity threshold* $\underline{a}^p(n_1^*)$*, above which* $\bar{b_2^\pi} > \bar{b_2^k}$*, and below which* $\bar{b_2^\pi} < \bar{b_2^k}$*.*

Lemma 3 establishes a productivity threshold for each given level of net worth, above which earnings-based borrowing provides a larger credit supply. Intuitively, higher productivity raises the limit on earnings-based credit through improved recovery value in the event of default. In contrast, collateral-based credit supply remains fixed regardless of productivity. Thus, for the same net worth, firms with sufficiently high productivity benefit from a larger credit supply under earnings-based borrowing compared to collateral-based borrowing.

Lemma 4. *In periods 0 and 1, for any given level of net worth* n_t*, there exists a productivity threshold* $\underline{a}^k(n_t)$ *such that if a firm with* $a \geq \underline{a}^k(n_t)$ *chooses collateral-based borrowing,* $b_{t+1} = \bar{b_{t+1}^k}$*.*

The limit of collateral-based credit supply is determined by the firm's net worth, which serves as a form of down payment. The firm's optimal unconstrained demand increases with productivity, since the marginal product of capital is higher for each level of capital. Therefore, a threshold $\underline{a}^k(n_t)$ exists for every given level of net worth n_t, above which the borrowing demand exceeds the supply limit. Thus, the firm is only able to borrow at the limit $b_{t+1} = \bar{b_{t+1}^k}$, and becomes constrained under collateral-based borrowing. This threshold applies to both periods, as the firm's optimization problem under collateral-based borrowing remains the same for a given level of net worth in both periods.

The following presents the main proposition in this paper, emphasizing the substitution between earnings-based and collateral-based credit:

Proposition 1. *Given net worth n_1^*, a firm with $a > \max\{\underline{a}^k(n_1^*), \underline{a}^\pi(n_1^*)\}$ will switch from collateral-based borrowing in period* 0 *to earnings-based borrowing in period* 1*.*

The proof of Proposition 1 is as follows: Lemma 1 and Lemma 2 jointly establish that in period 0, only collateral-based credit is available to firms; when information asymmetry is reduced in period 1, according to Lemma 2, earnings-based credit becomes available; in period 1, a firm with net worth n_1^* and productivity $a > \max\{\underline{a}^k(n_1^*), \underline{a}^\pi(n_1^*)\}$ is credit-constrained under collateral requirements (see Lemma 4) and will optimally switch to earnings-based borrowing, which provides greater credit availability (see Lemma 4). This proposition highlights the model's key findings: credit relationships can relax a firm's borrowing capacity through increased access to earnings-based credit as a result of bank learning. Consequently, a firm faces a dynamic borrowing constraint that is predominantly collateral-based early in the relationship, transitioning to earnings-based as the relationship develops.

The effect of a credit relationship on firm's borrowing decisions, as stated in Proposition 1, is heterogeneous across varying productivities. For firms with productivity $a \leq \max\{\underline{a}^k(n_1^*), \underline{a}^\pi(n_1^*)\}$, the effect depends on the assumptions regarding the functional form of $f(k)$ and parameter values. Under assumptions such that $\underline{a}^k(n_1^*) > \underline{a}^\pi(n_1^*)$ holds, firms with $a < \underline{a}^\pi(n_1^*)$ will still opt for collateral-based borrowing, as it is less restrictive than earnings-based borrowing. Firms with $a \in [\underline{a}^\pi(n_1^*), \underline{a}^k(n_1^*)]$ will be indifferent between the two types, as they are unconstrained under either. Conversely, if $\underline{a}^k(n_1^*) < \underline{a}^\pi(n_1^*)$, all firms with productivity below the threshold in Proposition 1 (i.e. $a < \underline{a}^\pi(n_1^*)$) will stick to collateral-based borrowing, which provides greater availability than earnings-based borrowing.

The results established above lead to the following corollaries, which serve as testable predictions of the model.

Corollary 1. *Conditional on initial net worth, the incidence of earnings-based borrowing increases with relationship strength.*

Corollary 1 follows directly from Lemma 2 and Proposition 1, and suggests that firm's access to earnings-based credit increases as a relationship enhances.

Corollary 2. *Conditional on initial net worth and relationship length, the size of loans increases with the incidence of earnings-based borrowing.*

Corollary 2 follows from Proposition 1 that when in a credit relationship, firms opt for earnings-based borrowing because it provides larger loan amounts than collateral-based borrowing.

With the assumption that the production function exhibits decreasing returns to scale, the following corollary emerges:

Corollary 3. *Conditional on relationship length, if procution function exhbits decreasing returns to scale, the incidence of earnings-based borrowing is decreasing in firm's initial pledgeable assets.*

Corollary 3 follows directly from Proposition 1 and the property of a decreasing returns to scale production function (see proof in Appendix A). With higher initial net worth n_1^*, the thresholds stated in Lemma 3 and Lemma 4 are both higher, meaning that only firms with higher productivity will opt for earnings-based credit. Intuitively, when a firm is more constrained by its initial pledgeable assets, earnings-based borrowing becomes more likely in a credit relationship.

4.7 Illustration of main findings

In order to illustrate the results above, I assume a Cobb-Douglas production function, $y_t = af(k_t) = ak_t^\alpha$, where $\alpha \in (0, 1)$, and solve the model analytically. Model solutions are presented in Appendix A. Thresholds derived in Lemma 3 and Lemma 4 are given by:

$$\underline{a}^k(n_t) = \left(\frac{r+\delta}{\alpha}\right)\left(\frac{(1+r)n_t}{1-\theta(1-\delta)}\right)^{1-\alpha},$$

where $n_t \in \{n_0.n_1^*\}$ in periods 0 and 1, respectively, and

$$\underline{a}^p(n_1^*) = \left(\frac{\theta(1-\delta)}{\eta}\right)\left(\frac{(1+r)n_1^*}{1-\theta(1-\delta)}\right)^{1-\alpha}.$$

Additionally, in period 1, given net worth n_1^*, the threshold above which a firm's optimal unconstrained borrowing demand exceeds the limit of earnings-based credit supply, $\underline{a}^\pi(n_1^*)$, is given by:

$$\underline{a}^\pi(n_1^*) = \left(\frac{r+\delta}{\alpha}\right)\left(\frac{\alpha(1+r)n_1^*}{\alpha(1+r)-\eta(r+\delta)}\right)^{1-\alpha}.$$

Above this threshold, a firm is credit-constrained under earnings-based borrowing. With a production that exhibits decreasing returns to scale, $\underline{a}^{j'}(n_1^*) > 0$ and $\underline{a}^{j''}(n_1^*) < 0$ for $j \in \{k, \pi, p\}$. I set structural parameters to values to match stylized facts in U.S. business cycles, as well as observations from the Compustat and DealScan data, and are provided in Appendix A. I make the following assumption:

Assumption 1. $\eta = 1$ *such that:*

$$\frac{\alpha}{r+\delta} < \frac{\eta}{r+\theta(1-\delta)}$$

This assumption suggests that the bank holds significant bargaining power during the renegotiation process, enabling it to claim all profits as repayment from the firm. In practice, this is analogous to the standard practice that the lender freezes a defaulting firm's bank accounts to secure creditor protection and ensure that the firm's available resources are directed toward settling outstanding debt.[9] I relax this assumption in Appendix A, and

[9] In practice, control rights allow lenders to enjoy not only current but also future cash flows from operations. Thus, η is often considerably larger than 1 and is close to the borrower's earnings multiplier. The inequality following Assumption 1 will not change with an η larger than 1.

the results that the bank relationship relaxes the borrower's credit constraints by increasing inclusion of covenants in loan contracts remains unchanged.

With Assumption 1, it follows that:

$$\underline{a}^{\pi}(n_1^*) > \underline{a}^{k}(n_1^*) > \underline{a}^{p}(n_1^*). \tag{10}$$

Additionally, I assume that at the start of period 1, a firm separates from the relationship exogenously with probability q. A practical example of such separation could be the unexpected departure of a bank's monitoring staff responsible for the firm, leading to insufficient learning effort and preventing the bank from acquiring the firm's private information. As a result, the firm would enter the period-1 contracting process without any prior relationship, similar to the situation in period 0. This separation shock does not affect a firm's optimal decisions in period 0, as shown in Appendix A, where I show that the firm's objective in period 0 is to maximize n_1, independent of its relationship status in period 1. I illustrate results in period 1 in Figure 5, considering both the continuation and separation cases.

Figure 5: Collateral vs. covenant in period 1

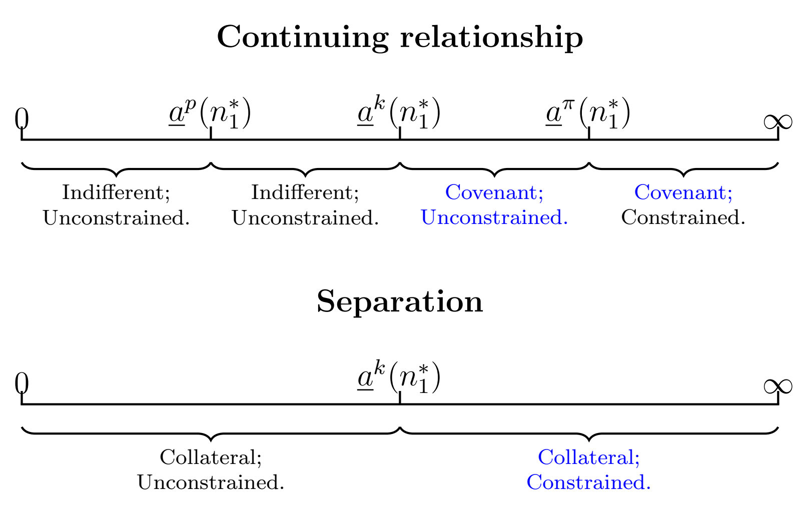


Figure 5 summarizes for different levels of productivity that given initial net worth n_1^*, whether a firm's optimal choice includes a contract with collateral, or a contract with covenant, or is indifferent between the two. It also shows under such choice whether a firm is credit-constrained. In a continuing credit relationship, information asymmetry is reduced, enabling access to earnings-based credit. From Lemma 3, firms with productivity $a \geq \underline{a}^p(n_1^*)$ can borrow through contracts with covenant requirements, which offer greater credit availability compared to loans with collateral requirements. Because $\underline{a}^{p'}(n_1^*) > 0$, as stated in Corollary 3, firms are more likely to borrow through earnings-based contracts when they are more constrained by their initial wealth. According to Proposition 1, firms with productivity $a > \underline{a}^p(n_1^*)$ switch from collateral-based borrowing in period 0 to earnings-based borrowing in period 1. Under earnings-based contracts, firms with productivity $a > \underline{a}^\pi(n_1^*)$ would be credit-constrained. Firms with more initial wealth are less likely to be constrained since $\underline{a}^{\pi'}(n_1^*) > 0$.

