The London School of Economics and Political Science

Essays on Macroeconomics and Corporate Finance

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A thesis submitted to the Department of Economics of the London School of Economics and Political Science for the degree of Doctor of Philosophy

London, August 2025

Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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I declare that my thesis consists of approximately 28,000 words, excluding graphs, tables, and appendices.

Statement of Inclusion of Previous Work

I can confirm that Chapter 3 is extended from a previous study for the Master of Research (MRes) degree in Economics at the London School of Economics and Political Science, awarded in July 2020.

Abstract

This thesis explores how capital market imperfections influence firm borrowing and macroeconomic outcomes.

Chapter 1 uses U.S. syndicated loan data to show that stronger credit relationships between borrowers and lenders shift borrowing from collateral-based to earnings-based loans. I develop a model of limited commitment and asymmetric information, where repeated interactions allow lenders to learn about borrower quality. As relationships grow, lenders offer covenants linked to earnings in place of collateral, relaxing borrowing constraints. Empirically, I find that covenant use rises and collateral use declines with relationship strength, especially for smaller, more opaque firms, demonstrating a dynamic credit constraint driven by credit relationships.

Chapter 2 examines the long-term shift in U.S. corporate loan contracting from covenant-based to collateral-based borrowing since the late 1990s, coinciding with a secular decline in interest rates. I develop a model in which banks and Nonbank Financial Institutions (NBFIs) differ in funding, regulation, and monitoring capacities. Lower interest rates diminish banks' funding advantage, encouraging NBFI participation through loan securitization. In U.S. syndicated loan data, I show that interest rate-driven NBFI participation is associated with higher collateral incidence and lower covenant incidence. The results reveal a new channel through which monetary conditions influence the nature of firm credit constraints and shock transmissions.

Chapter 3 studies how project heterogeneity interacts with financial frictions to shape credit relationships and aggregate investment. In a model of credit relationships under matching and liquidity allocation frictions, project heterogeneity raises continuation thresholds for low-productivity projects and lowers them for high-productivity projects, causing liquidity–productivity mismatches that amplify capital misallocation. Analytical results show that greater right-skewness in the productivity distribution increases relationship fragility. Temporary increases in the share of high-productivity projects can have prolonged adverse effects on investment, potentially pushing the economy into a no-investment equilibrium.

Acknowledgements

My PhD journey has been filled with both peaks and (mostly) troughs. Along the way, I have been fortunate to receive unwavering support, encouragement, and guidance from many people. I owe a deep debt of gratitude to all who have supported me, without whom this thesis would not have been possible.

Firstly, I am deeply grateful to my supervisor, Francesco Caselli, for his kindness, generosity, and unwavering support. He offered guidance whenever needed, shared his time and knowledge selflessly, and was always ready to help. His patience and encouragement fostered an environment where I could grow both intellectually and personally, and his mentorship has been a constant source of inspiration. I owe much of my growth as a researcher, and as a person, to his guidance, and I will carry the lessons learned from him into the future.

I am also sincerely grateful to my advisor, Maarten De Ridder, for his generosity, insightful advice, and steadfast guidance throughout my PhD. His thoughtful feedback, constructive advice, and encouragement have greatly shaped my research and contributed to my growth as a researcher.

I am grateful to the faculty members at LSE for their guidance and support throughout my PhD journey. I thank Eduard Boehm, Wouter den Haan, Matthias Doepke, Benjamin Moll, Rachel Ngai, Ricardo Reis, Jane Olmstead-Rumsey, Kevin Sheedy, and Alwyn Young for their valuable feedback and encouragement, which have helped me improve my work and expand my perspectives.

I am thankful to my coauthors, Xiaolan Fu and Du Liu, for the opportunity to collaborate and for the many insights I have gained from working with them. I have learned a great deal from their expertise, dedication, and perspectives, and our collaborations have been an important part of my development as a researcher.

I have been fortunate to be surrounded by friends and colleagues at LSE, whose support, encouragement, and good company have made this journey more enjoyable and rewarding.

I am grateful to Maitreesh Ghatak, Peter Mills, Joan Roses, Emma Taverner, and to my supervisor Francesco Caselli, for their kindness, understanding, and support during particularly challenging times. Their generosity and thoughtfulness have meant more to me than words can convey, and I feel fortunate to have had their support along the way. I am also grateful to Shengxing Zhang for his guidance and support at the initial stages of my PhD.

Finally, I am forever grateful to my family and friends for their unconditional love, patience, and belief in me. My deepest thanks go to my parents, whose boundless love and support have given me the freedom to pursue any path in life; to my maternal grandparents, who dedicated their lives to teaching and whose example has been a constant source of inspiration; and above all to my partner, Shan, whose unwavering encouragement, understanding, and companionship have been my greatest source of strength and joy throughout this journey. I am also deeply thankful to my friends, whose encouragement and support have brightened this journey and made it far more enjoyable. Though too many to name individually, each of them has contributed in their own way, and I feel fortunate to have shared this time with them.

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Chapter 1

Credit Relationships and Dynamic Credit Constraints

1.1 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 con-

[1] See, e.g., Bernanke & Gertler (1989) and Kiyotaki & Moore (1997).

[2] See, e.g., Petersen & Rajan (1994) and Berger & Udell (1995).

tributions. 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 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

[3]See, e.g., Greenwald (2019), Lian & Ma (2021), and Drechsel (2023).

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.

1.1.1 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.

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.

[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.

1.1.2 Structure of the paper

Section 1.2 provides an institutional background of loan syndication. Section 1.3 provides microeconomic evidence on credit relationships and collateral versus covenant choice, motivating my further research. Section 1.4 develops a parsimonious model that shows how bank learning in a credit relationship affects choices between collateral and covenants, and presents testable predictions. Section 1.5 tests for empirical relevance of these predictions. Section 1.6 concludes.

1.2 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.

1.2.1 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.

1.2.2 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.

1.3 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.

1.3.1 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 1.1 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 1.7.2.

Table 1.1: 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. nonfinancial 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.

1.3.2 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 1.1 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 1.2 [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,

[6]A detailed explanation of the method used to identify relationship lender and relationship formation is shown in Appendix 1.7.2

[7]This table shows equal-weighted means of loan characteristics. A volume-weighted version is included in Appendix 1.7.2, and findings are consistent.

Table 1.2: Summary of loan characteristics by relationship strength (equal-weighted)

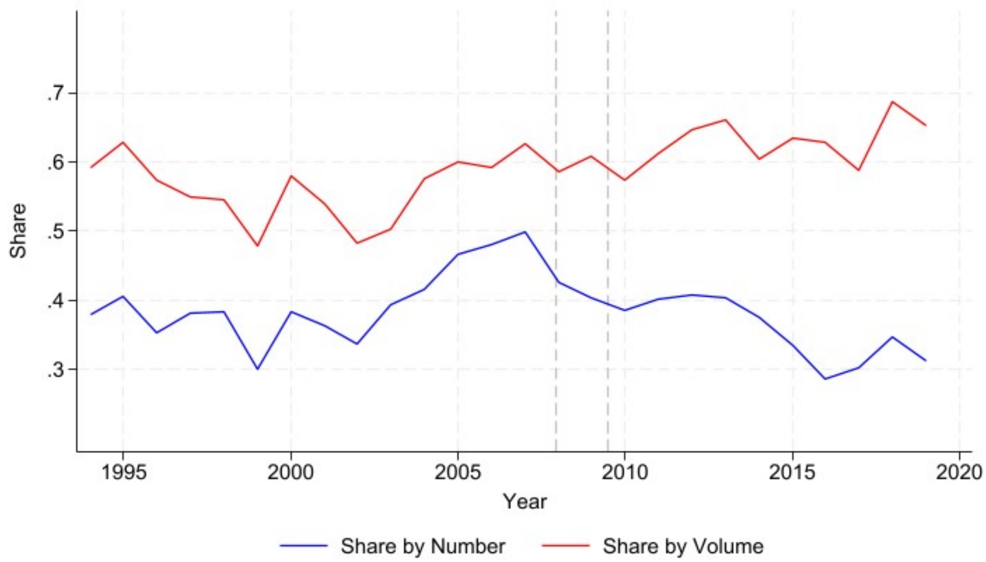
Panel A: Interaction Sort	Full Sample	Low Rel.	Medium Rel.	High Rel.
Loan Amount (millions 2017 USD)	417.61	277.07	485.62	834.05
Maturity (months)	42.37	42.43	42.58	41.96
Spread (drawn spread bps)	193.43	205.68	188.07	156.51
Collateral (frequency)	45.33%	47.73%	45.58%	36.67%
Covenant (frequency)	31.68%	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. nonfinancial 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.

while the relationship strength appears to have little effect on loan maturity.

Figure 1.1: Share of loans incurred by firms in credit relationships



Notes: This figure shows shares of loans issued 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. nonfinancial 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 1.1 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.

1.3.3 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 1.1 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 substitution. Table 1.2 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 1.7.2 that the differences in covenant and collateral use across varying relationship strengths documented in Table 1.2 are statistically significant.

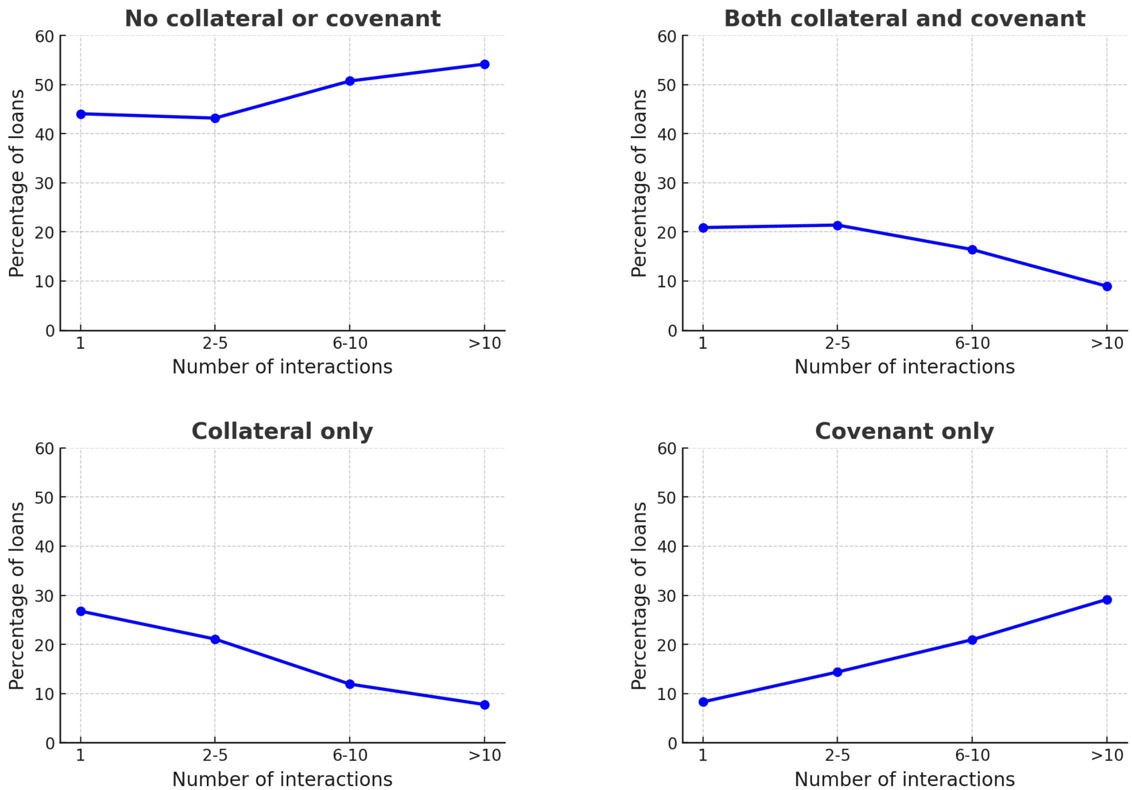
The patterns documenting a switch from collateral-based to earnings-based borrowing within a credit relationship are illustrated by the following examples. WLR Foods Inc, previously the largest poultry producer in Virginia, United States, borrowed 135 million USD in 1995 from the First Union National 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 1.2 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 subfigures in Figure 1.2). 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.

1.4 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

Figure 1.2: 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. nonfinancial 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, $N = 168$).

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.

1.4.1 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 1.7.1.5, 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

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

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 $U^F(d_2) = d_2$.

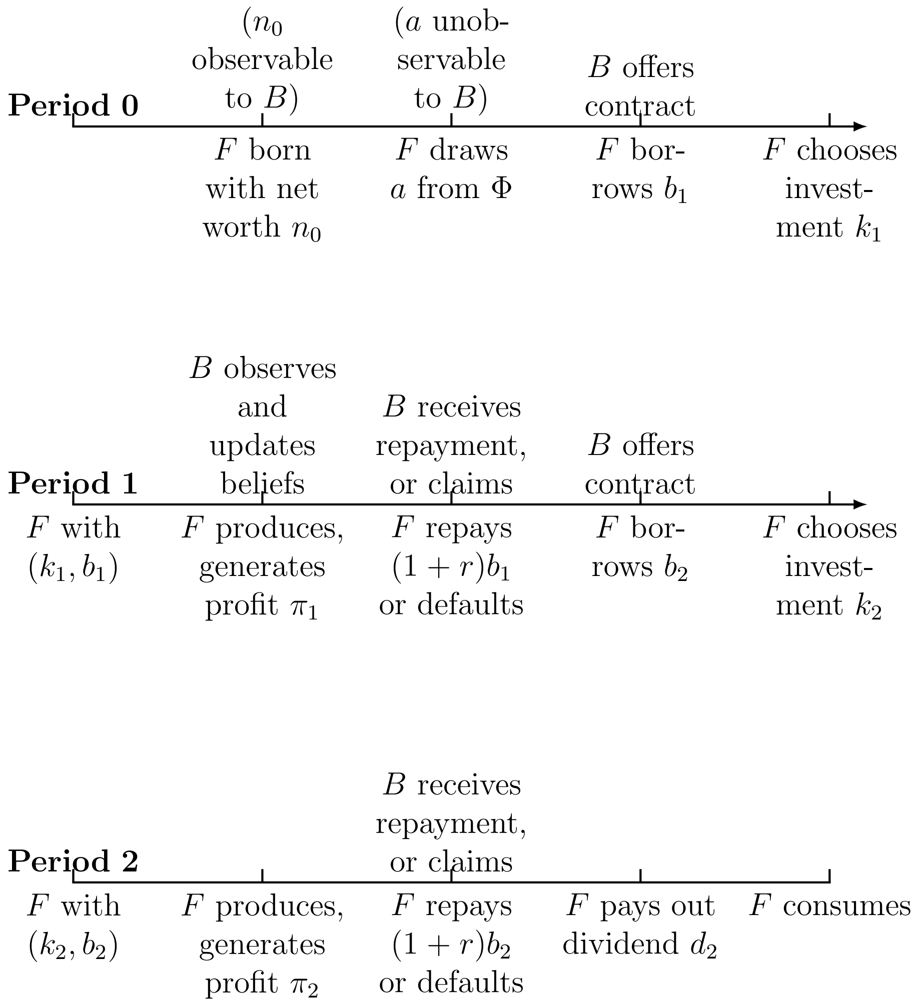
1.4.2 Timeline

Figure 1.3 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.

1.4.3 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.

Figure 1.3: Timelines of each period



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 1.1 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.

1.4.4 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:

$$(1 + r)b_t \leq (1 - \delta)k_t; \quad (1.1)$$

$$(1 + r)b_t \leq \eta a f(k_t). \quad (1.2)$$

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

$$\bar{b_t^k} = (\frac{1}{1 + r})\theta^k (1 - \delta)k_t, \quad (1.3)$$

and

$$\bar{b_t^\pi} = (\frac{1}{1 + r})\eta \mathbb{E}_{t-1}(\pi_t \mid \text{default}). \quad (1.4)$$

The assumption that a loan contract can only contain collateral requirements or covenant requirements is relaxed to allow for both in Appendix 1.7.1. 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.

1.4.5 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 (1.3) and (1.4):

$$b_{t+1} \leq \max\{b^{\bar{k}}_{t+1}, b^{\bar{\pi}}_{t+1}\} = \frac{1}{1+r}\max\{\theta^k(1-\delta)k_{t+1}, \eta\mathbb{E}_t(\pi_{t+1} \mid \text{default})\}. \tag{1.5}$$

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

$$k_1 = b_1 + n_0; \tag{1.6}$$

$$k_2 + (1+r)b_1 = b_2 + af(k_1) + (1-\delta)k_1; \tag{1.7}$$

$$d_2 + (1+r)b_2 = af(k_2) + (1-\delta)k_. \tag{1.8}$$

The firm's optimization problem is characterized by:

$$\max_{b_1,k_1,b_2,k_2,d_2} \quad U^F(d_2) = d_2 \tag{1.9}$$

subject to borrowing constraint (1.5) and budget constraints (1.6), (1.7), and (1.8).

Firm's contractual device choice depends on its borrowing constraint (1.5), i.e. whether a collateral-based or a 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.

1.4.6 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 1.1. $\bar{b_t^k} > 0 \quad \forall t \in \{1, 2\}$.

Lemma 1.1 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 (1.3) becomes:

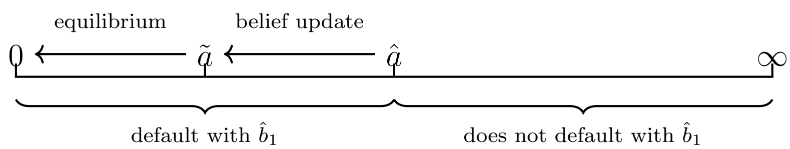
$$\bar{b_t^k} = (\frac{1}{1+r})\theta^k(1-\delta)k_t = (\frac{1}{1+r})\theta^k(1-\delta)(b_t + n_{t-1}),$$

and since borrowing $b_t \geq 0$ and net worth $n_{t-1} > 0$, we have the result in Lemma 1.1. 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 1.2. *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 1.2 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 1.2 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 1.7.1, and a brief sketch is provided below in Figure 1.4. 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 (1.4) 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 1.2. 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 1.4: Sketch proof of Lemma 1.2



The intuition of Lemma 1.2 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 (1.4), 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 1.3. *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 1.3 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 1.4. *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 1.1. *Given net worth* n_1^**, a firm with* $a > \max\{\underline{a}^k(n_1^*), \underline{a}^p(n_1^*)\}$ *will switch from collateral-based borrowing in period* 0 *to earnings-based borrowing in period* 1*.*

The proof of Proposition 1.1 is as follows: Lemma 1.1 and Lemma 1.2 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 1.2, earnings-based credit becomes available; in period 1, a firm with net worth n_1^* and productivity $a > \max\{\underline{a}^k(n_1^*), \underline{a}^p(n_1^*)\}$ is credit-constrained under collateral requirements (see Lemma 1.4) and will optimally switch to earnings-based borrowing, which provides greater credit availability (see Lemma 1.4). 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 1.1, is heterogeneous across varying productivities. For firms with productivity $a \leq \max\{\underline{a}^k(n_1^*), \underline{a}^p(n_1^*)\}$, the effect depends on the assumptions regarding the functional form of $f(k)$ and parameter values. Under assumptions such that $\underline{a}^k(n_1^*) > \underline{a}^p(n_1^*)$ holds, firms with $a < \underline{a}^p(n_1^*)$ will still opt for collateral-based borrowing, as it is less restrictive than earnings-based borrowing. Firms with $a \in [\underline{a}^p(n_1^*), \underline{a}^k(n_1^*)]$ will be indifferent between the two types, as they are unconstrained under either. Conversely, if $\underline{a}^k(n_1^*) < \underline{a}^p(n_1^*)$, all firms with productivity below the threshold in Proposition 1.1 (i.e. $a < \underline{a}^p(n_1^*)$) 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 1.1. *Conditional on initial net worth, the incidence of earnings-based borrowing increases with relationship strength.*

Corollary 1.1 follows directly from Lemma 1.2 and Proposition 1.1, and suggests that firm's access to earnings-based credit increases as a relationship enhances.

Corollary 1.2. *Conditional on initial net worth and relationship length, the size of loans increases with the incidence of earnings-based borrowing.*

Corollary 1.2 follows from Proposition 1.1 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 1.3. *Conditional on relationship length, if production function exhibits decreasing returns to scale, the incidence of earnings-based borrowing is decreasing in firm's initial pledgeable assets.*

Corollary 1.3 follows directly from Proposition 1.1 and the property of a decreasing returns to scale production function (see proof in Appendix 1.7.1). With higher initial net worth n_1^*, the thresholds stated in Lemma 1.3 and Lemma 1.4 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.

1.4.7 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 1.7.1. Thresholds derived in Lemma 1.3 and Lemma 1.4 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, $\underline{a}^{j\prime}(n_1^*) > 0$ and $\underline{a}^{j\prime\prime}(n_1^*) < 0$ 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 1.7.1. I make the following assumption:

Assumption 1.1. $\eta = 1$ *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 1.7.1, and the results that the bank relationship relaxes the borrower's credit constraints by increasing inclusion of covenants in loan contracts remains unchanged.

With Assumption 1.1, it follows that:

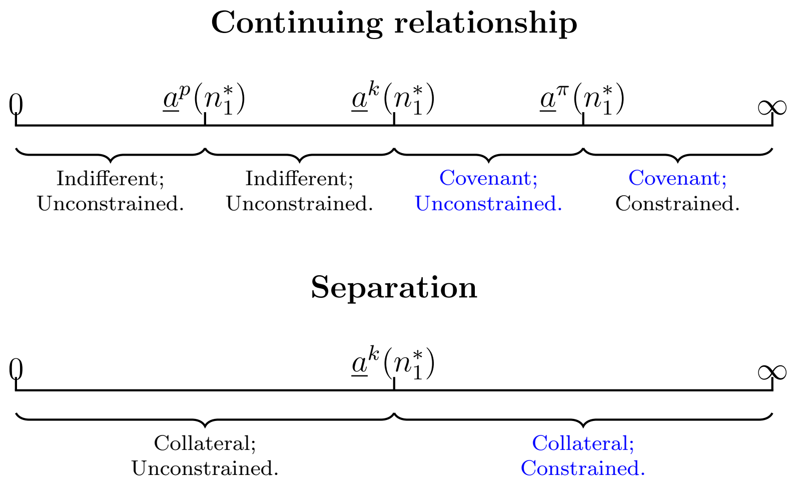
$$\underline{a}^{\pi}(n_1^*) > \underline{a}^{k}(n_1^*) > \underline{a}^{p}(n_1^*). \tag{1.10}$$

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 1.7.1, 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 1.5, considering both the continuation and separation cases.

Figure 1.5 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 1.3, 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 1.3, firms are more likely to

[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 1.1 will not change with an η larger than 1.

Figure 1.5: Collateral vs. covenant in period 1



borrow through earnings-based contracts when they are more constrained by their initial wealth. According to Proposition 1.1, 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 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 1.3 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 more likely to be 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.

1.5 Empirical verification of model's testable predictions

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

1.5.1 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. nonfinancial 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).

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 1.3[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

[10]More summary statistics are provided in Appendix 1.7.2.

Table 1.3: 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. nonfinancial 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.

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 1.1.

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 1.7.2.

1.5.2 Empirical verification

1.5.2.1 Empirical specification

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

$$Y_{i,j,t} = \beta_{Rel} Rel_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \qquad (1.11)$$

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

[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 1.7.2, and the estimated effects of bank-firm

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.

1.5.2.2 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 1.1, and decreases with a firm's investable and pledgeable assets, as outlined in Corollary 1.3. To test these predictions, I estimate specification (1.11) 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 1.4 summarizes results of OLS fixed effect regressions for specification (1.11). Across all specifications, as the credit relationship strengthens, covenants are more likely to be used in loan deals, as indicated by the positive and statistically significant coefficients on log(Relation) in Columns 1 to 4. This confirms Corollary 1.1, 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 1.3. 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

relationship on covenant use are consistent with my main findings in Table 1.4.

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 (1.11) using this new proxy for relationship and results are presented in Table 1.5. Consistent with previous findings, across all specifications, covenant use increases with relationship length, and is higher when firms are more constrained, confirming Corollary 1.1 and Corollary 1.3.

Table 1.4: 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 1.5: 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 1.4, 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 1.4. 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.

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 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 syndication, the unexpected large drawdowns 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 1.6 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:

$$Rel_{i,t} = \beta_{IV} Failed/Exposed_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \quad (1.12)$$

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 1.6: Relationship and Covenant: IV Estimation

	1^{st} stage	2^{nd} stage	1^{st} stage	2^{nd} 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 1.4 and Table 1.5. 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.

1.5.2.3 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 1.1; and second, this substitution provides larger credit availability according to Corollary 1.2.

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:

$$COL_{i,j,t} = \beta_{COV}\widehat{COV_{i,j}}_{,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \tag{1.13}$$

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 1.5, 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 1.7, 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 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

Table 1.7: 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 1.6. Control variables are the same as in Table 1.4. 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.

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 (1.11) 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 1.8, 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 1.8 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.

1.5.2.4 Do lenders learn?

An important mechanism in the model presented in Section 1.4 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

Table 1.8: 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 nonfinancial 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 1.4. 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.

borrowing constraints. 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 1.9, 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 use an IV approach by augmenting specification (1.11) 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:

$$COV_{i,j,t} = \beta_{Rel} Rel_{i,t} + \beta_{RXS} Rel_{i,t} \times Small_{i,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}. \tag{1.14}$$

Second-stage results are presented in Table 1.10. Columns 1 and 2 use *Relation* and *Duration* 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 1.9: 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 1.10: 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 1.4. 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.

1.6 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-based nature of credit.

1.7 Appendices

1.7.1 Solutions and proofs

1.7.1.1 Proof of Lemma 1.2

Suppose any bank's arbitrary belief such that

$$\mathbb{E}_0(a \mid \text{default}) \equiv \tilde{\mu} > 0. \tag{1.15}$$

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:

$$(1+r)\hat{b}_1^{\pi} \equiv \eta \underline{\hat{a}} f(k_1) = (1+r)b_1^k. \tag{1.16}$$

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:

$$(1+r)b_1^{\pi} = \eta \mathbb{E}_0(a \mid \text{default}) f(k_1) > \eta a f(k_1). \tag{1.17}$$

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 $b_1^{\pi} \leq 0$.

1.7.1.2 Proof of Corollary 1.3

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 1.4.

The threshold stated in Lemma 1.3, $\underline{a}^p(n_1^*)$, solves $\bar{b_2^\pi} = \bar{b_2^k}$. We hence have

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

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 $\underline{a}^p(n_1^*)$ is increasing in n_1^*.