To illustrate the effect of a relationship on a firm's credit access and availability, I compare a firm in a continuing relationship with an otherwise identical firm that separates from the relationship in period 1. A separated firm can only borrow collateral-based credit, and is credit-constrained if productivity $a \geq \underline{a}^k(n_1^*)$. In contrast, a continuing relationship relaxes borrowing relax borrowing constraints for firms with productivity $a \in [\underline{a}^k(n_1^*), \underline{a]^\pi(n_1^*)}$ by allowing access to earnings-based borrowing, under which they are unconstrained. In a relationship, although firms with $a > \underline{a}^\pi(n_1^*)$ remain credit-constrained, Lemma 3 shows that they would still be able to access more credit than they would if the relationship were separated.

The effects of relationships on access to earnings-based credit are also heterogeneous across firms with varying initial net worth. Since $\underline{a}^{j'}(n_1^*) > 0$ and $\underline{a}^{j''}(n_1^*) < 0$ for $j \in \{k, p\}$, firms with lower initial assets will be more likely to credit-constrained under collateral-based borrowing when they are separated from a relationship, but will be more likely to access earnings-based credit which relaxes their credit constraints if a relationship is continuing.

We next turn to the empirical analysis to test the predictions derived from the model.

5 Empirical verification of model's testable predictions

This section evaluates the empirical validity of the model's predictions.

5.1 Data description

To test these predictions empirically, I obtain data from the Loan Pricing Corporation's Dealscan database on U.S. Dollar denominated syndicated loans incurred by U.S. non-financial corporations between 1990 and 2019. The Dealscan database provides deal-level information on loan amounts, yield spreads, covenants, collateral, maturities, and other deal-specific characteristics. This dataset covers around 75% of the U.S. commercial loan market by volume. Firm-level balance sheet information is obtained from Standard and Poor's Compustat Northamerica Quarterly, and is merged with loan-level data using a linking table provided by Chava & Roberts (2008).

Table 3: Summary Statistics for DealScan-Compustat Sample

	Observations	Mean	SD
Firm Characteristics			
Real Total Assets (bn 2017 USD)	34488	8.42	61.11
Real Sales (qtr, bn 2017 USD)	35489	1.25	4.22
Real Total Debt (bn 2017 USD)	35994	2.64	18.92
Employment (thousands)	33697	17.23	56.68
Book Leverage	34486	0.40	6.90
Current Ratio	26790	1.97	3.26
Market-to-Book Ratio	26932	4.76	121.08
Deal Characteristics			
Loan Amount (mn 2017 USD)	35994	514.91	1355.32
Maturity (months)	35994	40.98	78.31
Interest spread (drawn spread, bps)	35994	172.13	155.67
Collateral	35994	48.55%	0.50
Covenant	35994	46.84%	0.50
Repeated Interaction	35994	43.38%	0.50

Notes: This table shows summary of selective loan characteristics from merged DealScan-Compustat sample for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. Sample means weighted by number of observations. All dollar amounts are deflated using NIPA's nonresidential fixed investment goods deflator.

The merged sample provides 35,994 individual deal observations with corresponding borrower financial statement data, and the firm and deal characteristics are summarized in Table 3[10]. In this sample, the average borrower has real total assets of $8.42 billion, real total debts of $2.64 billion, and real sales of $1.25 billion in the quarter of deal origination. On average, borrowers in this sample secure larger and cheaper loans compared to the DealScan sample, with an average loan size of $514.91 million compared to $417.61 million, and an all-in drawn spread of 172.13 basis points versus 193.43 basis points. This difference arises primarily from a selection bias toward larger firms when merging the datasets, a common occurrence in similar research using this merged dataset. Compustat mainly covers firms that are publicly traded or are comparable to such firms in terms of size and information transparency. As discussed earlier, given the focus on credit relationships, this bias enhances the external validity of the findings: the positive effects of relationships observed in this sample likely represent a lower bound, implying even stronger effects across the entire firm population. Furthermore, in this merged sample, the prevalence of covenant compared to collateral use, as well as the presence of credit relationships, is consistent with the findings in the original DealScan sample, which are presented in Table 1.

A typical syndicated loan deal may contain several lenders with different roles in the syndication process. To measure credit relationships, I focus on relationship formation between a borrower and lender(s) with a lead role, who are most informed. A detailed explanation of how I identify lenders who form a relationship with a borrower in a loan deal is provided in Appendix B.

5.2 Empirical verification

5.2.1 Empirical specification

To test the effects of credit relationship on the incidence of earnings-based borrowing and its consequences, I consider the following specification:

[10] More summary statistics are provided in Appendix B.

$$Y_{i,j,t} = \beta_{Rel} Rel_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \tag{11}$$

where $Y_{i,j,t}$ is the outcome variable of interest; $Rel_{i,t}$ is a measure of relationship intensity for a loan incurred by firm i at time t; $D_{i,t}$ is a vector of deal characteristics at original; and $X_{i,t-1}$ is a vector of other firm characteristics prior to origination of loan. Additionally, firm, year, lead lender(s), and industry fixed effects are included to address potential endogeneity. μ_i is a firm fixed effect for firm i, and μ_t is a year fixed effect for the year that time t is in. μ_j is a lead lender fixed effect for bank j if it is a lead lender of the loan. In the syndicated loan market, because loan amounts are typically large, firm i and time t can almost perfectly identify a single unique loan deal.

The measure of bank-firm relationship for a loan deal, $Rel_{i,t}$, is proxied by the maximum number of interactions among any borrower-lead lender pair since the start date of the dataset.[11] The firm's investable and pledgeable assets prior to origination of the loan deal, which are included in the vector of firm characteristics, $X_{i,t-1}$, are proxied by: 1) total assets; 2) current assets; 3) net PP&E; and 4) working capital.

5.2.2 Effects on the incidence of earnings-based borrowing

The model provides two testable predictions regarding the incidence of earnings-based borrowing: it increases with relationship length, as stated in Corollary 1, and decreases with a firm's investable and pledgeable assets, as outlined in Corollary 3. To test these predictions, I estimate specification (11) with $COV_{i,j,t}$ as the outcome variable, where $COV_{i,j,t}$ is a dummy variable that equals 1 if a loan that originated at time t incurred by firm i contains covenants.

Table 4 summarizes results of OLS fixed effect regressions for specification (11). Across all specifications, as the credit relationship strengthens, covenants are more likely to be

[11] Due to data limitations, it is difficult to reliably obtain the first interaction and actual number of interactions between a borrower and lender. Thus, $Rel_{i,t}$ is likely to be censored. To mitigate this problem, I re-estimate the regression using observations between 2005 and 2019, generating $Rel_{i,t}$ since 1990. Results are shown in Appendix B, and the estimated effects of bank-firm relationship on covenant use are consistent with my main findings in Table 4.

used in loan deals, as indicated by the positive and statistically significant coefficients on log(Relation) in Columns 1 to 4. This confirms Corollary 1, and indicates that lenders learn about borrowers' private information from the bank-firm relationship, thereby reducing asymmetric information and affecting choices regarding contractual terms to protect creditor rights. Columns 1 to 4 use the borrower's total assets, current assets, net PP&E, and working capital as proxies for its investable and pledgeable assets; the results show that firms with lower initial investable/pledgeable assets tend to enter loan agreements that feature covenants, confirming Corollary 3. Intuitively, in a credit relationship, firms with lower pledgeable assets are more likely to be constrained in collateral requirements, and earnings-based borrowing constraints with more credit availability can be a good substitute for collateral constraints. Also, for every column, covenant use increases with borrower's Market-to-Book ratio. A higher Market-to-Book ratio can be interpreted as higher market expectations of the firm's future growth prospects and future profit levels, and this corresponds to higher expected productivity in my theoretical framework, which also leads to an increase in covenant use in loan contracting.

Because loans with collateral (asset-backed credit) and loans with covenants (earnings-based credit) can have different implications for credit availability and aggregate fluctuations (Drechsel (2023)), my results provides evidence that credit relationships can have nontrivial effects on firms' access to credit and investment decisions. A related study on credit relationships and covenant use by Prilmeier (2017) found that covenant intensity is relaxed over the duration of a relationship, and the effect of relationship intensity on the number of covenants included follows an inverted-U shape. My results do not contradict this finding, and on the contrary complement it in the following ways. First, this paper examines the ex-ante incidence of covenants - whether covenants are included in a relationship instead of collateral, while Prilmeier (2017) focuses on ex-post covenant terms change in a relationship when covenants are included in contracting. Second, a loan contract with very tight covenants in my theoretical framework corresponds to a loan offered by the lender ex-ante but not incurred by the borrower ex-post due to lower credit availability compared to other contract options. Over the duration of a relationship, as information asymmetry is reduced, covenant tightness is relaxed which increases credit availability, and ex-post firms are more likely to take up loan contracts with covenants.

As a robustness check, I introduce an additional proxy for relationship intensity, *Duration*, which measures the length of relationship in years since the earliest interaction between any borrower-lender pair in a given deal. I re-estimates specification (11) using this new proxy for relationship and results are presented in Table 5. Consistent with previous findings, across all specifications, covenant use increases with relationship length, and is higher when firms are more constrained, confirming Corollary 1 and Corollary 3.

There is reason to believe that OLS estimates of the effect of covenant incidence may be biased. A key concern is the potential omission of variables that are correlated with both relationship formation and covenant incidence. Previous research has demonstrated that geographical proximity between borrowers and lenders facilitates relationship formation (e.g., Berger et al., 2005; Bharath et al., 2011). This proximity may also increase covenant incidence, as lenders are better positioned to gather detailed information on borrowers located nearby. Alternatively, the possibility of reverse causality, where borrowers are more likely to establish relationships with lenders that favor earnings-based borrowing, could also bias the OLS estimates of the effect of relationships on covenant incidence. I address this problem with an instrumental variable (IV) approach.

The key to IV estimation is to find an instrument that is correlated with relationship strength, but has no effect on the incidence of covenant other than the channel through relationship. I explore the exogenous separation from relationships with previous lenders who either failed during the Great Recession or were exposed to failed institutions. Specifically, the instrument is a dummy variable that equals 1 for a loan deal if 1) it was the first loan incurred by a borrower since 2007Q4; and 2) the borrower's most recent lender failed in the Great Recession, or was exposed to a failed institution by co-leading syndicates with failed

Table 4: Relationship and Covenant: by Interaction

	(1)	(2)	(3)	(4)
log(Relation)	0.0194***	0.0189***	0.0195***	0.0218***
	(2.73)	(2.66)	(2.73)	(2.75)
log(Total Assets)	-0.0755***			
	(-8.60)			
log(Current Assets)		-0.0661***		
		(-7.80)		
log(Net PP&E)			-0.0605***	
			(-7.28)	
log(Working Capital)				-0.0270***
				(-4.49)
Tangibility	-0.0094	-0.0656	0.1932***	-0.0979
	(-0.18)	(-1.22)	(3.38)	(-1.53)
log(1+Coverage Ratio)	0.0071*	0.0081*	0.0064	0.0072
	(1.64)	(1.85)	(1.48)	(1.52)
Market-to-Book	0.0001***	0.0001***	0.0001***	0.0001**
	(3.00)	(2.92)	(2.97)	(2.25)
Current Ratio	-0.0051	0.0008	-0.0046	0.0028
	(-1.18)	(0.19)	(-1.07)	(0.57)
Leverage	0.0150	-0.0083	0.0024	-0.0554
	(0.39)	(-0.22)	(0.06)	(-1.30)
Rating	0.0005	0.0012	0.0014	-0.0011
	(0.16)	(0.40)	(0.45)	(-0.31)
No rating	0.0006	0.0175	0.0184	-0.0033
	(0.02)	(0.46)	(0.48)	(-0.08)
log(Loan Amount)	0.0740***	0.0722***	0.0723***	0.0692***
	(15.60)	(15.29)	(15.28)	(13.74)
log(Maturity)	0.0552***	0.0548***	0.0551***	0.0619***
	(9.94)	(9.86)	(9.91)	(9.91)
Spread	0.0001***	0.0002***	0.0002***	0.0002***
	(3.59)	(3.80)	(3.69)	(3.85)
Constant	0.3375***	0.2409***	0.1367**	0.1717***
	(6.45)	(4.97)	(3.00)	(3.40)
Firm effects	Yes	Yes	Yes	Yes
Lead lender(s) effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	19078	19078	19077	15153
Adj. R-squared	0.5355	0.5348	0.5347	0.5584

Notes: This table shows OLS regressions of covenant use on relationship intensity, firm's pledgeable assets and control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Covenant use is measured as a dummy variable that equals one if at least one covenant is included in a loan contract between a lender and a borrowing firm and zero otherwise. *Relation* is a measure of relationship intensity, captured by the number of interactions between the borrower-lender pair in a loan deal that has interacted most since the start date of the dataset. *Total Assets*, *Current Assets*, *Net PP&E*, and *Working Capital* are proxies for borrowing firm's pledgeable assets, where *Net PP&E* is the net property, plant, and equipment of the firm, and *Working Capital* is firm's current assets minus current liabilities. *Loan Amount* is the total amount of the deal. All dollar amounts are in millions and deflated using NIPA's nonresidential fixed investment goods deflator (base year = 2017). *Tangibility* is the ratio of net PP&E to total assets. *Leverage* is the ratio of firm's book value of debt to total assets. *Market-to-Book* is ratio of market value of the firm's shares outstanding plus the book value of debt and preferred stock divided by the book value of assets. *Current Ratio* is the ratio of current assets to current liabilities and *Coverage Ratio* is calculated as EBITDA divided by interest expense. *Rating* is a variable that equals zero if the firm has no S&P long-term issuer credit rating, 1, 2, 3, 4, if the rating is AAA, AA+, AA, AA-, respectively, and so on. *No Rating* is a dummy variable that equals one if the firm has no S&P rating. *Maturity* and *Spread* are the weighted average maturity and yield spread over base reference rate for each dollar drawn on the loan respectively. All specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Relationship and Covenant: by Duration

	(1)	(2)	(3)	(4)
log(Duration)	0.0214***	0.0214***	0.0217***	0.0223***
	(3.92)	(3.92)	(3.96)	(3.68)
log(Total Assets)	-0.0747***			
	(-8.53)			
log(Current Assets)		-0.0654***		
		(-7.73)		
log(Net PP&E)			-0.0599***	
			(-7.21)	
log(Working Capital)				-0.0269***
				(-4.49)
Tangibility	-0.0153	-0.0710	0.1854***	-0.1045
	(-0.29)	(-1.32)	(3.25)	(-1.63)
log(1+Coverage Ratio)	0.0073*	0.0082*	0.0066	0.0074
	(1.67)	(1.88)	(1.51)	(1.56)
Market-to-Book	0.0001***	0.0001***	0.0001***	0.0001**
	(3.04)	(2.95)	(3.00)	(2.28)
Current Ratio	-0.0053	0.0006	-0.0048	0.0026
	(-1.21)	(0.14)	(-1.10)	(0.53)
Leverage	0.0177	-0.0054	0.0053	-0.0495
	(0.46)	(-0.14)	(0.14)	(-1.16)
Rating	0.0006	0.0013	0.0015	-0.0009
	(0.21)	(0.44)	(0.50)	(-0.27)
No rating	0.0021	0.0187	0.0196	-0.0016
	(0.05)	(0.49)	(0.51)	(-0.04)
log(Loan Amount)	0.0738***	0.0719***	0.0721***	0.0692***
	(15.54)	(15.23)	(15.22)	(13.74)
log(Maturity)	0.0561***	0.0558***	0.0561***	0.0624***
	(10.13)	(10.06)	(10.11)	(10.01)
Spread	0.0001***	0.0002***	0.0002***	0.0002***
	(3.55)	(3.76)	(3.66)	(3.79)
Constant	0.3320***	0.2360***	0.1327**	0.1688***
	(6.33)	(4.85)	(2.90)	(3.32)
Firm effects	Yes	Yes	Yes	Yes
Lead lender(s) effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	19077	19077	19076	15154
Adj. R-squared	0.5358	0.5351	0.5350	0.5587

Notes: This table shows OLS regressions of covenant use on relationship intensity, firm's pledgeable assets and control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. This table replicates Table 4, while changing the relationship proxy to *Duration*, which is 1 plus the maximum relationship length measured in years since first interaction between any borrower-lender pair in a loan deal. All other variables are defined in Table 4. All specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

institutions between 2004Q4 and 2007Q3. By default, relationships with failed lenders are severed as these lenders exit the syndicated loan market. When lenders were exposed to failed institutions by previously co-leading syndications, the unexpected large drawn down on credit lines by previous borrowers led to draining of liquidity, restricting new lending (Ivashina & Scharfstein, 2010; Chodorow-Reich, 2014). This is analogous to a negative shock to a lender's current credit supply. Consequently, borrowers seeking new loans are likely to separate from relationships these lenders, and the instrument is correlated with relationship. The instrument is unlikely to influence covenant incidence through channels other than relationship strength, as the financial health of previous lenders is unlikely to have a direct effect on the borrower's loan contracting with current lenders. This ensures that the exclusion restriction of the instrument is satisfied. The list of failed institutions are obtained from the National Information Center (NIC) of the Federal Reserve System. The IV estimation is conducted on a sample period spanning from 2004Q4 to 2009Q3, focusing on the time frame surrounding the Great Recession.

Table 6 shows the results from IV estimation. Relationship strength is measured by interactions in columns 1 and 2, and by duration in columns 3 and 4. Columns 1 and 3 show first-stage coefficients for the failure/exposure instrument for both measures of relationship strength respectively from estimating the following first-stage specification:

$$Rel_{i,t} = \beta_{IV} Failed/Exposed_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \tag{12}$$

where $Failed/Exposed_{i,t}$ is the instrument that indicates if borrower i's most recent lender(s) prior to time t failed during the Great Recession, was exposed to a failed institution prior to the Great Recession. If the most recent lender of a borrower failed, or was exposed to a failed institution, separation is more likely to take place, and relationship strength is significantly lower. Second-stage results are presented in columns 2 and 4, and they show that covenant incidence increases with relationship strength, and are statistically significant.

The estimated coefficients are much larger than in the OLS regression. When relationship strength is measured by interaction, Cragg-Donald F statistic from weak instrument test is 31.06, which is above Stock & Yogo (2005) critical value, strongly rejecting instrument weakness. The instrument may be weaker for relationship strength measured by duration, possibly due to the existence of multiple relationships and the fact that borrowers may separate from a failed/exposed lender and switch to other previous lenders. With both measures of relationship strength, covenant incidence also decreases in the borrower's initial pledgeable asset (proxied by total assets), which is consistent with OLS results. Compared to IV estimates, OLS estimates are biased towards zero, indicating potential endogeneity. One potential explanation is that as a relationship grows, bargaining power of the borrower, which is omitted from the specification, increases, and loan contractual terms are less restrictive.