1.7.1.3 Model solutions

I solve firm's problem in (1.9) 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:

$$d_2 \leq n_2^* \equiv af(k_2^*) + (1-\delta)k_2^* - (1+r)b_2^*, \tag{1.18}$$

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:

$$\max_{b_2, k_2} n_2 = af(k_2) + (1-\delta)k_2 - (1+r)b_2, \tag{1.19}$$

subject to borrowing constraint (1.5), and budget constraint (1.7). 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:

$$b_2^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}} - n_1^*, \max\{\frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_1^*, b_2^\pi(n_1^*)\}\right\}, \tag{1.20}$$

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:

$$k_2^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}}, \max\{\frac{1+r}{(1+r)-\theta(1-\delta)}n_1^*, b_2^\pi(n_1^*) + n_1^*\}\right\}. \tag{1.21}$$

Under optimality conditions, resulting n_2^*:

$$n_2^* = af(k_2^*) + (1-\delta)k_2^* - (1+r)b_2^* = af(k_2^*) - (r+\delta)k_2^* + (1+r)n_1^*, \tag{1.22}$$

and:

$$\frac{dn_2^*}{dn_1^*} = [af'(k_2^*) - (r+\delta)]\frac{dk_2^*}{dn_1^*} + (1+r) > 0, \tag{1.23}$$

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:

$$\max_{b_1} n_1 = af(k_1) + (1-\delta)k_1 - (1+r)b_1, \tag{1.24}$$

subject to borrowing constraint with only collateral requirement $(1+r)b_1 \leq \theta(1-$

$\delta)k_1$, and budget constraint (1.6). Optimal borrowing and capital choices are given by:

$$b_1^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}} - n_0, \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_0\right\}, \tag{1.25}$$

and

$$k_1^* = \min\left\{(\frac{\alpha a}{r+\delta})^{\frac{1}{1-\alpha}}, \frac{1}{(1+r)-\theta(1-\delta)}n_0\right\}. \tag{1.26}$$

1.7.1.4 Deriving thresholds

In period 0, from (1.25), 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:

$$\left\{\frac{\alpha \underline{a}^k(n_0)}{r+\delta}\right\}^{\frac{1}{1-\alpha}} - n_0 = \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_0, \tag{1.27}$$

which solves for

$$\underline{a}^k(n_0) = \left(\frac{r+\delta}{\alpha}\right)\left(\frac{(1+r)n_0}{1-\theta(1-\delta)}\right)^{1-\alpha}. \tag{1.28}$$

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

In period 1, from (1.20), $\underline{a}^p(n_1^*)$ is solved from the case when supply of credit with collateral requirement is equal to supply with covenant requirement:

$$\frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_1^* = b_2^\pi(n_1^*, \underline{a}^p(n_1^*)). \tag{1.29}$$

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:

$$\left\{\frac{\alpha \underline{a}^k(n_1^*)}{r+\delta}\right\}^{\frac{1}{1-\alpha}} - n_1^* = \frac{\theta(1-\delta)}{(1+r)-\theta(1-\delta)}n_1^*, \tag{1.30}$$

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:

$$\left\{\frac{\alpha \underline{a}^\pi(n_1^*)}{r+\delta}\right\}^{\frac{1}{1-\alpha}} - n_1^* = b_2^\pi(n_1^*, \underline{a}^\pi(n_1^*)). \tag{1.31}$$

1.7.1.5 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 1.1) becomes:

$$(1 + r_t)b_t^k \leq (1 - \delta)k_t. \tag{1.32}$$

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:

$$(1 - p_t^k)(1 + r_{t+1}^k)b_{t+1}^k + p_t^k\theta(1 - \delta)k_{t+1} = (1 + r)b_{t+1}^k, \tag{1.33}$$

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 (1.32), i.e. firm will not voluntarily default, then $p_t^k = 0$ and (1.33) implies $r_t^k = r$. If the bank chooses a debt limit that violates (1.32), firm will always choose to default and $p_t^k = 1$. (1.33) becomes

$(1+r)b^k_{t+1} = \theta(1-\delta)k_{t+1}$, 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 $\theta(1+r^k_t) > (1+r)$. Such contract can be replicated by bank choosing $r^k_t = r$ and $(1+r)b^k_{t+1} = \theta(1-\delta)k_{t+1}$, 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 (1.2)) becomes:

$$(1+r^\pi_t)b^\pi_t \le \eta\pi_t. \tag{1.34}$$

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

$$(1-p^\pi_t)(1+r^\pi_{t+1})b^\pi_{t+1} + p^\pi_t\eta\mathbb{E}_t(\pi_{t+1} \mid \text{default}) = (1+r)b^\pi_{t+1} \tag{1.35}$$

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 (1.34) is satisfied, then probability of default is zero, and according to bank's break-even constraint 1.35, bank charges no spread. If the contract violates (1.34), 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:

$$\max_{r_1^\pi, b_1^\pi}(1-\Phi(\bar{a^\pi}))(1+r_1^\pi)b_1^\pi + \Phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da - (1+r)b_1^\pi, \quad (1.36)$$

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

$$\begin{aligned}&(1-\Phi(\bar{a^\pi}))b_1^\pi - \frac{\partial\bar{a^\pi}}{\partial r_1^\pi}\phi(\bar{a^\pi})(1+r_1)b_1^\pi \\ &+\frac{\partial\bar{a^\pi}}{\partial r_1^\pi}\phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da + \Phi(\bar{a^\pi})\eta\bar{a^\pi}b_1^\pi\phi(\bar{a^\pi}) = 0,\end{aligned} \quad (1.37)$$

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

$$\begin{aligned}&(1-\Phi(\bar{a^\pi}))(1+r_1^\pi) - \frac{\partial\bar{a^\pi}}{\partial b_1^\pi}\phi(\bar{a^\pi})(1+r_1^\pi)b_1^\pi + \frac{\partial\bar{a^\pi}}{\partial b_1^\pi}\phi(\bar{a^\pi})\eta\int^{\bar{a^\pi}} a(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi})da \\ &+\Phi(\bar{a^\pi})\eta(\frac{\partial\bar{a^\pi}}{\partial b_1^\pi}\bar{a^\pi}(n_0+b_1^\pi)^\alpha\phi(\bar{a^\pi}) + \int^{\bar{a^\pi}}\alpha a(n_0+b_1^\pi)^{\alpha-1}\phi(\bar{a^\pi})da) = 1+r.\end{aligned} \quad (1.38)$$

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 (1.34), 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 (1.35) 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:

$$0.5\eta a_L(n_0 + b_1^\pi)^\alpha + 0.5(1 + r_1^\pi)b_1^\pi - (1 + r)b_1^\pi. \tag{1.39}$$

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:

$$b_1^\pi = \left(\frac{\alpha\eta a_L}{1 + r - (r_1^\pi - r)}\right)^{\frac{1}{1-\alpha}} - n_0. \tag{1.40}$$

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.

1.7.1.6 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 (1.5) becomes:

$$b_{t+1} = b_{t+1}^k + b_{t+1}^{\pi} \leq \frac{1}{1+r}\left(\theta^k(1-\delta)k_{t+1} + \eta\mathbb{E}_t(\pi_{t+1} \mid \text{default})\right). \tag{1.41}$$

In period 0, as shown in Appendix 1.7.1.1, 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 1.7.1.3.

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:

$$b_2 \leq \frac{1}{1+r}\left(\theta^k(1-\delta)k_2 + \eta a k_2^{\alpha}\right). \tag{1.42}$$

Firm's maximization problem in period 1 becomes maximizing (1.19) subject to borrowing constraint (1.42) and a budget constraint $n_1^* + b_2 \geq k_2$. Note that since $\eta > 0$, borrowing constraint in a relationship (1.42) 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.

1.7.1.7 Parameter calibration

Table 1.11 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 1.11: 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

1.7.1.8 Relaxing Assumption 1.1

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

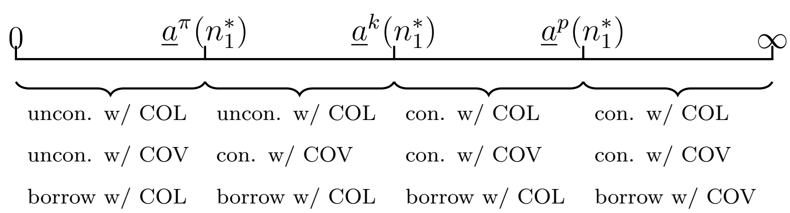
$$\frac{\alpha}{r+\delta} > \frac{\eta}{\theta(1-\delta)},$$

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:

$$\underline{a}^p(n_1^*) > \underline{a}^k(n_1^*) > \underline{a}^\pi(n_1^*). \tag{1.43}$$

Figure 1.6 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 1.6: (More efficient) Collateral vs. covenant in credit relationship



1.7.2 Data and measurement

1.7.2.1 Additional summary statistics of DealScan Sample

Table 1.12 provides additional summary statistics that describe the DealScan sample.

Table 1.12: 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. nonfinancial corporations between 1990 and 2019. All variables are defined in Table 1.1.

Table 1.13 provides a summary of deal purposes in the DealScan sample.

Table 1.13: Frequency of deal purpose

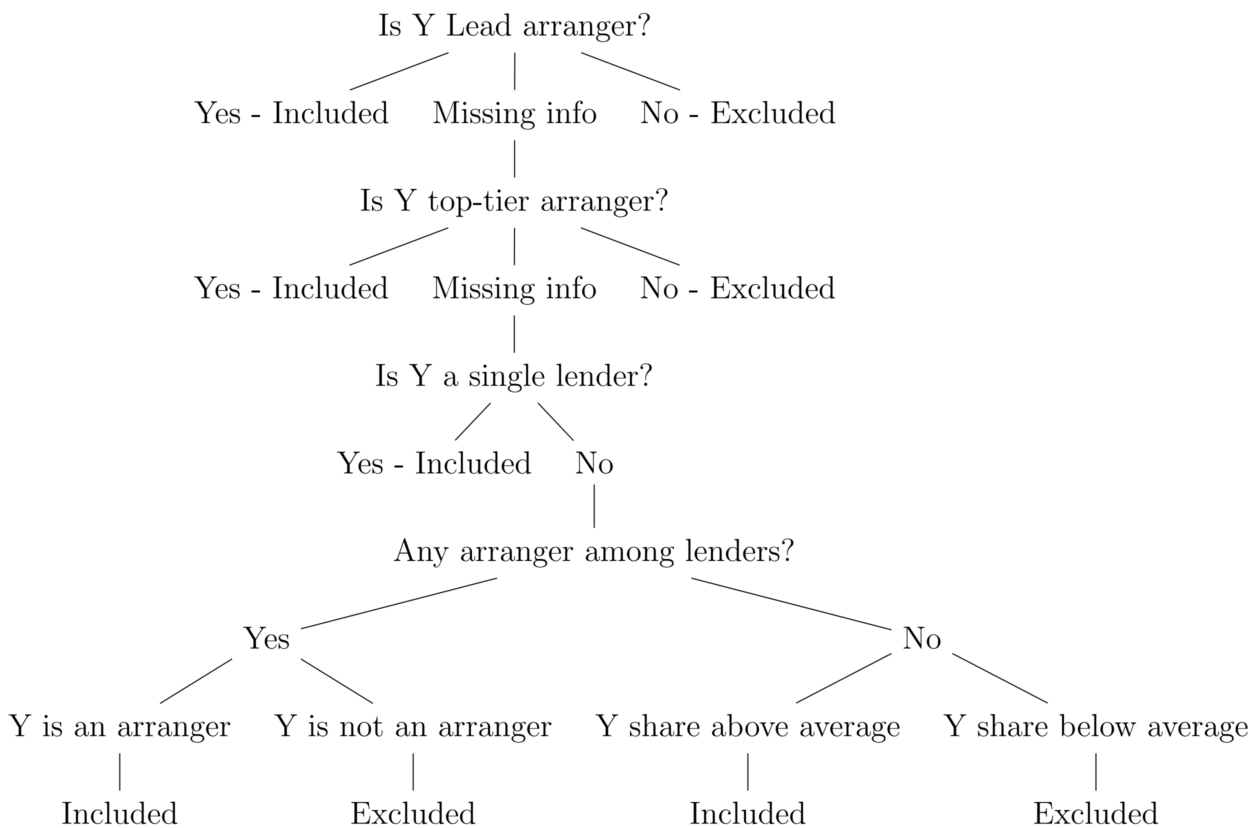
Deal Purpose	Frequency(%) Equal-Weighted	Frequency(%) Volume-Weighted
General Purpose	43.81	39.80
Working capital	12.30	6.75
Refinance	11.40	8.32
Takeover	6.52	16.90
Acquisition	6.06	5.22
Leveraged Buyout	5.30	5.73
Commercial paper backup	3.70	7.55
Dividend Recapitalization	1.60	1.48
Real estate loan	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. nonfinancial corporations between 1990 and 2019.

1.7.2.2 Identifying relationship lender in a loan

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

Figure 1.7: Road map to identify borrower-lender relationship pair



1.7.2.3 Summary statistics by relationship sort (volume-weighted)

Table 1.14 replicates Table 1.2 and shows volume-weighted averages of loan characteristics for different relationship groups.

Table 1.14: 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. nonfinancial 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.

1.7.2.4 Mean differences in summary statistics by relationship sort

Table 1.15 extends Table 1.2 and shows differences in summary statistics across different relationship categories.

Table 1.15: Summary of loan characteristics by relationship (equal-weighted differences)

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

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

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. nonfinancial 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.

1.7.2.5 Relationship sort in DealScan-Compustat merged sample

Table 1.16 replicates Table 1.2 on the DealScan-Compustat merged sample. Findings are consistent.

Table 1.16: Summary statistics for DealScan-Compustat sample by relationship strength

Panel A: Duration Sort	Full Sample	Low	Medium	High
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	Medium.	High
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. nonfinancial 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.

1.7.2.6 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 1.17, and are consistent with previous findings.

Table 1.17: 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 1.4. 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.

1.8 Bibliography

Aghion, P. & Bolton, P. (1987). Contracts as a barrier to entry. *The American Economic Review*, 77, 388–401.

Amberg, N., Jacobson, T., Quadrini, V., & Picco, A. R. (2023). Dynamic credit constraints: Theory and evidence from credit lines. *Sveriges Riksbank Working Paper Series*, 422.

Berger, A. N., Miller, N. H., Petersen, M. A., Rajan, R. G., & Stein, J. C. (2005). Does function follow organizational form? evidence from the lending practices of large and small banks. *Journal of Financial Economics*, 76, 237–269.