Table 6: Relationship and Covenant: IV Estimation

	1st stage	2nd stage	1st stage	2nd stage
	(1)	(2)	(3)	(4)
Most Recent Lender Failed/Exposed	-0.1626***		-0.1236**	
	(-4.26)		(-2.47)	
log(Relation)		0.4194**		
		(1.96)		
log(Duration)				0.5517*
				(1.67)
log(Total Assets)		-0.2048***		-0.1904***
		(-3.22)		(-2.77)
Deal controls	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Firm effects	Yes	Yes	Yes	Yes
Lead lender(s) effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	3100	3100	3100	3100
Cragg-Donald F		31.06		11.44
Kleibergen-Paap rk F		18.16		6.11
Stock-Yogo (2005) crit.		16.38		16.38

Notes: This table shows 2SLS estimates of the effects of relationship strength on covenant incidence in a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 2004Q4–2009Q3. The instrument used is a dummy variable indicating if a loan deal was the first deal by a borrower since 2007Q4, and the borrower's most recent lender failed during the Great Recession or was exposed to a failed institution. Columns 1 and 2 use *log(Relation)* as a measure of relationship strength, and columns 3 and 4 use *log(Duration)* as the a measure of relationship strength. Columns 1 and 3 are first stage results, with the measure of relationship strength being the dependent variable. Columns 2 and 4 are second stage results, with covenant dummy being the dependent variable. All variables are defined in Table 4 and Table 5. All specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.2.3 Consequences of earnings-based borrowing in a relationship

The model predicts two consequences of the incidence of earnings-based borrowing in a relationship: first, earnings-based credit replaces collateral-based credit, as shown in Proposition 1; and second, this substitution provides larger credit availability according to Corollary 2.

To test whether there is a substitution from collateral to covenant requirements in loan contracting between lenders and constrained firms as a result of relationship, I estimate the following specification:

$$COL_{i,j,t} = \beta_{COV}\widehat{COV_{i,j,t}} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \tag{13}$$

where $COL_{i,t}$ is a dummy variable that equals 1 if a loan that originated at time t incurred by firm i contains at least a tranche that is secured, and $\widehat{COV_{i,j,t}}$ is the predicted value of $COV_{i,j,t}$ obtained from IV estimations from above. Intuitively, $\widehat{COV_{i,j,t}}$ is the variation in covenant incidence as a result of an exogenous relationship separation shock, and coefficient β_{COV} should capture the effect of such exogenous variation in covenant incidence on collateral incidence. Additionally, the specification is estimated on a subsample of loans that contain collateral and/or covenants. According to Figure 5, unconstrained borrowers are indifferent between collateral-based and earnings-based borrowing, and including them in the analysis could introduce bias in the estimates. Thus, I exclude loan observations that contain neither collateral nor covenant, as they do not require any legal provision for monitoring purpose and are more likely to represent unconstrained borrowing compared to loans with loans that contain collateral and/or covenants.

The results are presented in Table 7, and confirm that there is a substitution between collateral-based and earnings-based borrowing. Column 1 uses *Relation* and column 2 uses and *Duration* as the relationship strength proxy, respectively, and the findings remain consistent regardless of the proxies used. In a credit relationship between a constrained borrower

Table 7: Effect of Covenant Incidence on Collateral Incidence

	(1)	(2)
$\widehat{\text{Covenant}}$	-0.1089**	-0.0723**
	(-2.33)	(-2.53)
Deal controls	Yes	Yes
Firm controls	Yes	Yes
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Constrained sample	Yes	Yes
Observations	2325	2325
Adj. R-squared	0.8442	0.8444

Notes: This table shows OLS estimates of the effects of covenant incidence on collateral incidence in a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 2004Q4–2009Q3. Dependent variable is a dummy variable that equals one if at least a tranche of the loan deal is secured. Column 1 uses *log(Relation)* as a measure of relationship strength, and column 2 uses *log(Duration)* as the a measure of relationship strength. $\widehat{Covenant}$ is the predicted values from IV estimation presented in Table 6. Control variables are the same as in Table 4. OLS regressions are run on a subsample of loans with covenant and/or collateral (constrained firm sample). Both specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

and a lead lender, covenant use is negatively correlated with collateral use. Controlling for all other firm and deal-level characteristics including loan amount and interest spread, because both collateral and covenants can serve as monitoring devices, the increase in covenant use can reduce the need for collateral requirements. Since the incidence of covenant increases with relationship length, the results indicate that, as the relationship develops, earnings-based credit gradually replaces collateral-based credit.

To test the prediction that this substitution as a result of credit relationship increases credit availability for firms, I estimate specification (11) with $Loan\ Amount_{i,j,t}$ as the dependent variable, where $Loan\ Amount_{i,j,t}$ is the deflated real loan amount of a loan incurred by firm i in time t. Additionally, collateral dummy, covenant dummy, and the interaction of both are included as independent variables. Intuitively, comparing the coefficients on the covenant dummy and the collateral dummy is equivalent to comparing credit availability between loans with only collateral and loans with only covenants, which aligns with the theoretical setting. Since the main focus is on whether the substitution from collateral-based to earnings-based borrowing increases credit availability in a relationship, I estimate this on a subsample of loans with credit relationships (i.e., *Relation* > 1, or *Duration* > 0).

The results are presented in Table 8, and support the prediction that covenant use increases credit availability more than collateral use. In these columns, *Relation* and *Duration* are used as relationship proxies in columns 1 and 2, respectively. Results show that loan amount is positively correlated with covenant incidence, while it is not the case for loans that contain only collateral requirement. When taking collateral incidence as given, the incidence of covenant increases loan amount for borrowers. The results remain consistent across both measures, confirming the robustness of the findings.

The findings also highlights the limitations of covenant-lite loans. These loans, which impose fewer or no covenant restrictions, grant borrowers more flexibility while offering less protection for creditors. Their rapid expansion has played a major role in the growth of the loan market in recent years, particularly during the COVID-19 pandemic and the subsequent recovery period. While covenant-lite loans reduce the risk of technical defaults, thereby offering greater flexibility to borrowers, Table 8 shows that such benefit comes at a cost of reduced credit availability. This finding has important policy implications, suggesting that increasing lender competition in offering loans with ever less restrictive terms to borrowers may adversely affect overall credit supply.

Overall, the empirical results provide evidence of the following mechanism: the incidence of earnings-based borrowing increases in a credit relationship due to bank learning, leading to a substitution from collateral-based credit to earnings-based credit, which offers firms greater credit availability.

5.2.4 Do lenders learn?

An important mechanism in the model presented in Section 4 is bank learning: being in a credit relationship allows the lender to learn about the borrower's private information, and updates its belief dynamically. thereby reducing information asymmetry, and increasing borrower's access to earnings-based credits and relaxing overall borrowing constraints.

Table 8: Covenant, Collateral, and Credit Availability

	(1)	(2)
log(Relation)	0.0546*	
	(1.91)	
log(Duration)		0.0407*
		(1.69)
Collateral	0.0296	0.0250
	(0.63)	(0.52)
Covenant	0.2809***	0.2825***
	(8.85)	(8.78)
Collateral × Covenant	0.1091**	0.1084**
	(2.10)	(2.07)
Deal controls	Yes	Yes
Firm controls	Yes	Yes
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Relationship sample	Yes	Yes
Observations	8862	8627
Adj. R-squared	0.8229	0.8195

Notes: This table shows OLS regressions of loan amount as a measure of credit availability on different combinations of contractual device choices in a sample of U.S. Dollar denominated loans incurred by US non-financial corporations from 1990–2019. *Collateral* is a dummy variable that equals one if at least a tranche of the loan deal is secured. *Covenant* × *Collateral* is the interaction of *Covenant* dummy and *Collateral* dummy. All other variables are defined in Table 4. Column 1 uses *Relation* as a proxy for relationship strength, and column 2 uses *Duration* as a proxy for relationship strength. Both specifications are run on a subsample of loans which are not the first interaction between any borrower-lender pair since the start date of the dataset. All specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

However, directly testing whether a lender learns in a credit relationship is challenging, as it requires access to sensitive and proprietary information, including the borrower's private data and the lender's loan pricing and risk assessment models. Due to data limitations, I adopt an indirect approach, testing whether a firm's information opacity influences the impact of relationship strength on covenant use. Intuitively, if lenders do learn, interacting with a more informationally opaque firm would result in more substantial updates to their beliefs, leading to more significant adjustments in contractual terms.

I follow Prilmeier (2017) and divide the sample into small and large borrower groups, based on whether real total assets are below or above the sample median, and run regressions on each subsample. Smaller borrowers are typically more informationally opaque. Additionally, I restrict the analysis to constrained borrowers that face contractual restrictions (i.e. loans with collateral and/or covenant requirements), who are more likely to benefit from relationships according to the model's predictions. Results are presented in Table 9, where specifications 1 and 2 compare small and large borrowers using *Relation* as a proxy for relationship intensity, while specifications 3 and 4 make the same comparison using *Duration* as an alternative relationship intensity proxy. I find that smaller and more informationally opaque borrowers benefit more from credit relationships in terms of increased access to earnings-based credits, providing indirect empirical evidence that lenders learn from these relationships. Such finding is robust across both proxies for relationship intensity.

To address the concern about potential omitted variable bias or reverse causality, I sue an IV approach by augmenting specification (11) and including an interaction term between relationship measure and a small borrower dummy, and instrumenting relationship measure and the interaction term by the failure/exposure dummy and its interaction with small borrower dummy:

$$COV_{i,j,t} = \beta_{Rel} Rel_{i,t} + \beta_{RXS} Rel_{i,t} \times Small_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}. \quad (14)$$

Second-stage results are presented in Table 10. Columns 1 and 2 use *Relation* and *Duraton* as measures of relationship strength, respectively. For both measures, the coefficients on the interaction terms between relationship measure and the small borrower dummy are positive and statistically significant. This confirms that the effects of relationship on covenant incidence are indeed stronger for smaller and more informationally opaque borrowers. The IV estimates are consistent with OLS estimates. The Cragg-Donald F statistics are above the Stock & Yogo (2005) critical value, rejecting instrument weaknesses.