Berger, A. N. & Udell, G. F. (1995). Relationship lending and lines of credit in small firm finance. *The Journal of Business*, 68, 351–381.

Bernanke, B. & Gertler, M. (1989). Agency costs, net worth, and business fluctuations. *The American Economic Review*, 79, 14–31.

Bharath, S., Dahiya, S., Saunders, A., & Srinivasan, A. (2007). So what do i get? the bank's view of lending relationships. *Journal of Financial Economics*, 85, 368–419.

Bharath, S. T., Dahiya, S., Saunders, A., & Srinivasan, A. (2011). Lending relationships and loan contract terms. *The Review of Financial Studies*, 24, 1141–1203.

Chava, S. & Roberts, M. R. (2008). How does financing impact investment? the role of debt covenants. *The Journal of Finance*, 63, 2085–2121.

Chodorow-Reich, G. (2014). The employment effects of credit market disruptions: Firm-level evidence from the 2008–9 financial crisis. *The Quarterly Journal of Economics*, 129, 1–59.

Chodorow-Reich, G. & Falato, A. (2022). The loan covenant channel: How bank health transmits to the real economy. *The Journal of Finance*, 77, 85–128.

Drechsel, T. (2023). Earnings-based borrowing constraints and macroeconomic fluctuations. *American Economic Journal: Macroeconomics*, 15, 1–34.

Duqi, A., Tomaselli, A., & Torluccio, G. (2018). Is relationship lending still a mixed blessing? a review of advantages and disadvantages for lenders and borrowers. *Journal of Economic Surveys*, 32, 1446–1482.

D'Auria, C., Foglia, A., & Reedtz, P. M. (1999). Bank interest rates and credit relationships in italy. *Journal of Banking & Finance*, 23, 1067–1093.

Even-Tov, O., Li, X., Wang, H., & Williams, C. (2023). The importance of individual-pair lending relationships. *Review of Accounting Studies*.

Garmaise, M. J. & Natividad, G. (2010). Information, the cost of credit, and operational efficiency: An empirical study of microfinance. *The Review of Financial Studies*, 23, 2560–2590.

Greenwald, D. (2019). Firm debt covenants and the macroeconomy: The interest coverage channel. *MIT Sloan Research Paper*.

Harhoff, D. & Körting, T. (1998). Lending relationships in germany – empirical evidence from survey data. *Journal of Banking & Finance*, 22, 1317–1353.

Ivashina, V. & Scharfstein, D. (2010). Bank lending during the financial crisis of 2008. *Journal of Financial Economics*, 97, 319–338.

Kehoe, T. J. & Levine, D. K. (1993). Debt-constrained asset markets. *The Review of Economic Studies*, 60, 865–888.

Kiyotaki, N. & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, 105, 211–248.

Lian, C. & Ma, Y. (2021). Anatomy of corporate borrowing constraints. *The Quarterly Journal of Economics*, 136, 229–291.

Nini, G., Smith, D. C., & Sufi, A. (2012). Creditor control rights, corporate governance, and firm value. *The Review of Financial Studies*, 25, 1713–1761.

Park, C. (2000). Monitoring and structure of debt contracts. *The Journal of Finance*, 55, 2157–2195.

Petersen, M. A. & Rajan, R. G. (1994). The benefits of lending relationships: Evidence from small business data. *The Journal of Finance*, 49, 3–37.

Prilmeier, R. (2017). Why do loans contain covenants? evidence from lending relationships. *Journal of Financial Economics*, 123, 558–579.

Rajan, R. & Winton, A. (1995). Covenants and collateral as incentives to monitor. *The Journal of Finance*, 50, 1113–1146.

Stock, J. & Yogo, M. (2005). Testing for weak instruments in linear iv regression. *Identification and Inference for Econometric Models*, (pp. 80–108).

Chapter 2

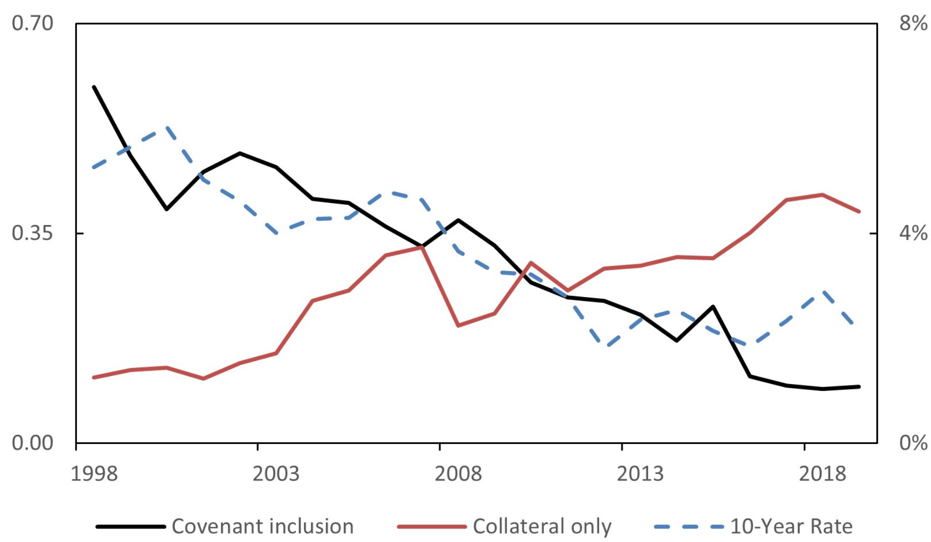
The Secular Decline in Interest Rates and Credit Constraints

2.1 Introduction

Covenants as a loan contracting device are an important determinant of firm credit access, investment, and macroeconomic fluctuations (see e.g., Lian & Ma, 2021; Chodorow-Reich & Falato, 2022). However, they have become less common in corporate loan contracts over the past two decades, raising questions about the underlying drivers and their aggregate implications. This paper proposes a new explanation for this long-term trend based on the secular decline in interest rates. I argue that falling interest rates reduce the funding disadvantage of Nonbank Financial Institutions (NBFIs), encouraging their participation in the corporate loan market. Because NBFIs differ from banks in regulation, funding structure, and monitoring capacity, their growing presence drives a shift away from covenant-based toward collateral-based contracting. This substitution helps explain the observed decline in covenant incidence in corporate loans and sheds light on a new channel through which monetary conditions influence the structure of firm credit constraints.

This paper documents a long-term decline in the incidence of covenants in the U.S. corporate loan market since 1998, as shown in Figure 2.1. In the syndicated loan market, which accounts for roughly 75% of all U.S. corporate loans by volume, the share of newly issued loans containing at least one covenant fell from 59.4% in 1998 to just under 10% in 2019. Over the same period, there was a considerable increase in the use of collateral as a primary form of creditor protection: the share of loans relying solely on collateral rose from about 10% to over 40%. This trend reflects the growing prevalence of covenant-light (cov-lite) loans, which impose fewer restrictions on borrowers and are typically secured by collateral (Prilmeier & Stulz, 2020). Importantly, this new stylized fact, the substitution away from covenant-based toward collateral-based borrowing, coincided with a secular decline in long-term interest rates.

Figure 2.1: Loan contractual devices and 10-year interest rate



Notes: This figure shows covenant incidence in syndicated loan deals incurred by U.S. nonfinancial corporations (solid black line, left axis), measured by the fraction of loans issued in each year that contain at least one covenant restriction, and the fraction of loans issued in each year that require only collateral (solid red line, left axis), and interest rate on U.S. Treasury securities at 10-year constant maturity (dashed line, right axis). Source: DealScan, FRED.

Motivated by empirical evidence on the institutional differences between banks and Nonbank Financial Institutions (NBFIs) (see e.g., Buchak et al., 2018; Irani et al., 2021; Chernenko et al., 2022; Sarto & Wang, 2025), I develop a simple model with heterogeneous creditors to formalize the mechanism linking interest rates, lender composition, and contract design. The bank acts as the financial intermediary and has the technology to monitor, and thus can offer both collateral-based and covenant-based loan contracts to firms. The bank also has a funding cost advantage. The NBFI provides credit through loan securitization: a collateral-based loan can be securitized and sold to the NBFI. It also enjoys a regulatory advantage, which allows it to recover a higher fraction of the loan than the bank in the event of default. When the interest rate is high, the NBFI's cost disadvantage dominates the regulatory advantage, and hence does not provide credit through loan securitization. The bank offers both collateral-based and covenant-based loans. When the interest rate falls, the regulatory advantage of the NBFI starts to dominate and the NBFI increases collateral-based credit supply to the loan market. As a result, the bank is able to originate collateral-based loans with more credit availability and then distribute/sell the loans to the NBFI. This increases credit availability under collateral-based borrowing for firms, and leads to reduced covenant incidence. The model is relatively parsimonious and aims at illustrating the mechanism that the secular decline in interest rates drives a shift in the composition of credit supplier towards NBFIs, which in turn leads to a long-term decline in covenant incidence. The mechanism also shows how interest rates can have real effects on firms' credit constraints and borrowing and investment decisions through a nonbank participation channel. This provides insights on future research on shock transmissions during the Covid episode following a prolonged period of low interest rate environment.

Using U.S. firm-level, bank-level, and loan-level data, I examine empirically how the long-run decline in interest rates affects the composition of lenders, the contractual structure of loans, and ultimately, credit availability for firms. First, I find that falling interest rates lead to a rise in nonbank participation in loan syndication, particularly when lead banks are more exposed to interest rate changes through their funding structure. Then, I show that increased nonbank participation is associated with a shift away from covenant-based contracting and toward collateral-based loans, suggesting a substitution between collateral and covenant as contractual devices. Finally, I find that this shift is associated with greater availability of collateral-based credit. These findings highlight a possible channel through which monetary conditions affect loan contracting and firm financing via changes in the composition of lenders and contractual devices.

This paper is the first to call attention to the secular decline in the relative use of covenant-based lending and to offer an explanation for this trend in the context of falling long-term interest rates. The model provides predictions that are of significant policy relevance and should inform policymaking decisions. First, the presence of Nonbank Financial Institutions amplifies credit cycles. When interest rates fall, NBFI participation provides extra liquidity to the loan market, thereby relaxing corporate financing constraints and allowing investment and output to grow further. When interest rates rise, NBFIs' regulatory advantage is quickly diminished by their funding disadvantage, causing a contraction in the overall credit supply. Financing frictions become more severe, leading to amplifications in the fluctuations of investment and output. The procyclicality of nonbank liquidity in credit cycles raises concerns about financial stability. Second, monetary policy can have real and unintended consequences on firm borrowing and investment decisions. Previous studies highlight the key role of the Fed's monetary policy announcement in driving the long-term decline in interest rates (e.g., Hillenbrand, 2025; Hofmann et al., 2025). Nonbank entry fueled by the secular decline in interest rates changes the composition of loan creditors and shifts the demand for loans away from earnings-based lending. This can have unbalanced effects on the firm population: firms with abundant assets that can be collateralized experience more favorable borrowing conditions, while firms with little assets become more credit-constrained due to contraction in earnings-based credit supply. Third, shock and policy transmission can vary over time with monetary policy itself. In a low interest rate environment, NBFI participation fuels the growth in cov-lite provisions, and covenant-based lending is less favored than collateral-based lending. The conventional 'financial accelerator' channel of shock and policy transmission would dominate (Bernanke et al., 1996; Kiyotaki & Moore, 1997). When the interest rate rises, as in the post-Covid era, trends in cov-lite issuance reverted, and the loan covenant channel of shock and policy channel (Greenwald, 2019; Lian & Ma, 2021; Chodorow-Reich & Falato, 2022; Drechsel, 2023) starts to function and gain importance. Differences in the magnitudes and directions of two distinct transmission mechanisms underscore the importance of the varying distribution of corporate borrowing constraints driven by long-term interest rate changes in understanding the aggregate fluctuations of the economy.

2.1.1 Related literature

This paper makes several contributions to the existing literature. First, this paper contributes to the macro-finance literature studying how credit constraints affect corporate and macroeconomic outcomes (e.g., Bernanke et al., 1996; Kiyotaki & Moore, 1997; Chodorow-Reich, 2014). A recent development in the literature has emphasized the importance of earnings-based credit constraints in amplifying macroeconomic fluctuations (Greenwald, 2019; Lian & Ma, 2021; Chodorow-Reich & Falato, 2022; Drechsel, 2023). I contribute to this literature by showing that the nature of credit constraint changes with long-term interest rate in the presence of both banks and Nonbank Financial Institutions.

Second, this paper contributes to the literature studying the causes and the consequences of the rise of the under-regulated nonbank sector. Previous theoretical studies highlight regulatory arbitrage as the cause of nonbanks (Plantin, 2015; Farhi & Tirole, 2021), and empirical studies have documented the high cyclicality of nonbank lending and its role in fueling pre-crisis booms (Ivashina & Sun, 2011; Shivdasani & Wang, 2011; Becker & Ivashina, 2014). This paper builds on this strand of the literature and contributes by identifying the secular decline in interest rate as an alternative cause, and the shift away from earnings-based towards collateral-based lending as a plausible consequence that poses threat to financial instability.

Third, this paper is related to studies on the consequences of the secular decline in interest rates. Sarto & Wang (2025) studies the harmful effects of low interest rates on banks and the response of nonbanks in the U.S. residential mortgage market. This paper complements by focusing on the effects of the secular decline in interest rate on corporate borrowers.