Table 9: Effects of Relationship by Firm Size: OLS

	(1) Covenant	(2) Covenant	(3) Covenant	(4) Covenant
log(Relation)	0.0286**	0.0230**		
	(2.34)	(2.38)		
log(Duration)			0.0202**	0.0145*
			(2.36)	(1.92)
log(Total Assets)	-0.0091	-0.0359**	-0.0082	-0.0350**
	(-0.58)	(-2.45)	(-0.52)	(-2.39)
Tangibility	-0.0308	0.0613	-0.0331	0.0625
	(-0.34)	(0.72)	(-0.36)	(0.73)
log(1+Coverage Ratio)	0.0058	-0.0010	0.0059	-0.0010
	(1.02)	(-0.10)	(1.04)	(-0.11)
Market-to-Book	0.0000***	0.0013	0.0000***	0.0013
	(2.87)	(1.46)	(2.93)	(1.45)
Current Ratio	-0.0078	-0.0038	-0.0079	-0.0036
	(-1.65)	(-0.54)	(-1.68)	(-0.51)
Leverage	0.0012	-0.0712	0.0034	-0.0690
	(0.02)	(-1.08)	(0.06)	(-1.05)
Rating	-0.0007	-0.0045	-0.0005	-0.0044
	(-0.07)	(-1.05)	(-0.05)	(-1.02)
No Rating	0.0204	-0.0501	0.0228	-0.0490
	(0.15)	(-0.99)	(0.17)	(-0.97)
log(Loan Amount)	0.0592***	0.0519***	0.0595***	0.0522***
	(6.48)	(6.40)	(6.52)	(6.45)
log(Maturity)	0.0132	-0.0111	0.0133	-0.0112
	(1.25)	(-1.38)	(1.26)	(-1.39)
Spread	-0.0001	-0.0004***	-0.0001	-0.0004***
	(-0.83)	(-4.40)	(-0.79)	(-4.42)
Constant	0.7236***	0.9439***	0.7212***	0.9414***
	(4.89)	(10.48)	(4.87)	(10.42)
Firm effects	Yes	Yes	Yes	Yes
Lead lender(s) effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Constrained sample	Yes	Yes	Yes	Yes
Small borrower	Yes	No	Yes	No
Observations	6112	5623	6112	5623
Adj. R-squared	0.7163	0.6071	0.7163	0.6068

Notes: This table shows OLS regressions of covenant use on relationship intensity, firm's pledgeable assets and control variables, by firm size, for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Firms with less real total assets than the sample median of each year are classified as small borrowers. Specifications 1 and 3 are run on a subsample of loans by small borrowers, and specifications 3 and 4 is run on a subsample of loans by large borrowers. Specifications 1 and 2 use *Relation* as a proxy for relationship intensity, and specifications 3 and 4 use *Duration* as a proxy for relationship intensity. All specifications are run on a subsample of loans with covenant and/or collateral (constrained firm sample), controlling for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Effects of Relationship by Firm Size: IV

	(1)	(2)
log(Relation)	-0.1411	
	(-0.97)	
log(Relation) ×Small	0.2448*	
	(1.71)	
log(Duration)		-0.0701
		(-0.45)
log(Relation) ×Small		0.1493*
		(1.67)
Deal controls	Yes	Yes
Firm controls	Yes	Yes
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Constrained sample	Yes	Yes
Observations	2166	2166
Cragg-Donald F	17.81	9.87
Kleibergen-Paap rk F	17.11	5.98
Stock-Yogo (2005) crit.	7.03	7.03

Notes: This table shows 2SLS estimates of the effects of relationship strength on covenant incidence in a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 2004Q4–2009Q3. *Small* is a dummy variable that equals one for a borrower with less real total assets than the sample median of each year. All other variables are defined in Table 4. Column 1 uses *Relation* as a proxy for relationship strength, and column 2 uses *Duration* as a proxy for relationship strength. Both specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. Results reported are the second-stage results of IV estimations. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

6 Conclusion

This paper studies the effect of credit relationships on loan contractual device choices between collateral and covenants. Empirical evidence shows that loan covenants substitute for collateral requirements, and their use increases over the duration of a credit relationship. I develop a model with limited commitment and information asymmetry to explain a credit relationship channel through which bank learning in a relationship reduces information asymmetry, thereby increasing feasibility of use of covenants in loan contracts and hence improving access to credit. The model predicts that covenant use is more pervasive as the credit relationship strengthens and for more constrained firms, that covenants can be substituted for collateral as contractual devices, and that covenant use improves credit access. All of these predictions are confirmed by empirical findings. Furthermore, empirical evidence supports that lenders learn from these relationships.

This paper has the following policy implications and insights for further research. First, it presents new evidence of the economic benefits of credit relationships on improving access to credit. Policies targeting information and accounting transparency can foster relationship formation, and thus relax credit constraints. Second, substitution between collateral and covenants as contractual devices has direct implications for whether credit is collateral-based or earnings-based, and is crucial for how credit constraints should be modeled in standard macroeconomic modeling. Finally, credit relationships can be a non-trivial driver in the dynamics of credit constraints, not only in terms of credit availability, but also dependent on the collateral-based or earnings-base nature of credit.

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A Solutions and proofs

A.1 Proof of Lemma 2

Suppose any bank's arbitrary belief such that

$$\mathbb{E}_0^a \mid \text{default}) \equiv \tilde{\mu} > 0. \tag{15}$$

Suppose for a given level of n_0, there exist a value of productivity $\underline{\hat{a}}$ and hence $\hat{b}_1^\pi$ such that it is indifferent between a contract with collateral requirement and one with covenant requirement, assuming bank had perfect information on productivity:

$$(1+r)\hat{b}_1^\pi \equiv \eta \underline{\hat{a}} f(k_1) = (1+r) b_1^k. \tag{16}$$

If bank's initial belief is one such that $\tilde{\mu} < \underline{\hat{a}}$, no firm will pledge control right as $b_1^\pi < b_1^k$. Bank should update its belief and $\mathbb{E}_0(a \mid \text{default}) \to 0$. If initial $\tilde{\mu} \geq \underline{\hat{a}}$, any firm will choose to pledge control right as $b_1^\pi \geq b_1^k$. However, any firm with $a < \tilde{\mu}$ has incentive to voluntarily default, as a firm retains more if it defaults than what it has to repay in period 1:

$$(1+r) b_1^\pi = \eta \mathbb{E}_0(a \mid \text{default}) f(k_1) > \eta a f(k_1). \tag{17}$$

Bank will have to update its belief and eventually $\mathbb{E}_0(a \mid \text{default}) = \mathbb{E}_0(a \mid a < \tilde{\mu}) \to 0$.

The analysis is repeated for any level of n_0 and same result applies. Resulting borrowing constraint under loan contract with covenant requirement becomes $b_1^\pi \leq 0$.

A.2 Proof of Lemma 3

From firm's budget constraint we have $k_{t+1} = b_{t+1} + n_t$ is increasing in firm's net worth n_t. Hence, the limit of collateral-based credit supply is increasing n_t, and $\underline{a}^k(n_t)$ is increasing in n_t following Lemma 4.

The threshold stated in Lemma 3, $\underline{a}^\pi(n_1^*)$, solves $\bar{b}_2^\pi = \bar{b}_2^k$. We hence have

$$\underline{a}^\pi(n_1^*) = \frac{\theta(1-\delta)}{\eta} \frac{k^*(n_1^*)}{f(k^*(n_1^*))},$$

where the second term on the right-hand side is the inverse of average product of capital. Since average product of capital is decreasing in capital for a production function that exhibits decreasing returns to scale (i.e. it is concave), and $k^*(n_1^*)$ is increasing in n_1^*, we have that $\underline{a}^\pi(n_1^*)$ is increasing in n_1^*.

A.3 Model solutions

I solve firm's problem in (9) backwards. Firm's production function is assumed to be $y_t = af(k_t) = ak_t^\alpha$, where $\alpha \in (0,1)$.

In period 2, after repaying outstanding loan, firm chooses optimal level of dividends to be paid out to the owner for consumption, and firm's resource constraints is given by:

$$d_2 \leq n_2^* \equiv af(k_2^*) + (1-\delta)k_2^* - (1+r)b_2^*, \tag{18}$$

and optimal decision of dividend payout is hence $d_2^* = n_2^*$. Firm's optimization problem is hence choosing k_2 and b_2 in period 1 that maximizes n_2:

$$\max_{b_2,k_2} n_2 = af(k_2) + (1-\delta)k_2 - (1+r)b_2, \tag{19}$$

subject to borrowing constraint (5), and budget constraint (7). As the credit relationship continues from start of period 1, the bank is able to fully observe firm's productivity. Let firm's period-1 post-production net worth (i.e. investable/pledgeable assets at the end of period 1) be $n_1^* \equiv af(k_1^*) + (1-\delta)k_1^* - (1+r)b_1^*$, and we have:

$$b_2^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}} - n_1^*, \max\{\frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_1^*, b_2^\pi(n_1^*)\}\right\}, \tag{20}$$

where $b_2^\pi(n_1^*)$ solves $(1+r)b_2^\pi(n_1^*) = \eta af(b_2^\pi(n_1^*) + n_1^*)$. Intuitively, if firm's demand for borrowing is less than the supply of borrowing by the bank, the firm is unconstrained and is able to borrow up to its demand. If demand exceeds supply, the firm can only borrow up to its maximum credit constraint between the two types of contracts. If the firm is constrained under one type of contract while unconstrained under the other type, it will optimally select into the contract that allows for optimal leverage. Resulting capital choice is given by:

$$k_2^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}}, \max\{\frac{1+r}{(1+r)-\theta(1-\delta)}n_1^*, b_2^\pi(n_1^*) + n_1^*\}\right\}. \tag{21}$$

Under optimality conditions, resulting n_2^*:

$$n_2^* = af(k_2^*) + (1-\delta)k_2^* - (1+r)b_2^* = af(k_2^*) - (r+\delta)k_2^* + (1+r)n_1^*, \tag{22}$$

and:

$$\frac{dn_2^*}{dn_1^*} = [af'(k_2^*) - (r+\delta)]\frac{dk_2^*}{dn_1^*} + (1+r) > 0, \tag{23}$$

since $af'(k_2^*) - (r+\delta) \geq 0$ with strict inequality when firm is constrained, and $\frac{dk_2^*}{dn_1^*} \geq 0$ with strict inequality when firm is constrained. Thus, firm's period-0 problem is equivalent to choosing k_1 and b_1 that maximizes n_1:

$$\max_{b_1} n_1 = af(k_1) + (1-\delta)k_1 - (1+r)b_1, \tag{24}$$

subject to borrowing constraint with only collateral requirement $(1+r)b_1 \leq \theta(1-\delta)k_1$, and budget constraint (6). Optimal borrowing and capital choices are given by:

$$b_1^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}} - n_0, \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_0\right\}, \tag{25}$$

and

$$k_1^* = \min\left\{ (\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}}, \frac{1}{(1+r)-\theta(1-\delta)} n_0 \right\}. \tag{26}$$

A.4 Deriving thresholds

In period 0, from (25), let $a = \underline{a}^k(n_0)$ be the level of productivity such that firm's credit demand is equal to the maximum level of credit supply under a loan contract with collateral requirement:

$$\left\{ \frac{\alpha \underline{a}^k(n_0)}{r+\delta} \right\}^{\frac{1}{1-\alpha}} - n_0 = \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)} n_0, \tag{27}$$

which solves for

$$\underline{a}^k(n_0) = \left(\frac{r+\delta}{\alpha} \right) \left(\frac{(1+r)n_0}{1-\theta(1-\delta)} \right)^{1-\alpha}. \tag{28}$$

Above such threshold, credit demand exceeds supply, and the firm is credit-constrained, and vice versa.

In period 1, from (20), $\underline{a}^p(n_1^*)$ is solved from the case when supply of credit with collateral requirement is equal to supply with covenant requirement:

$$\frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)} n_1^* = b_2^\pi(n_1^*, \underline{a}^p(n_1^*)). \tag{29}$$

If the firm borrows with a loan contract with collateral requirement, productivity threshold above which it is constrained $\underline{a}^k(n_1^*)$ is solved from:

$$\left\{ \frac{\alpha \underline{a}^k(n_1^*)}{r+\delta} \right\}^{\frac{1}{1-\alpha}} - n_1^* = \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)} n_1^*, \tag{30}$$

which is identical to the period-0 case if $n_0 = n_1^*$. If the firm borrows with a loan contract with covenant requirement, productivity threshold above which it is constrained $\underline{a}^\pi(n_1^*)$ is solved from:

$$\left\{ \frac{\alpha \underline{a}^\pi(n_1^*)}{r+\delta} \right\}^{\frac{1}{1-\alpha}} - n_1^* = b_2^\pi(n_1^*, \underline{a}^\pi(n_1^*)). \tag{31}$$

A.5 An Extension with Endogenous Spread

This section relaxes the assumption that bank lends to the firm at no spread, and allows the bank to choose a level of spread. Overall, endogenously chosen spread by the bank is either 0, which is identical to original assumption, or does not affect firm's access to credit and hence does not alter the main results.

I first consider the case of borrowing with collateral constraint. Suppose bank's funding cost is r, and charges an interest rate r_t^k which can be different from its funding cost. Firm's no voluntary default condition (formerly 1) becomes:

$$(1+r_t)b_t^k \leq (1-\delta)k_t. \tag{32}$$

Denote bank's period-t expected probability of firm default on collateralized debt in period $t+1$ as p_t^k. Bank's break-even condition is given by:

$$(1-p_t^k)(1+r_{t+1}^k)b_{t+1}^k + p_t^k\theta(1-\delta)k_{t+1} = (1+r)b_{t+1}^k, \tag{33}$$

where the first part of left-hand side of the equation is the expected value of repayment, and the second part is the expected value of collateral recovery, and the right-hand side is the required returns to depositors.

If the bank chooses a debt limit that satisfies (32), i.e. firm will not voluntarily default, then $p_t^k = 0$ and (33) implies $r_t^k = r$. If the bank chooses a debt limit that violates (32), firm will always choose to default and $p_t^k = 1$. (33) becomes $(1+r)b_{t+1}^k = \theta(1-\delta)k_{t+1}$, which is identical to the collateral borrowing constraint in the main model. In this case, firm's access to credit is determined by bank's funding cost as well as the recovery value of collateral, and is not dependent on the spread that bank charges. The only role that the spread plays is that bank acts irrationally and charges a sufficiently high r_t to induce firm default. In such case, the spread has to satisfy $\theta(1+r_t^k) > (1+r)$. Such contract can be replicated by bank choosing $r_t^k = r$ and $(1+r)b_{t+1}^k = \theta(1-\delta)k_{t+1}$, allowing same firm's access to credit and motivating firms not to default, while bank still breaks even. Therefore, this irrational equilibrium is of little economic meaning and I exclude from this discussion. Overall, with collateral borrowing constraint, bank either charges no spread, or irrationally charges a high spread only to elicit default, while having no material impact on firm's access to credit.

If a firm borrows with covenant, Firm's no voluntary default condition (formerly (2)) becomes:

$$(1+r_t^\pi)b_t^\pi \leq \eta\pi_t. \tag{34}$$

Denote bank's period-t expected probability of firm default on collateralized debt in period $t+1$ as p_t^π. Bank's break-even condition becomes:

$$(1-p_t^\pi)(1+r_{t+1}^\pi)b_{t+1}^\pi + p_t^\pi\eta\mathbb{E}_t(\pi_{t+1} \mid \text{default}) = (1+r)b_{t+1}^\pi \tag{35}$$

I first focus on the period-1 problem, in which bank has perfect information about firm's productivity. If bank offers a contract such that (34) is satisfied, then probability of default is zero, and according to bank's break-even constraint 35, bank charges no spread. If the contract violates (34), expected probability of default is 1. Same as in the collateral case, firm's access to earnings-based credit is determined by bank's funding cost and the pledgeable value of earnings, not by the spread charged by the bank. The bank charges a spread only to induce default. Ultimately, in equilibrium, firm's access to earnings-based credit is unaffected by the spread that bank charges, and this is consistent with the main results of the model.

I turn on the period-0 problem, in which information asymmetry is present. The period-0 expected probability of default is hence given by $p_0^\pi = \Phi(\bar{a^\pi})$, where $\bar{a^\pi} \equiv \frac{(1+r_1^\pi)b_1}{\eta(n_0+b_1^\pi)^\alpha}$.

Bank's period-0 problem is hence:

$$\max_{r_1^\pi, b_1^\pi}(1-\Phi(\bar{a^\pi}))(1+r_1^\pi)b_1^\pi + \Phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da - (1+r)b_1^\pi, \tag{36}$$

subject to break-even constraint. First order condition with respect to r_1^π is given by:

$$\begin{aligned}(1-\Phi(\bar{a^\pi}))b_1^\pi - \frac{\partial \bar{a^\pi}}{\partial r_1^\pi}\phi(\bar{a^\pi})(1+r_1)b_1^\pi \\ + \frac{\partial \bar{a^\pi}}{\partial r_1^\pi}\phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da + \Phi(\bar{a^\pi})\eta\bar{a^\pi}b_1^\pi\phi(\bar{a^\pi}) = 0,\end{aligned} \tag{37}$$

And first order condition with respect to b_1^π is given by:

$$\begin{aligned}(1-\Phi(\bar{a^\pi}))(1+r_1^\pi) - \frac{\partial \bar{a^\pi}}{\partial b_1^\pi}\phi(\bar{a^\pi})(1+r_1^\pi)b_1^\pi + \frac{\partial \bar{a^\pi}}{\partial b_1^\pi}\phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da \\ + \Phi(\bar{a^\pi})\eta(\frac{\partial \bar{a^\pi}}{\partial b_1^\pi}\bar{a^\pi}(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi}) + \int^{\bar{a^\pi}} \alpha a(n_0+b_1^\pi)^{\alpha-1}\phi(\bar{a^\pi})da) = 1+r.\end{aligned} \tag{38}$$

It is challenging to solve for the optimal behaviours algebraically, and I turn to numerical methods. I calibrate the model with suitable parameters, including $\Phi(a) = U[0,2]$, $\theta = \eta = 0.8$, $r = 0.02$, $\delta = 0.1$, $\alpha = 0.33$, and $n_0 = 0.3$, and could not find any interior solution with default threshold $\bar{a^\pi} < a_{max} = 2$. This implies that firms always default when spread and loan amounts are endogenously set by the bank, eventually leading to breakdowns of earnings-credit access with information asymmetry. This is due to an adverse feedback loop between spread and loan amount.

For firms with n_0, the maximum amount they could borrow with collateral is fixed and do not vary with productivity. In order to incentivize 'good' borrowers, who are constrained and are willing to pay a spread to borrow more with covenants, the loan amount offered by an earnings-based contract must be higher than that offered by a collateral-based contract. Suppose that bank offers such contract at its funding cost, then low-productivity ('bad') borrowers have incentives to pretend that they are 'good' borrowers, but will always default after production as the opportunity cost of default is much lower. This incurs losses on the bank, and in order to break-even, bank has to raise spread, since lowering loan amount would lead to a complete default equilibrium when all 'good' borrowers do not choose earnings-based contracts. As spread increases, 'good' borrowers borrow less, which reduces bank profit from repayment, and bank has to further increase loan amount. Increasing loan amount increases loss per loan extended to a 'bad' borrower, and according to (34), it also increases the probability that a borrower defaults, resulting in further loss. Eventually, this adverse spiral leads to a complete default equilibrium, and earnings-based credit access is fully shut down, same as the main model with no spread.

To further illustrate this, I augment the model slightly to show that how learning that that reduces information asymmetry can improve access to earnings-based credit to constrained firms in the context of endogenous spread decision.

Consider now that there are two firms with different productivities, and $a_H > a_L$. Both firms have same initial net worth n_0, which is very small such that both firms are credit constrained if they were to borrow with collateral. In the presence of information asymmetry, bank does not know which firm has high or low productivity. Bank offers an earnings-based contract with endogenously chosen spread r_1^π and loan amount b_1^π to both firms.

Case 1: No default equilibrium: contract is set such that neither firm defaults. Bank's break-even constraint (35) implies that $r_1^\pi = r$ as default probability is zero. A contract will need to satisfy no-default constraints $(1+r)b_1^\pi \leq \eta a_L(n_0 + b_1^\pi)^\alpha < \eta a_H(n_0 + b_1^\pi)^\alpha$. Credit availability is thus determined by the lower bound of productivity in the firm population. When information asymmetry is reduced in a repeated interaction, bank is able to identify firm's productivity, and will be able to offer more credit availability to firm H, which is more credit constrained, while firm L will not see any increase in credit availability.