2.1.2 Structure of the paper

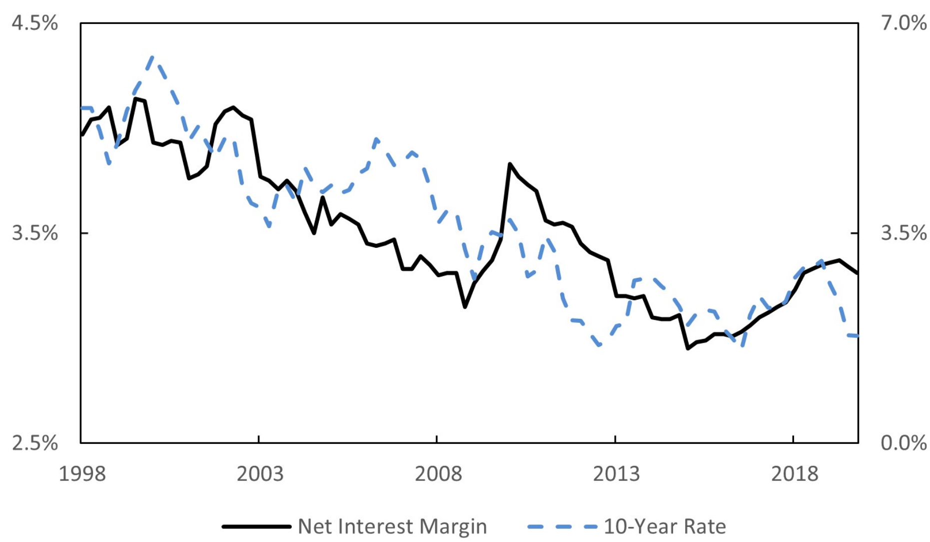
The remainder of the paper is organized as follows. Section 2.2 discusses the differences between banks and Nonbank Financial Institutions in the corporate loan market. Section 2.3 develops a model with heterogeneous creditors that shows how changes in interest rates affect the participation of NBFI and the choices of contractual devices and presents testable predictions. Section 2.4 tests for the empirical relevance of these predictions. Section 2.5 concludes.

2.2 Banks vs. nonbanks in corporate loan market

Although both banks and Nonbank Financial Institutions (NBFIs) provide liquidity to the corporate loan market, they differ in several key dimensions. These differences can help explain the long-term decline in covenant incidence observed during the secular decline in interest rates. First, the deposit franchise allows banks to raise funds through cheaper traditional retail deposit, while NBFIs typically rely on wholesale funding. This competitive advantage is reduced when the interest rate is persistently declining, as deposit rates are not fully adjusting with market rates.

This leads to reduced profitability of banks, who earn the spread between assets and liabilities, and compressed net interest margin, which is evident in the case of U.S. banks (see Figure 2.2).

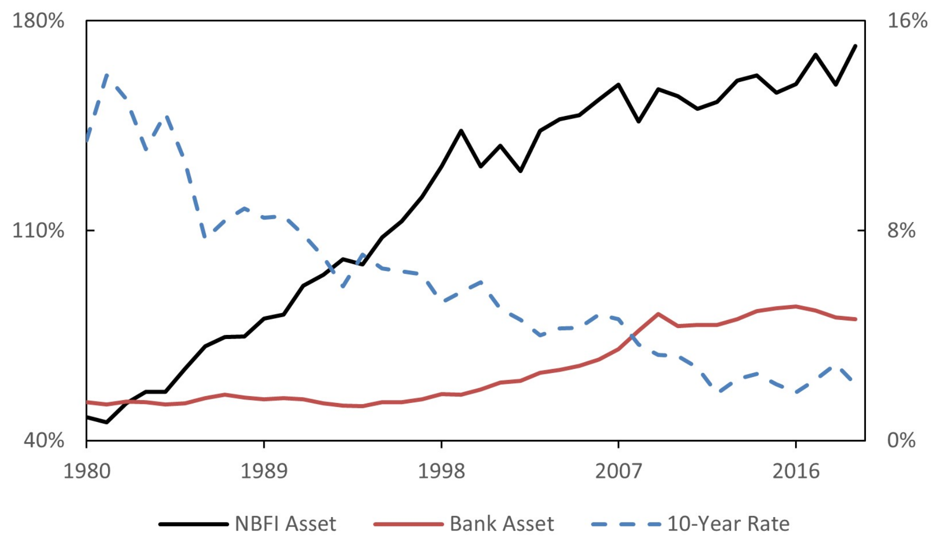
Figure 2.2: Net interest margin and 10-year interest rate



Notes: This figure shows average net interest margin for U.S. banks (solid line, left axis) and interest rate on U.S. Treasury securities at 10-year constant maturity (dashed line, right axis). Source: FRED.

Second, the banking industry is a heavily regulated sector, while NBFIs are much less regulated. It is widely documented in the literature that banking regulations are increasingly tighter (e.g., Jiménez et al., 2017; Òscar Jordà et al., 2021; Begenau & Landvoigt, 2022), especially after the Great Recession, and tighter regulations such as capital reserve requirements and liquidity requirements lead to contractions in credit supply. Thus, this regulatory advantage allows NBFIs to gain market share in loan markets when banks lose competitive advantage from the deposit franchise when the interest rate is low. Existing literature has documented an increased presence of Nonbank Financial Institutions (Buchak et al., 2018; Irani et al., 2021; Gopal & Schnabl, 2022), who actively participate in loan market transactions and loan securitization activities since the 1990s. Nonbank Financial Institutions including entities like insurance companies, pension funds, and investment firms are institutions that provide financial services but do not hold a full banking license, and hence they are not subject to any banking regulation. Figure 2.3 shows that NBFIs rapidly expanded their balance sheets compared to banks when long-term interest rates were on a long-term declining trend since long-term interest rates peaked in the U.S. in the early 1980s.

Figure 2.3: Nonbank Financial Institutions Asset and 10-year interest rate



Notes: This figure shows total assets held by Nonbank Financial Institutions and commercial banks as percentages of U.S. GDP (solid lines in black and red respectively, left axis) and interest rate on U.S. Treasury securities at 10-year constant maturity (dashed line, right axis). Source: Board of Governors of the Federal Reserve System (U.S.); FRED; Author's own calculations.

Heavy banking regulations also affect banks' valuation of collateral. In the event of default, banks have to book provisions for loan loss, which directly affects their liquidity coverage, and the foreclosed collateral sitting on banks' balance sheet carries a high risk weight, which affects their capital adequacy. Therefore, banking regulations result in more conservative valuations of collateral in asset-based lending due to regulatory costs associated with default. Degryse et al. (2021) found that banks that were subject to more stringent capital reserve requirements required more collateral, which provides evidence that banking regulations reduce banks' risk tolerance and hence more conservative valuation of collateral. Ramcharan (2020) shows that banks whose liquidity positions were closer to regulatory thresholds experienced an accelerated pace of collateral sales and lower liquidation values, suggesting the regulatory disadvantages of banks. Haque et al. (2024) documented that NBFIs like private equity firms saw higher loan recovery rates compared to banks in the U.S. loan market.

Third, banks and NBFIs can play different roles in loan contracting and enforcement. In syndicated loan markets, banks as delegated monitors (e.g., Diamond, 1984; Winton, 1995) lead the loan origination, and oversee borrowers on behalf of depositors and other lenders during the contract period. Banks have the ability to acquire information on borrowers through monitoring activities, and hence have an information advantage on offering covenant-based credit, which requires bank learning. NBFIs participate in the loan market through direct lending and/or loan securitization. Collateralized Loan Obligations (CLOs), a main investment vehicle in loan securitization, saw a record issuance of 451 billion U.S. Dollar in the U.S. market in 2024, compared to 1.337 trillion U.S. Dollar leveraged loan issuance in the same year. Since collateral-based loans are more standardized and easier to be packaged and securitized, they are preferred to covenant-based loans that require monitoring, which NBFIs do not have an advantage on (e.g., Chernenko et al., 2022). When NBFIs actively participate in the syndicated loan markets, banks shift to operate an 'originate-to-distribute' model: they originate a loan deal and sell the majority of the loan on to NBFIs. The lack of skin-in-the-game thus reduces the banks' incentives to monitor and acquire information on the borrowers. This, together with the demand preference over collateral-based loans by NBFIs, leads to a falling incidence of covenants when NBFIs actively participate in loan market due to the secular decline in interest rate.

Motivated by these differences, the next section develops a model with banks and NBFIs as creditors that are heterogeneous in their funding, regulation, and monitoring capacities.

2.3 A simple model on interest rate and credit constraints

To capture how interest rates influence credit constraint dynamics, I develop a benchmark two-period model with $t \in \{1, 2\}$. The economy features three types of risk-neutral agents: a continuum of firms F, a representative bank B, and a representative nonbank investor N. A firm borrows one-period loan from the bank in period 1, and repays in period 2. The firm cannot fully commit to repayment, so the bank requires either collateral or covenant to protect its creditor rights. The bank specializes in financial intermediation, and can choose to hold the loan on its balance sheet until maturity, or to originate-to-distribute: the bank originates loans and then sells or securitizes them and distribute to the nonbank investor. Importantly, the bank's ability to use different contractual devices (collateral or covenant) depends on whether the loan is intended to be securitized. When nonbank participation in the securitized loan market is dependent on the interest rate, the nature of the firm's credit constraint is hence linked to the interest rate through a loan securitization channel.

2.3.1 Agents

Bank: The representative bank specializes in financial intermediation and borrows from depositors at an exogenous interest rate r. The banking sector is perfectly competitive, with free entry, so the bank is price-taking and breaks even. To focus on non-price terms of a loan contract, I assume the bank charges no spread and lends to firms at rate $R = r$.

In period 1, the bank offers a one-period loan b_2, which may involve either a collateral requirement or a covenant restriction. It expects repayment of $(1+r)b_2$ in period 2. The bank can choose to hold the loan until maturity or securitize and sell it to the nonbank investor in period 1. The bank's objective 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).

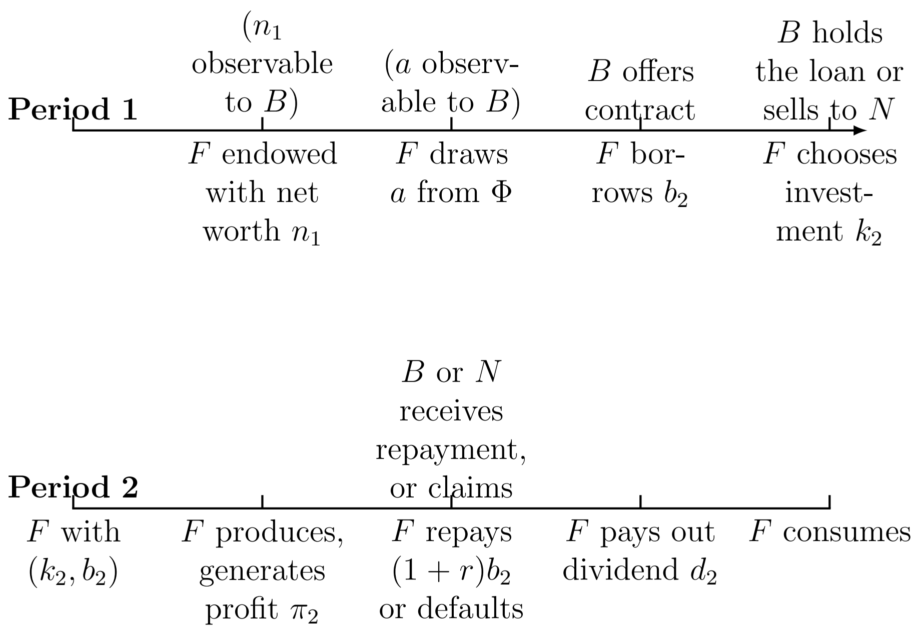
Nonbank investor: Since the 2008 financial crisis, the growth in aggregate financial assets is largely driven by nonbank entities. In corporate loan market, nonbank financial institutions, such as private equity firms and investment funds, participate through various means including direct lending, loan securitization, and investment in syndicated loans originated by banks. In this model, I assume that the nonbank investor can raise funds at the same cost r as the bank, but it must rely on the bank as the financial intermediary to originate loans. The nonbank investor needs to pay a fixed cost C per loan investment.

Firm: At the beginning of period 1, a firm is endowed with productivity a drawn from a known distribution $\Phi(a)$ with cumulative distribution function Φ and probability density function ϕ, as well as net worth n_1. The firm owns a production technology that produce output $y_2 = af(k_2)$ in period 2 with capital k_2 installed in period 1, where $f(\cdot)$ is increasing and concave, and capital depreciates at rate δ. The cost of production is assumed to be zero, because it is equivalent to re-scaling n_1 and will not qualitatively affect the results, and hence profits (earnings) from production $\pi_2 = y_2$. The production technology is finite and fully exhausts its productive capacity by the end of period 2. The firm finances capital investment k_2 by borrowing b_2 and its own net worth n_1. It derives utility from dividends d_2 paid out in period 2, with objective function $U^F(d_2) = d_2$.

2.3.2 Timeline

Figure 2.4 summarizes the timing of actions taken by all agents in each period. There is no information asymmetry in the benchmark model, and the bank is able to observe both the productivity and the net worth of the firm.

Figure 2.4: Timelines of each period



2.3.3 Collateral versus covenant in a loan contract

Due to the problem of limited commitment, the bank as the financial intermediary requires either collateral or covenant as contractual devices to protect its creditor rights. Collateral requirements necessitate the verifiability of capital stock, while covenant requirements often rely on the verifiability of the firm's earnings. Since there is no information asymmetry in the benchmark model and the bank can observe both the firm's productivity and its net worth in period 1, the bank is able to include either contractual device into the loan contract at origination.

Collateral-based loans are standardized and generally require less monitoring by financial intermediaries. In contrast, covenant-based loans typically contain conditions that are linked to volatile performance indicators such as firm earnings, and hence require more active monitoring. For this reason, collateralized loans are preferred in loan securitization and offloading by banks to nonbank investors. I assume that the nonbank investor invests only in collateral-based loans. This is consistent with empirical findings that nonbank financial institutions purchase bank-originated loans primarily through Collateralized Loan Obligation (CLO) vehicles, and that these investors favor secured and covenant-lite (few or no covenant) structures (see e.g., Prilmeier & Stulz, 2020; Haque et al., 2024; Ivashina & Vallée, 2025).