Case 2: Both default equilibrium: contract is set such that both firms default. Such contract requires $(1+r_1^\pi)b_1^\pi > \eta a_H(n_0 + b_1^\pi)^\alpha > \eta a_L(n_0 + b_1^\pi)^\alpha$. Bank's break-even condition becomes: $(1+r)b_1^\pi = \eta \frac{a_H + a_L}{2}(n_0 + b_1^\pi)^\alpha$. Now, access to earnings-based credit is determined by the population average productivity and bank's funding cost, while the spread that bank charges only plays the role in inducing default. When information asymmetry is reduced, more constrained firm H can receive more credit availability, while less constrained firm L receives less credit availability. The overall investment (and hence credits) and output should increase, as the marginal product of capital of H is higher than L, and removing information friction improves credit allocation.

Case 3: Mixed equilibrium: H repays and L defaults. Bank's expected profit is now:

$$0.5\eta a_L(n_0 + b_1^\pi)^\alpha + 0.5(1+r_1^\pi)b_1^\pi - (1+r)b_1^\pi. \tag{39}$$

Bank's optimality condition is choosing b_1^π that maximizes the profit function, while then choosing r_1^π such that it breaks even. First order condition with respect to b_1^π is given by:

$$b_1^\pi = \left(\frac{\alpha \eta a_L}{1 + r - (r_1^\pi - r)}\right)^{\frac{1}{1-\alpha}} - n_0. \tag{40}$$

Such mixed equilibrium only exists when optimal choices of b_1^π and r_1^π satisfy $\eta a_L(n_0 + b_1^\pi)^\alpha < (1 + r_1^\pi)b_1^\pi \leq \eta a_H(n_0 + b_1^\pi)^\alpha$, and may not exist for certain parameter values. The bank's maximization problem can be regarded as bank maximizing firm L's profit, given its funding cost subsidized by a 'tax' levied on the more productive firm H. Firm H's credit access is still determined by the lower bound of population productivity. Hence as information asymmetry is reduced, firm H will be able to access cheaper and more credits.

Overall, the extension of allowing endogenous credit spread choice does not alter the main results that bank learning which reduces information asymmetry increases access to earnings-based credits for constrained firms.

A.6 Relaxing Assumption on Collateral vs. Covenant Choice

This section considers the case of relaxing the assumption that firm can only borrow with collateral or covenant, and allowing for both.

Borrowing constraint in (5) becomes:

$$b_{t+1} = b_{t+1}^k + b_{t+1}^\pi \leq \frac{1}{1+r}\left(\theta^k(1-\delta)k_{t+1} + \eta \mathbb{E}_t(\pi_{t+1} \mid \text{default})\right). \tag{41}$$

In period 0, as shown in Appendix A.1, with information asymmetry, bank forms beliefs

$\mathbb{E}_0(a \mid \text{default}) = 0$, and we still have $\mathbb{E}_0(\pi_1 \mid \text{default}) = 0$. Thus, in period-0 contracting, the nonrelationship case, firm's access to earnings-based credits is still shut down, and firm still faces a collateral-based constraint. Therefore, period-0's firm problem remains the same as when only collateral or covenant is allowed, and solutions are the same as ones derived in Appendix A.3.

In period 1, when the firm and the bank are in a repeated interaction, bank is able to fully observe the firm's cash flow and hence productivity. Bank updates its belief and $\mathbb{E}_1(a \mid \text{default}) = a$. Resulting period-1 borrowing constraint becomes:

$$b_2 \leq \frac{1}{1+r}\left(\theta^k(1-\delta)k_2 + \eta a k_2^\alpha\right). \tag{42}$$

Firm's maximization problem in period 1 becomes maximizing (19) subject to borrowing constraint (42) and a budget constraint $n_1^* + b_2 \geq k_2$. Note that since $\eta > 0$, borrowing constraint in a relationship (42) is still less binding than a collateral constraint if the firm were not in a relationship. Hence for a given n_1^*, a firm with $a > a^k(n_1*)$ would have been constrained if not a relationship, while if it is in a relationship, it will be able to pledge future cash flow in addition to collateral in order to borrow more. On the other hand, for a firm with productivity marginally higher than $a^\pi(n_1*)$, the firm is not credit constrained, since compared to the original case, now the firm is able to pledge collateral in addition to future cash flow for more credit availability. This implies that the productivity threshold above which the firm with n_1^* becomes credit-constrained will be higher than $a^\pi(n_1*)$. However, this does not affect the main conclusions, as this is merely a quantitative change.

Overall, main results and conclusions do not alter qualitatively when relaxing the assumption that the firm would only be able to borrow with collateral or covenant.

A.7 Parameter calibration

Table 11 presents value I set for structural parameters of the model. The first two parameters are standard in US data. I set loan interest rate to match the average in the DealScan sample, and collateral constraint tightness to match the average debt-to-asset ratio of borrowers facing collateral constraints in Compustat-DealScan data.

Table 11: Model Parameterization

Parameter	Value	Details
α Capital share of output	0.33	Standard value for US data
δ Capital depreciation rate	0.1	Standard value for US annual data
r Loan interest rate	5.32%	Avg. loan rate in DealScan
θ Collateral constraint tightness	0.41	Avg. debt/asset ratio in Compustat-Dealscan

A.8 Relaxing Assumption 1

Suppose that the bank has less bargaining power (hence lower η) such that:

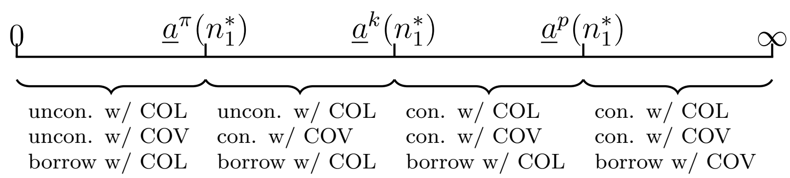
$$\frac{\alpha}{r+\delta} > \frac{\eta}{\theta(1-\delta)},$$

which can be rearranged as $\frac{\text{MPK}}{\text{User cost of capital}} > \frac{b^{\pi}}{b^{k}}$, indicating that loans with collateral provide larger credit availability than loans with covenant for a constrained firm. It follows that:

$$\underline{a}^{p}(n_1^*) > \underline{a}^{k}(n_1^*) > \underline{a}^{\pi}(n_1^*). \tag{43}$$

Figure 6 presents the optimal contract choices, and whether a firm is credit-constrained under each type of contracts for firms of different productivity levels in a relationship. Compared to non-relationship benchmark, firms with $a \geq \underline{a}^{p}(n_1^*)$ take up contracts with covenant requirement, and their borrowing constraints are relaxed as a result of a continuing relationship.

Figure 6: (More efficient) Collateral vs. covenant in credit relationship



B Data and measurement

B.1 Additional summary statistics of DealScan Sample

Table 12 provides additional summary statistics that describe the DealScan sample.

Table 12: Summary Statistics for DealScan Data

	Loan Amount (Millions 2017 USD)	Maturity (Months)	Spread (Drawn Spread bps)
Mean	417.61	42.37	193.43
Standard Deviation	1184.69	65.69	176.33
25th Percentile	52.88	15	37.50
Median	136.26	38	175
75th Percentile	376.45	60	300
Observations	60322	60322	60322

Notes: This table shows additional summary of selective loan characteristics from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. All variables are defined in Table 1.

Table 13 provides a summary of deal purposes in the DealScan sample.

Table 13: Frequency of deal purpose

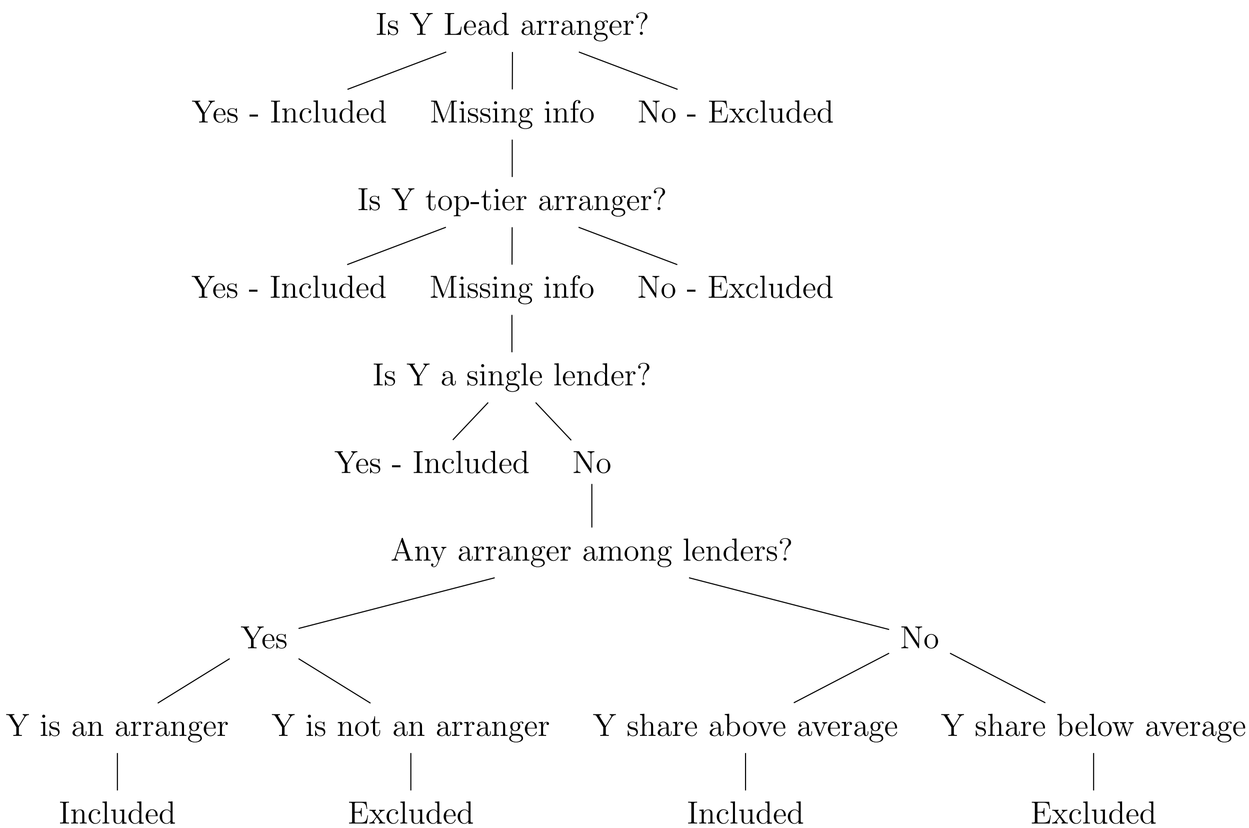
Deal Purpose	Frequency(%) Equal-Weighted	Frequency(%) Volume-Weighted
General Purpose	43.81	39.80
Working capital	12.30	6.75
Refinance	11.40	8.32
Takeover	6.52	16.90
Acquisition	6.06	5.22
Leveraged Buyout	5.30	5.73
Commercial paper backup	3.70	7.55
Dividend Recapitalization	1.60	1.48
Real estate loan	1.55	0.45
Recapitalization	1.35	0.64
Observations	60322	60322

Notes: This table shows summary of deal purposes from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019.