If a loan contract contains covenant restrictions, I follow the existing literature and the setup in the previous chapter in assuming that the firm's borrowing constraint is linked to its future cash flows. Specifically, I assume that the covenant restriction takes the form of a maximum debt-to-EBITDA ratio. Because the loan lasts only one period, this ratio is non-negative during the contract and zero at maturity, when repayment is due. If a covenant is breached and technical default is triggered, control rights are partially transferred from the firm to the bank. Bargaining and the exercise of these rights lead to a fraction η of the firm's cash flow being paid out as dividends to the bank to service the debt, because seizure and liquidation of capital is costly and less efficient. This is equivalent to the firm pledging control rights over a proportion η of its earnings at 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 $\bar{b_2^{\pi}} = (\frac{1}{1+r})\eta\pi_2$.

If a loan contract includes collateral requirements, then in the event of default, the bank or the nonbank investor can seize and liquidate the collateral pledged by the firm. Seizure and liquidation incur legal and administrative costs, such that only a fraction $\theta_j^k \in (0, 1)$ of the collateral value is recoverable by lender $j \in \{B, N\}$.

Consistent with empirical findings that nonbank institutions like private equity funds experience lower loan losses and higher recovery rates upon default (Haque et al., 2024), I assume $\theta_B^k < \theta_N^k$. This difference can also be interpreted as reflecting the differences in regulatory requirements. Compared to nonbanks, banks face more stringent rules on loan defaults and foreclosures on collateral. Banks must book loan-loss provisions, which affect liquidity coverage ratios, and foreclosed collateral on their balance sheets carries high risk weights, resulting in lower capital adequacy. To restore regulatory buffers and lending capacity, banks must liquidate collateral quickly, typically through private or public auctions, which incurs a larger haircut.

If the bank holds the loan until maturity, the bank's participation constraint implies that it will only lend up to the recovery value of depreciated collateral, with a collateral-based limit:

$$\bar{b}_{2,hold}^k = \left(\frac{1}{1+r}\right)\theta_B^k(1-\delta)k_2.$$

If the loan is securitized and sold to the nonbank investor at price $P_1(k_2)$ after origination, the bank's participation constraint implies that it would be able to lend up to the sale price. Therefore, if a loan contract includes collateral requirement, the maximum collateral-based borrowing limit is given by:

$$\bar{b}_2^k = \max\left\{\bar{b}_{2,hold}^k, P_1(k_2)\right\}.$$

2.3.4 Loan securitization and transaction

The bank may choose to originate a collateral-based loan and sell it to the nonbank investor via loan securitization. Without loss of generality, I assume that the nonbank investor purchases the entire loan in a single transaction, and the bank does not retain any share of the loan[1]. I further assume that securitization involves

[1] In practice, banks often retain a small share, but this assumption does not affect the results qualitatively.

a fixed transaction cost C, which is borne by the nonbank investor.

The transaction price $P_1(k_2)$ is determined through Nash bargaining between the bank and the nonbank investor. Let the bank's bargaining power be $\kappa \in (0,1)$, and the nonbank investor's bargaining power be $1-\kappa$. The bank's surplus from trade is the difference between the transaction price and the discounted value of the liquidated collateral the loan is held to maturity:

$$\text{Bank's surplus} = P_1(k_2) - \frac{1}{1+r}\theta_B^k(1-\delta)k_2.$$

Similarly, the nonbank investor's surplus from trade is the discounted value of collateral it would recover minus the transaction price and the fixed cost of securitization:

$$\text{Nonbank's surplus} = \frac{1}{1+r}\theta_N^k(1-\delta)k_2 - P_1(k_2) - C.$$

The Nash bargaining solution maximizes the weighted product of the surpluses, yielding the transaction price:

$$P_1^*(k_2) = \frac{1}{1+r}\theta^k(r)(1-\delta)k_2, \tag{2.1}$$

where the effective recovery rate $\theta^k(r)$ is defined as:

$$\theta^k(r) \equiv (1-\kappa)\theta_B^k + \kappa\theta_N^k - \frac{(1+r)\kappa C}{(1-\delta)k_2},$$

and $\theta^k(r)$ is decreasing in r. Therefore, as the interest rate falls, two effects lead to a higher transaction price. First, the present value of future collateral recovery increases due to lower discounting. Second, the fixed cost of securitization becomes less binding relative to the total gains from trade. Hence, loan securitization becomes more attractive, and the collateral-based credit supply expands as a result of nonbank participation when interest rates are low.

Therefore, in the presence of nonbank participation and loan securitization, the bank's participation constraint implies that the firm's collateral-based borrowing limit becomes:

$$\bar{b_2^k} = \max\left\{\bar{b_{2,hold}^k}, P_1^*(k_2)\right\} = \frac{1}{1+r}\max\left\{\theta_B^k, \theta^k(r)\right\}(1-\delta)k_2. \tag{2.2}$$

2.3.5 The bank's problem

In period 1, the bank offers two types of contracts at origination: collateral-based and covenant-based contracts. If the firm decides to borrow with a collateral-based loan, the bank can either hold the loan until maturity in period 2, or securitize and sell the loan to the nonbank investor. A covenant-based loan can only be held to maturity by the bank. The bank's problem is to set contractual terms for both types of contract such that: 1) the firm borrows; 2) the firm will not voluntarily default; and 3) the bank breaks even.

The firm will choose not to default if the repayment obligation does not exceed the value of collateral or cash flows retained after default. For a collateral-based loan, the no-default condition is:

$$(1+r)b_2 \leq (1-\delta)k_2. \tag{2.3}$$

For a covenant-based loan, the condition is:

$$(1+r)b_2 \leq \eta a f(k_2). \tag{2.4}$$

The bank's participation constraint determines the maximum amount it is willing to lend under each contract type. For a collateral-based loan, the borrowing limit is:

$$\bar{b_2^k} = \left(\frac{1}{1+r}\right)\max\left\{\theta_B^k, \theta^k(r)\right\}(1-\delta)k_2, \tag{2.5}$$

where the $\theta^k(r)$ term incorporates the possibility of nonbank participation and securitization as in equation (2.2). For a covenant-based loan, the borrowing limit is:

$$\bar{b_2^{\pi}} = \left(\frac{1}{1+r}\right)\eta\pi_2 = \left(\frac{1}{1+r}\right)\eta a f(k_2). \tag{2.6}$$

The assumption that a loan contract contains *either* collateral requirements or covenant requirements can be relaxed to allow for both simultaneously without qualitatively affecting the main results. Intuitively, collateral requirements link borrowing capacity to a stock variable (capital), while covenant requirements link it to a flow variable (earnings). Allowing both would simply add the two constraints together.

2.3.6 The firm's problem

The firm makes borrowing and investment decisions in period 1, and repayment, dividend payout, and consumption decisions in period 2.

In $t = 1$, based on realizations of net worth n_1 and productivity a, and borrowing cost $R = r$, the firm chooses (i) its level of leverage b_2 and (ii) whether to take a collateral-based or a covenant-based loan. If it is credit-constrained under at least one contract type, the borrowing capacity is determined by:

$$b_2 \leq \max\left\{\bar{b_2^k}, \bar{b_2^{\pi}}\right\}, \tag{2.7}$$

where $\bar{b_2^k}$ and $\bar{b_2^{\pi}}$ are given by equations (2.5) and (2.6).

Conditioning on repaying any existing loan, the firm's budget constraints are:

$$k_2 = b_2 + n_1, \tag{2.8}$$

$$d_2 + (1+r)b_2 = af(k_2) + (1-\delta)k_2, \tag{2.9}$$

where d_2 is dividend payout in period 2.

The firm maximizes the utility from consuming dividends in period 2:

$$\max_{b_2, k_2, d_2} \quad U^F(d_2) = d_2, \tag{2.10}$$

subject to the borrowing constraint (2.7) and budget constraints (2.8) and (2.9).

The firm's contractual device choice depends on its borrowing constraint (2.7), i.e., whether the collateral-based or covenant-based contract yields greater borrowing capacity. Since collateral-based and covenant-based borrowing limits are affected by interest rate in different ways, a firm may shift from one to the other in response to interest rate changes. In the interest of examining how interest rate and nonbank participation affect the contractual device choice, I assume that the firm chooses the contract with the higher credit limit.

2.3.7 Equilibrium characteristics

This section provides main results from the model. First, I examine the conditions under which the bank chooses to securitize a collateral-based loan and nonbank investor chooses to participate in the loan transaction.

Lemma 2.1. *Given an investment level k_2, there exists an interest rate threshold $\underline{r}(k_2)$, above which $\bar{b}^k_{2,hold} > P_1^*(k_2)$ and $\bar{b}^k_2 = \bar{b}^k_{2,hold}$, below which $\bar{b}^k_{2,hold} < P_1^*(k_2)$ and $\bar{b}^k_2 = P_1^*(k_2)$.*

Lemma 2.1 establishes an interest rate threshold $\underline{r}(k_2)$ such that, for $r > \underline{r}(k_2)$, the bank holds a collateral-based loan until maturity, while for $r < \underline{r}(k_2)$ the loan is securitized and sold to the nonbank investor. The threshold is obtained from the condition $\theta^k_B = \theta^k(\underline{r}(k_2))$, and since $\theta^k(r)$ is strictly decreasing in r, equation (2.2) confirms the result. This threshold can be interpreted as the nonbank participation cutoff rate in the loan market: when interest rates fall below $\underline{r}(k_2)$, the nonbank investor enters due to a reduced fixed-cost disadvantage, increasing their likelihood of providing liquidity. As a result, collateral-based credit availability increases because the higher recovery rate of nonbanks raises the effective collateral-based borrowing limit.

Lemma 2.2. *For each level of net worth n_1 and interest rate r, there exists a productivity threshold $\underline{a}^p(n_1, r)$ such that*

$$\bar{b_2^{\pi}} > \bar{b_2^{k}} \quad \text{if and only if} \quad a > \underline{a}^p(n_1, r),$$

where $\bar{b_2^{k}}$ and $\bar{b_2^{\pi}}$ are given by equations (2.5) and (2.6), respectively.

Proof. Given (n_1, r), the threshold $\underline{a}^p(n_1, r)$ is obtained by equating the covenant-based and collateral-based borrowing limits in equations (2.5) and (2.6), evaluated at the equilibrium investment level $k_2^*(n_1, r)$:

$$\underline{a}^p(n_1, r) \;=\; \frac{\max\{\theta_B^k, \theta^k(r)\}(1-\delta)}{\eta} \cdot \frac{k_2^*(n_1, r)}{f\big(k_2^*(n_1, r)\big)}.$$

A higher productivity a increases the covenant-based borrowing limit via a larger expected earnings pledge in the event of default. In contrast, the collateral-based limit depends only on capital recovery and is unaffected by a. Therefore, for a given n_1 and r, firms with $a > \underline{a}^p(n_1, r)$ obtain a larger credit supply from covenant-based borrowing, while those with $a < \underline{a}^p(n_1, r)$ obtain more from collateral-based borrowing. □

Lemma 2.3. *$\underline{a}^p(n_1, r)$ is (weakly) decreasing in r for non-increasing returns to scale production functions.*

Lemma 2.3 states that the productivity threshold characterized in Lemma 2.2 is decreasing in interest rate r when production function does not exhibit increasing returns to scale. Proof is provided in Appendix.This is resulting from two distinct channels: a loan demand channel, and a loan securitization channel. First, covenant-based borrowing capacity depends on future earnings, which are more sensitive to the cost of capital than collateral values: a higher r depresses investment and earnings more sharply than it reduces the recoverable value of collateral, making collateral-based credit relatively less restrictive. Second, higher interest rates decrease the effective recovery rate on collateral through securitization, which disincentivizes nonbank participation, further reducing collateral-based capacity and expanding the mass of firms for whom covenant-based contracts yield higher borrowing limits.

Proposition 2.1. *For any $r < \underline{r}(k_2^*(n_1, r))$, the absolute effect of r on the contract-choice productivity cutoff $\underline{a}^p(n_1, r)$ is strictly smaller in the absence of nonbank participation than when nonbanks are active.*

Proposition 2.1 combines Lemma 2.1 and Lemma 2.3, and states that nonbank participation amplifies the effect of interest rate on contractual device choice compared to a counterfactual economy when nonbank investor is absent. Intuitively, when interest rate is low and the nonbank investor participates in loan transactions, the loan securitization channel functions, increasing collateral-based credit availability, thereby raising the productivity cutoff above which borrowers would choose covenant-based contracts.

Proposition 2.2. *Covenant incidence, measured by the mass of firms with covenant-based borrowing, $1 - \Phi\left(\underline{a}^p(n_1)\right)$, increases with interest rate r.*

Proposition 2.2 follows from Lemma 2.3 that the productivity threshold above which firms choose covenant-based borrowing decreases with interest rate r. Intuitively, when interest rate falls to a sufficiently low level, loan securitization and transaction is active between the bank and nonbank investor. As a result, lower interest rate affects borrowing limits through not only discounting but also a loan securitization channel, and collateral-based borrowing limit is relaxed by more than covenant-based limit. Thus, covenant incidence is lower when interest rate falls, and there is a substitution away from covenant-based toward collateral-based loans.

2.3.8 Illustration of main findings

In order to illustrate the relationship between interest rates and contractual device choice in the presence of nonbank participation, I solve and calibrate the model. Solutions and calibration details are provided in Appendix. Figure 2.5 plots the productivity thresholds $\underline{a}^p(n_1, r)$ for different values of interest rates r. Areas above and below the curve are the combinations of productivity a and initial net worth n_1 such that a firm would choose covenant-based and collateral-based contracts, respectively.

As interest rate falls, the productivity threshold shifts upward, and the region within which firms would choose covenant-based borrowing becomes smaller, implying a fall in covenant incidence. For higher values of initial net worth and productivity, nonbank participation constraint is more likely to be satisfied since the fixed cost disadvantage is diminished by higher levels of investment and borrowing. Thus, the effect of a fall in interest rate on covenant incidence is larger, as indicated by the larger shift in productivity thresholds. This demonstrates a strong loan securitization channel driven by nonbank participation.

The next section tests model predictions in empirical data.

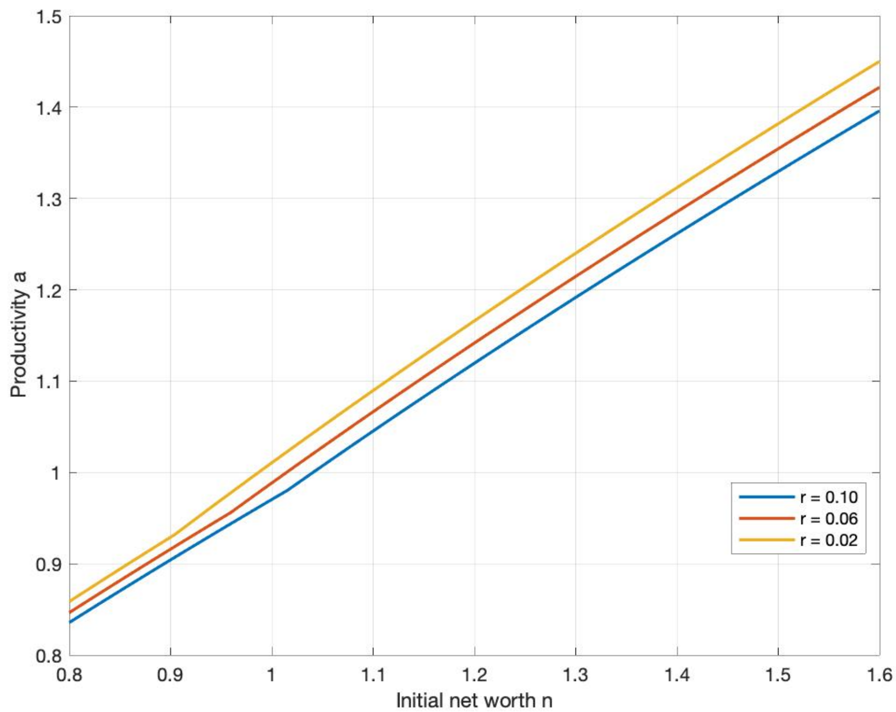
2.4 Model predictions and empirical verification

2.4.1 Model Predictions

The model generates several testable predictions on how interest rates and lender composition affect loan contractual devices.

First, the model predicts that nonbank participation in the corporate loan market increases as interest rates decline. This follows from Lemma 2.1 that lower interest

Figure 2.5: Contractual Device Choice and Interest Rate



Notes: This figure plots the productivity thresholds above which covenant-based loans yield greater credit availability, $\underline{a}^p(n_1, r)$ as characterized in Lemma 2.2, for interest rates r at 2%, 6%, and 10%. Model solutions and calibration details are summarized in Appendix. Nonbank participation constraint as characterized in Lemma 2.1 is satisfied for initial net worth n above around 0.9.

rates mitigate nonbanks' funding disadvantage. As a result, NBFIs become more competitive and increasingly participate in loan transactions.

Second, as nonbank participation rises, the incidence of covenant-based borrowing falls, while the use of collateral-based borrowing rises. This prediction, which follows from Proposition 2.2, reflects the fact that NBFIs favor collateral-based structures due to their securitization strategy and limited monitoring capacity. Consequently, higher nonbank participation leads to a substitution from covenants to collateral in loan contracts.

Third, all else equal, nonbank participation increases the size of collateral-based loans to firms, a prediction resulting from Lemma 2.1 and Proposition 2.1. Nonbank participation allows the bank to originate-to-distribute, and the gains from a loan portfolio transaction between the bank and the nonbank allows the bank to extend more collateral-based credit to firms. As a result, when the nonbank participates in the loan market, firms would be able to borrow more given same initial net worth.

2.4.2 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. nonfinancial 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). Bank regulatory data is obtained from Standard and Poor's Compustat Bank Fundamentals Quarterly, and is merged with DealScan loan-level data using a linking table provided by Schwert (2018). The data on Federal Funds Effective Rate and the 10-year rate is obtained from the Federal Reserve Economic Data (FRED).

DealScan provides detailed loan type classifications (term loans and credit lines). Since most of the loans held by nonbanks through CLOs are Term Loan Bs (Fleckenstein et al., 2025), I classify loan deals with a 'Term Loan B' tranche as deals with nonbank participation. Loan tranches labeled 'Term Loans C-K' are also classified as loans with nonbank participation. Overall, around 15% of loan deals saw participation by nonbank financial institutions at origination[2].

[2] This figure is comparable to other studies on nonbank lending using DealScan (e.g., Chernenko et al., 2022; Fleckenstein et al., 2025). The relatively low figure on nonbank presence is due to 1) the lack of disclosure in DealScan: a large proportion of term loans are not classified into Term Loan A or Term Loan B; 2) timing of data: this paper uses data on information collected at the time of loan origination, while post-origination, nonbanks participate actively in secondary markets as well; and 3) sample coverage: the sample covers a large time frame, including years when nonbanks were less active. In the sample, nonbanks participate in around 20% loan deals originated each year since the 2008 Financial Crisis.

2.4.3 Empirical verification

This section presents empirical specifications and results for testing 1) whether the secular decline in interest rates leads to increased nonbank participation in syndicated loan origination; 2) whether increased nonbank participation affects contractual device choices in loan contracting; and 3) whether such effect leads to increased credit availability for firms.

2.4.3.1 Nonbank participation and interest rate

In order to test for the effect of the secular decline in interest rate on nonbank participation, I estimate the following empirical specification using Ordinary Least Squares (OLS):

$$\begin{aligned} Nonbank_{i,j,t} =& \beta_R R_t + \beta_B \textit{Bank Exposure}_{j,t-1} + \beta_{R\times B} R_t \times \textit{Bank Exposure}_{j,t-1} \\ &+ \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,j,t}, \end{aligned} \tag{2.11}$$

where $Nonbank_{i,j,t} = 1$ if the loan incurred by firm i, syndicated by lead bank j in time t involves nonbank participation, and 0 otherwise, R_t is the interest rate proxy, $\textit{Bank Exposure}_{j,t-1}$ is a proxy for lead bank j's exposure to interest rate, D is a vector of deal-level controls, and X is a vector of firm-level controls, and firm, year, and lead lender fixed effects. The interaction term captures the cross-sectional variation in the lead bank's funding advantage due to interest rate change. Intuitively, if a bank relies more on deposit than other wholesale funding, when interest rate increases, its funding advantage over nonbanks would increase by more compared to other banks. This design can help capture the effects of the secular decline in interest rate on nonbank participation in loan market through the loan securitization channel. I use the lead bank's net interest margin and deposit-to-asset ratio as the proxies for the lead bank's exposure to interest rate change. A high net interest margin implies a larger buffer for the lead bank to absorb potential losses or fluctuations in interest income, and is hence less vulnerable to interest rate cuts, and less likely to curtail lending activities. A high deposit-to-asset ratio indicates that the lead bank has a high level of interest-bearing liability relative to its interest-generating asset, and is more likely to be vulnerable to interest rate cuts.

Table 2.1 presents the results from estimating specification (2.11). Columns 1 and 2 use 10-year interest rate as the proxy for interest rate, and columns 3 and 4 use Federal Funds Effective Rate as the proxy. Columns 1 and 3 use net interest margin as the proxy for the lead bank's exposure to interest rate change, and columns 2 and 4 use deposit-to-asset ratio. Results indicate that increasing nonbank participation in syndicated loan deals is associated with the secular decline in interest rates across all specifications. The statistical insignificance in coefficients of Fed Funds Effective Rate is mainly due to the prolonged period of zero lower bound (ZLB) during the post financial crisis period, in which the policy interest rate generates very little variation. Coefficients on the 10-year rate, which exhibits more variation over time and is less constrained by the ZLB, are statistically significant at 5% level.

The positive and significant coefficients on the interaction terms between interest rate proxies and net interest margin in columns 1 and 3 indicate that the channel through which the secular decline in interest rate reduces the lead bank's funding advantage, thereby increasing nonbank participation in loan market, is relevant. When policy interest rates decline, the stickiness of deposit rates on the downside compresses banks' net interest margins. Lead banks with lower pre-existing margins are more affected and may respond by scaling back their own lending and involving nonbank lenders to share risk and funding, resulting in higher nonbank participation in loan deals. In contrast, lead banks with higher net interest margins are more insulated from the margin pressure, and hence are less likely to adjust syndicate composition in response to interest rate changes. The negative and significant coefficients on interaction terms between interest rate proxies and deposit-to-asset ratio are also consistent with the proposed channel. Lead banks that are more reliant on deposit funding are more sensitive to interest rate declines and thus more likely to involve nonbank participants when interest rates fall.

2.4.3.2 Nonbank participation and contractual device choices

In order to test for the effects of nonbank participation on the incidence of contractual device choices (i.e. collateral and covenant incidence), the following empirical specification is estimated:

$$Y_{i,j,t} = \beta_{NB} Nonbank_{i,j,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \tag{2.12}$$

where $Y_{i,j,t}$ is the outcome variable (collateral/covenant incidence), $Nonbank_{i,j,t} = 1$ if the loan incurred by firm i, syndicated by lead bank j in time t involves nonbank participation, and 0 otherwise, D is a vector of deal-level controls, and X is a vector of firm-level controls, and firm, year, and lead lender fixed effects. Results are presented in Table 2.2, and outcomes of interest are collateral incidence and covenant incidence in columns 1 and 2, respectively.

The positive and significant coefficient on nonbank participation in column 1 confirms the prediction that nonbank participation leads to higher collateral incidence. This is mainly because collateral-based loans are more standardized and ready to be securitized, and hence are preferred by nonbanks. In contrast, increasing nonbank participation leads to lower collateral incidence in loan contracting due to relative complexity in securitization, as indicated by the negative and significant coefficient in column 2. Together, these results imply a substitution away from covenant-based toward collateral-based lending as nonbanks increase their participation in the syndicated loan market.

Table 2.1: Nonbank Participation and Interest Rate

	(1) Nonbank	(2) Nonbank	(3) Nonbank	(4) Nonbank
10-Year Rate	-0.0238**	-0.0280**		
	(-2.17)	(-2.11)		
Fed Funds Rate			-0.0070	-0.0121
			(-0.95)	(-1.56)
Net Interest Margin	-0.0390**		-0.0174**	
	(-2.68)		(-2.14)	
10-Year Rate × Net Interest Margin	0.0068**			
	(2.63)			
Fed Funds Rate × Net Interest Margin			0.0035**	
			(2.13)	
Deposit-to-Asset		-0.2642**		-0.1376**
		(-2.52)		(-2.32)
10-Year Rate × Deposit-to-Asset		-0.0485**		
		(-2.34)		
Fed Funds Rate × Deposit-to-Asset				-0.0333***
				(-2.79)
Deal-level controls	Yes	Yes	Yes	Yes
Firm-level 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	11125	12269	11125	12269
Adj. R-squared	0.5017	0.5061	0.5016	0.5061

Notes: This table shows OLS regressions of nonbank participation in a syndicated loan deal on policy interest rate, lead bank's interest rate sensitivity, and their interactions, and deal-level and loan-level control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Dependent variables in all columns are nonbank participation, *Nonbank*, a dummy variable that equals one if a deal contains at least a tranche that consists of "Term Loan B" as well as "Term Loans C-K", and is a proxy for nonbank participation in a loan deal. *10-Year Rate* is the quarterly average of market yield on U.S. Treasury Securities at 10-year constant maturity. *Fed Funds Rate* is the quarterly average of Federal Funds Effective Rate. *Net Interest Margin* is the maximum net interest margin among bank holding companies (BHCs) associated with all lead lenders in a syndicated loan deal. *Deposit-to-Asset* is the maximum ratio of total deposits to total assets among BHCs associated with all lead lenders in a syndicated loan deal. Deal-level and firm-level control variables are: *Total Assets* is the total assets of the borrowing firm, and as a proxy for borrowing firm's pledgeable assets, and *Loan Amount* is the total amount of the deal, and all dollar amounts are in millions and deflated using NIPA's nonresidential fixed investment goods deflator (base year = 2017); *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; *Maturity* and *Spread* are the weighted average maturity and yield spread over base reference rate for each dollar drawn on the loan respectively; *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;v*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; and *No Rating* is a dummy variable that equals one if the firm has no S&P rating. Columns 1 and 2 use 10-Year Rate as the proxies for interest rates, and Columns 3 and 4 use Fed Funds Rate as the proxies for interest rates. Columns 1 and 3 use net interest margin as the proxies for lead bank's interest rate exposure, and columns 2 and 4 use deposit-to-asset ratio as the proxies for lead bank's interest rate exposure. 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- and year-level clustering are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2.2: Nonbank Participation and Contractual Device Choices

	(1) Collateral	(2) Covenant
Nonbank	0.3326***	-0.0557***
	(21.97)	(-3.32)
log(Relation)	-0.0009	0.0198***
	(-0.13)	(2.60)
log(Loan Amount)	0.0128***	0.0910***
	(2.75)	(18.12)
log(Maturity)	0.0394***	0.0625***
	(7.49)	(10.65)
Spread	0.0006***	0.0001***
	(11.80)	(3.08)
log(Total Assets)	-0.0770***	-0.0752***
	(-8.42)	(-8.19)
Tangibility	-0.0543	-0.0637
	(-0.90)	(-1.09)
log(1+Coverage Ratio)	-0.0248***	0.0020
	(-5.12)	(0.44)
Market-to-Book	-0.0002	0.0002
	(-1.13)	(0.94)
Current Ratio	-0.0033	-0.0082*
	(-0.71)	(-1.71)
Leverage	-0.0130	-0.0492
	(-0.31)	(-1.19)
Rating	0.0218***	0.0026
	(7.47)	(0.79)
No rating	0.2384***	0.0288
	(6.63)	(0.69)
Constant	0.1719***	0.4179***
	(3.06)	(7.63)
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Observations	15992	15992
Adj. R-squared	0.6337	0.4658

Notes: This table shows OLS regressions of contractual device use on nonbank participation in a syndicated loan deal, and deal-level and loan-level control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Dependent variable in Column 1 (2), *Collateral* (*Covenant*) use is measured as a dummy variable that equals one if at least one collateral requirement (covenant) is included in a loan contract between a lender and a borrowing firm and zero otherwise. *Nonbank* is a dummy variable that equals one if a deal contains at least a tranche that consists of "Term Loan B" as well as "Term Loans C-K", and is a proxy for nonbank participation in a loan deal. *Total Assets* is the total assets of the borrowing firm, and as a proxy for borrowing firm's pledgeable assets. *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). *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. *Maturity* and *Spread* are the weighted average maturity and yield spread over base reference rate for each dollar drawn on the loan respectively. *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. 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.