B.2 Identifying relationship lender in a loan

For a loan-level observation of borrower X and lender Y:

Figure 7: Road map to identify borrower-lender relationship pair



B.3 Summary statistics by relationship sort (volume-weighted)

Table 14 replicates Table 2 and shows volume-weighted averages of loan characteristics for different relationship groups.

Table 14: Summary of loan characteristics by relationship strength (volume-weighted)

Panel A: Interaction Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Loan Amount (millions 2017 USD)	417.61	277.07	485.62	834.05
Maturity (months)	43.11	44.67	43.45	41.10
Spread (drawn spread bps)	165.39	185.20	173.07	137.57
Collateral (frequency)	36.66%	41.59%	38.97%	29.48%
Covenant (frequency)	36.55%	33.73%	37.43%	39.27%
No. of Prev. Interactions	1.59	0	1	3.82
Observations	60322	37741	11767	10814

Panel B: Duration Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Loan Amount (millions 2017 USD)	417.61	280.79	473.61	867.59
Maturity (months)	43.11	44.88	41.78	41.78
Spread (drawn spread bps)	165.39	187.07	149.36	148.91
Collateral (frequency)	36.66%	42.09%	36.68%	30.06%
Covenant (frequency)	36.55%	34.03%	36.81%	39.46%
Duration (years)	3.09	0	1.51	7.82
Observations	60322	38525	11518	10279

Notes: This table shows summary of selective loan characteristics from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. All statistics are sample averages weighted by loan volume. Two relationship strength proxies are used: *No. of Previous Interactions*, and *Duration*. Relationship strengths are sorted into three subgroups: Low, Medium, and High Relationship groups. The Low group includes all observations where the relationship proxy equals zero. The Medium group includes all observations where the relationship proxy is greater than zero but below the median of observations with a positive relationship proxy. The High group includes all observations where the relationship proxy is greater than zero and above the median of observations with a positive relationship proxy. Panel A and B present the summaries with relationship group sorted by *No. of Previous Interactions* and *Duration* respectively.

B.4 Mean differences in summary statistics by relationship sort

Table 15 extends Table 2 and shows differences in summary statistics acorss different relationship categories.

Table 15: Summary of loan characteristics by relationship (equal-weighted differences)

Panel A: Interaction Sort	M-L	H-M	H-L
Loan Amount	208.55***	348.43***	556.98***
(millions 2017 USD)			
Maturity	0.15	-0.62	-0.47
(months)			
Spread	-17.61***	-31.56***	-49.18***
(drawn spread bps)			
Collateral	-2.15%***	-8.91%***	-11.06%***
(frequency)			
Covenant	4.91%***	3.73%***	8.65%***
(frequency)			
No. of Prev. Interactions	1***	2.26***	3.26***

Panel B: Duration Sort	M-L	H-M	H-L
Loan Amount	192.81***	393.98***	586.80***
(millions 2017 USD)			
Maturity	-1.60**	2.97***	1.37*
(months)			
Spread	-34.94***	-1.61	-36.55***
(drawn spread bps)			
Collateral	-4.25%***	-6.28%***	-10.54%***
(frequency)			
Covenant	4.73%***	4.28%***	9.01%***
(frequency)			
Duration	1.46***	4.90***	6.36***
(years)			

Notes: This table shows t-tests of mean differences across different relationship strength categories of selective loan characteristics from Refinitiv LPC DealScan for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. All statistics are differences in sample averages weighted by number of loan observations. Two relationship strength proxies are used: *No. of Previous Interactions*, and *Duration*. Relationship strengths are sorted into three subgroups: Low, Medium, and High Relationship groups. The Low group includes all observations where the relationship proxy equals zero. The Medium group includes all observations where the relationship proxy is greater than zero but below the median of observations with a positive relationship proxy. The High group includes all observations where the relationship proxy is greater than zero and above the median of observations with a positive relationship proxy. Panel A and B present the summaries with relationship group sorted by *No. of Previous Interactions* and *Duration* respectively. Column *M-L* shows mean differences between medium and low groups, column *H-M* shows mean differences between high and medium groups, and column *H-L* shows mean differences between high and low groups. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

B.5 Relationship sort in DealScan-Compustat merged sample

Table 16 replicates Table 2 on the DealScan-Compustat merged sample. Findings are consistent.

Table 16: Summary statistics for DealScan-Compustat sample by relationship strength

Panel A: Duration Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Firm Characteristics				
Real Total Assets (bn 2017 USD)	8.42	6.23	7.81	15.29
Real Sales (qtr, bn 2017 USD)	1.25	0.84	1.32	2.29
Real Total Debt (bn 2017 USD)	2.64	2.01	2.45	4.67
Employment (thousands)	17.23	12.51	18.19	28.85
Book Leverage	0.40	0.43	0.36	0.35
Current Ratio	1.97	2.12	1.84	1.76
Market-to-Book Ratio	4.76	5.64	3.90	3.56
Deal Characteristics				
Deal Amount (mn 2017 USD)	514.91	333.75	564.01	1001.99
Maturity (months)	40.98	40.37	40.50	43.20
Interest spread (drawn spread, bps)	172.13	186.51	151.94	149.39
Collateral	48.55&	53.88%	45.62%	36.70%
Covenant	46.84%	46.13%	47.52%	50.83%
Duration (years)	1.62	0	1.95	6.47
Observations	35994	20929	4750	7205

Panel B: Interaction Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Firm Characteristics				
Real Total Assets (bn 2017 USD)	8.42	6.21	9.45	15.61
Real Sales (qtr, bn 2017 USD)	1.25	0.84	1.37	2.80
Real Total Debt (bn 2017 USD)	2.64	1.99	3.00	4.72
Employment (thousands)	17.23	12.42	18.85	34.57
Book Leverage	0.40	0.43	0.36	0.37
Current Ratio	1.97	2.13	1.85	1.63
Market-to-Book Ratio	4.76	5.65	3.66	3.72
Deal Characteristics				
Deal Amount (mn 2017 USD)	514.91	330.00	612.69	1121.66
Maturity (months)	40.98	40.29	42.12	41.25
Interest spread (drawn spread, bps)	172.13	185.39	162.82	134.45
Collateral	48.55&	53.86%	44.87%	33.37%
Covenant	46.84%	46.35%	47.55%	47.29%
No. of Previous Interactions	0.96	0	1.32	5.45
Observations	35994	20381	11208	4405

Notes: This table shows summary of selective loan characteristics from merged DealScan-Compustat sample for a sample of U.S. dollar denominated loans incurred by U.S. non-financial corporations between 1990 and 2019. All statistics are sample averages weighted by number of observations. Two relationship strength proxies are used: *No. of Previous Interactions*, and *Duration*. Relationship strengths are sorted into three subgroups: Low, Medium, and High Relationship groups. The Low group includes all observations where the relationship proxy equals zero. The Medium group includes all observations where the relationship proxy is greater than zero but below the median of observations with a positive relationship proxy. The High group includes all observations where the relationship proxy is greater than zero and above the median of observations with a positive relationship proxy. Panel A and B present the summaries with relationship group sorted by *Duration* and *No. of Previous Interactions* respectively.

B.6 Censored relationship measure

Due to data limitations, it is hard to keep track of details of first interaction and the actual number of interactions between a borrower and a lender. Thus, REL_{it} is likely to be censored. To mitigate this problem, I re-estimate the regression with observations between 2005 and 2019, while generating REL_{it} since 1990. Results are presented in Table 17, and are consistent with previous findings.

Table 17: Relationship and Covenant between 2005 and 2019

	(1)	(2)	(3)	(4)
log(Relation)	0.0336**	0.0338**	0.0340**	0.0354*
	(2.63)	(2.64)	(2.66)	(2.40)
log(Total Assets)	-0.0748***			
	(-3.71)			
log(Current Assets)		-0.0649**		
		(-3.24)		
log(Net PP&E)			-0.0649***	
			(-3.39)	
log(Working Capital)				-0.0181
				(-1.36)
Constant	0.4172***	0.3080**	0.2190*	0.1087
	(3.34)	(2.85)	(2.19)	(1.01)
Firm controls	Yes	Yes	Yes	Yes
Deal controls	Yes	Yes	Yes	Yes
Firm effects	Yes	Yes	Yes	Yes
Lead lender(s) effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Year range	2005-19	2005-19	2005-19	2005-19
Observations	6605	6605	6605	5208
Adj. R-squared	0.5241	0.5237	0.5238	0.5506

Notes: This table shows OLS regressions of covenant use on relationship intensity, firm's pledgeable assets and control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 2005–2019. *Relation* is a measure of relationship intensity, captured by the number of interactions between the borrower-lender pair in a loan deal that has interacted most since the start date of the dataset described in Table 1 (1990Q1). Firm-level controls include *Tangibility*, *Coverage Ratio*, *Market-to-book*, *Current Ratio*, *Leverage*, *Rating*, and *No Rating*. Deal-level controls include *Loan Amount*, *Spread*, and *Maturity*. All variables are defined in Table 4. All specifications control for borrowing firm fixed effects, lead lender(s) fixed effects, year fixed effects at the loan's origination date, and industry fixed effects at the one-digit SIC level. t-statistics adjusted for heteroskedasticity and firm-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.