2.4.3.3 Nonbank participation and credit availability

The following specification is estimated to test for the effect of nonbank participation on relaxing collateral-based borrowing capacity:

$$Pledgeability_{i,j,t} = \beta_{NB} Nonbank_{i,j,t} + \beta_D D_{i,t} + \beta_X X_{i,t-1} + \mu_i + \mu_t + \mu_j + \epsilon_{i,t}, \quad (2.13)$$

where $Pledgeability_{i,j,t}$ measures pledgeability of the firm i's assets, proxied by the ratio of deal amount at time t to the firm's property, plants, and equipment (PP&E) in $t-1$, $Nonbank_{i,j,t} = 1$ if the loan incurred by firm i, syndicated by lead bank j in time t involves nonbank participation, and 0 otherwise, D is a vector of deal-level controls, and X is a vector of firm-level controls, and firm, year, and lead lender fixed effects. The measure of pledgeability attempts to capture how much collateral-based leverage the borrowing is able to take on, and the coefficient on $Nonbank_{i,j,t}$ captures how much additional leverage is enabled through nonbank participation and loan securitization. The specification is estimated on subsamples of secured (i.e. collateral-based) and unsecured loans in order to compare the effects of nonbank participation on collateral-based borrowing.

Table 2.3 presents the results. Columns 1 and 2 estimate the specification on secured and unsecured loan subsamples, respectively. The larger positive and significant coefficient in the secured subsample than the unsecured subsample indicates that nonbank participation increases credit availability in collateral-based borrowing by more than unsecured lending, confirming the prediction that nonbank participation relaxes collateral-based borrowing constraints for firms. The positive effect observed in unsecured lending, although not explicitly modeled, may reflect complementary mechanisms such as reduced risk concentration, enhanced syndicate capacity, or reputational spillovers that improve borrower access more broadly.

While PP&Es as tangible long-term fixed assets are the most prevalent type of collateral, I also consider a broader definition that includes inventories as tangible current assets, which serve as short-term pledgeable assets, particularly in short-term collateral-based lending arrangements. Specifically, I use the ratio of deal amount to the sum of PP&E and inventory as an alternative proxy for asset pledgeability in a robustness check. Results are presented in Table 2.4, and remain consistent, supporting the interpretation that nonbank participation facilitates greater collateral-based borrowing capacity.

Table 2.3: Nonbank Participation and Collateral-Based Borrowing Capacity (Fixed Tangibles)

	(1) Pledgeability of tangible fixed assets	(2) Pledgeability of tangible fixed assets
Nonbank	2.0213***	1.3913**
	(4.55)	(2.47)
log(Relation)	-0.6141	0.1151**
	(-1.14)	(2.32)
log(Maturity)	-0.4663	0.0621*
	(-1.16)	(1.69)
Spread	0.0020	-0.0000
	(0.71)	(-0.08)
log(Total Assets)	-1.5777***	-0.6069***
	(-4.07)	(-6.59)
Tangibility	-11.5298**	-4.1979***
	(-2.52)	(-6.50)
log(1+Coverage Ratio)	0.3875	0.1313***
	(1.24)	(2.58)
Market-to-Book	-0.0049	0.0014**
	(-0.80)	(2.00)
Current Ratio	-0.0602	-0.0245
	(-0.38)	(-0.35)
Leverage	-2.3237	1.0013**
	(-1.00)	(2.12)
Rating	0.0451	-0.0697***
	(0.27)	(-2.76)
No rating	0.1236	-0.5224*
	(0.06)	(-1.78)
Constant	9.4319***	4.3640***
	(3.18)	(7.25)
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Secured loan subsample	Yes	No
Observations	6600	8355
Adj. R-squared	0.4769	0.8250

Notes: This table shows OLS regressions of asset pledgeability on nonbank participation in a syndicated loan deal, and deal-level and loan-level control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Dependent variables in both columns are pledgeability of tangible fixed assets, measured by *Loan Amount* relative to the borrowing firm's pledgeable assets for collateral-based borrowing, proxied by net property, plant and equipment (PP&E). All other variables are described in Table 2.2. Column 1 is estimated on the subsample of secured loans, while Column 2 is estimated on the subsample of unsecured loans. 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 2.4: Nonbank Participation and Collateral-Based Borrowing Capacity (All Tangibles)

	(1) Pledgeability of all tangible assets	(2) Pledgeability of all tangible assets
Nonbank	1.8855***	1.3441***
	(4.29)	(2.93)
log(Relation)	0.0060	0.0598**
	(0.05)	(2.27)
log(Maturity)	-0.0310	0.0240
	(-0.23)	(1.08)
Spread	-0.0020*	0.0001
	(-1.82)	(0.36)
log(Total Assets)	-0.7403***	-0.3000***
	(-3.58)	(-6.97)
Tangibility	-3.8145***	-1.6289***
	(-5.11)	(-6.54)
log(1+Coverage Ratio)	0.2469***	0.0819***
	(3.00)	(2.62)
Market-to-Book	-0.0032	0.0007*
	(-1.02)	(1.66)
Current Ratio	0.0308	0.0562
	(0.44)	(0.96)
Leverage	0.7687	0.9436***
	(0.96)	(2.98)
Rating	-0.0741	-0.0506***
	(-1.52)	(-3.07)
No rating	-0.4063	-0.2977
	(-0.74)	(-1.51)
Constant	4.3022***	2.0189***
	(3.72)	(6.24)
Firm effects	Yes	Yes
Lead lender(s) effects	Yes	Yes
Year effects	Yes	Yes
Industry effects	Yes	Yes
Secured loan subsample	Yes	No
Observations	6438	8178
Adj. R-squared	0.6480	0.8627

Notes: This table shows OLS regressions of asset pledgeability on nonbank participation in a syndicated loan deal, and deal-level and loan-level control variables for a sample of U.S. Dollar denominated loans taken out by US nonfinancial corporations from 1990–2019. Dependent variables in both columns are pledgeability of tangible fixed assets, measured by *Loan Amount* relative to the borrowing firm's pledgeable assets for collateral-based borrowing, proxied by net property, plant and equipment (PP&E), and inventories. All other variables are described in Table 2.2. Column 1 is estimated on the subsample of secured loans, while Column 2 is estimated on the subsample of unsecured loans. 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.

2.5 Conclusion

This paper documents a long-term shift in corporate loan contracting from covenant-based to collateral-based borrowing and argues that the secular decline in interest rates is a key driver of this trend. Using data from U.S. syndicated loans, I show that as interest rates have declined over the past two decades, the incidence of covenants has fallen sharply, while the use of collateral has risen. This shift coincides with the growing role of Nonbank Financial Institutions (NBFIs) in credit markets, particularly in syndicated lending.

To explain this pattern, I develop a model in which banks and NBFIs differ in funding costs, regulatory constraints, and roles in contracting. Banks have a comparative advantage in monitoring and can offer both collateral-based and covenant-based loan contracts, while NBFIs, which are less regulated and actively invest through securitization, prefer collateral-based structures. As interest rates fall, banks' deposit-based funding advantage is diminished, NBFI participation increases due to their relative regulatory advantage and higher loan recovery rates. As a result, banks increasingly originate collateral-based loans to be distributed to NBFIs, and covenant-based lending declines.

The empirical findings support this mechanism and reveal a new channel through which long-term interest rates affect firm borrowing constraints and credit market outcomes. Falling interest rates not only increase credit supply but also change the composition of lenders and the contractual terms of borrowing. The increased reliance on collateral-based lending has important implications for which firms gain access to credit, potentially disadvantaging those without sufficient pledgeable assets. It also alters the mechanism through which shocks and policies are transmitted to firms: when earnings-based credit is less prevalent, the role of covenants in amplifying shocks diminishes, and the financial accelerator channel through asset values becomes more dominant.

This shift in the nature of corporate borrowing raises important questions for financial stability and the design of monetary policy. In particular, the procyclical nature of nonbank liquidity provision may amplify credit cycles, making downturns more severe when interest rates rise. At the same time, monetary policy may have unintended distributional effects by changing the nature of credit constraints across firms.

By drawing attention to the changing composition of loan contracts and lenders, this paper contributes to the broader literature on macro-finance, financial intermediation, and the role of interest rates in determining firm-level credit conditions. Understanding how financial intermediation evolves in response to long-term trends in interest rates is crucial for evaluating the aggregate effects of policies and designing effective policy responses to future crises.

2.6 Appendix: proofs and model solutions

2.6.1 Proof of Lemma 2.3

The productivity threshold above which covenant-based contract provides greater credit availability than collateral-based contract is given by:

$$\underline{a}^p(n_1, r) \;=\; \frac{\max\{\theta_B^k, \theta^k(r)\}(1-\delta)}{\eta} \cdot \frac{k_2^*(n_1, r)}{f\big(k_2^*(n_1, r)\big)}.$$

First observe from equation (2.1) that $\theta^k(r)$ is decreasing in r and increasing in k.

Suppose that the production exhibits constant returns to scale. The term on the right hand side $\frac{k_2^*(n_1,r)}{f\left(k_2^*(n_1,r)\right)}$ is independent of k^*, and hence also independent or r. Since $\theta^k(r)$ is decreasing in r, the threshold is hence weakly decreasing in r.

Suppose instead that the production function exhibits decreasing returns to scale. As r increases, the optimal level of investment $k_2^*(n_1, r)$ falls due to higher user cost of capital. Given decreasing returns to scale, $\frac{k_2^*(n_1,r)}{f\left(k_2^*(n_1,r)\right)}$, which is increasing in k^*, falls as r increases. Since $\theta^k(r)$ is also decreasing in r, the threshold is hence strictly decreasing in r.

Overall, for non-increasing returns to scale production function, the productivity threshold is hence weakly decreasing in r.

2.6.2 Proof of Proposition 2.1

Lemma 2.1 indicates that the collateral-based credit supply limit varies with interest rate. Thus, the productivity threshold characterized in Lemma 2.2 becomes:

$$\underline{a}^p(n_1, r) = \begin{cases} \dfrac{\theta_B^k(1-\delta)}{\eta} \cdot \dfrac{k_2^*(n_1, r)}{f(k_2^*(n_1, r))}, & \text{if } r \geq \underline{r}(k_2^*(n_1, r)), \\ \dfrac{\theta^k(r)(1-\delta)}{\eta} \cdot \dfrac{k_2^*(n_1, r)}{f(k_2^*(n_1, r))}, & \text{if } r < \underline{r}(k_2^*(n_1, r)). \end{cases}$$

When $r < \underline{r}(k_2^*(n_1, r))$, both the demand channel and the loan securitization channel function in generating the negative effect of r on the productivity threshold. When $r \geq \underline{r}(k_2^*(n_1, r))$, only the demand channel functions, as nonbank does not participate in loan securitization and transaction.

Consider a counterfactual economy without nonbank investor, in which the demand channel is the only channel through which interest rate r has an effect on the threshold. This is analogous to the case when $r \geq \underline{r}(k_2^*(n_1, r))$ in the benchmark channel. Since $\theta^k(r)$ is decreasing in r, the absence of the loan securitization channel implies that the effect of r on $\underline{a}^p$ in the counterfactual economy is much weaker than the benchmark economy with nonbank participation.

For any $r < \underline{r}(k_2^*(n_1, r))$, the absolute effect of r on the contract-choice productivity cutoff $\underline{a}^p(n_1, r)$ is strictly smaller in the absence of nonbank participation than when nonbanks are active.

2.6.3 Model solutions

Firm's objective function in (2.10) can be rewritten as:

$$\max_{b_2, k_2, d_2} \quad U^F(d_2) = d_2 = af(k_2) + (1-\delta)k_2 - (1+r)(k_2 - n_1).$$

To solve the model analytically, I assume that the firm production function $y_2 = af(k_2) = ak_2^\alpha$, where $\alpha \in (0,1)$. Without loss of generality, I assume that the bank's bargaining power in determining price of transaction $\kappa = 1$.

The firm maximizes $U^F(d_2)$ stated above subject to borrowing constraint (2.7). First I consider the case of $r \geq \underline{r}(k_2)$, i.e., nonbank investor does not participate in the loan transaction. Resulting capital choice is given by:

$$k^*_{2,\text{hold}}(n_1, r) = \min\left\{\left(\frac{\alpha a}{r+\delta}\right)^{\frac{1}{1-\alpha}}, \max\left\{\frac{1+r}{(1+r)-\theta^k_B(1-\delta)}\, n_1,\ b^\pi_2(n_1)+n_1\right\}\right\}, \tag{2.14}$$

where $b^\pi_2(n_1)$ solves $(1+r)b^\pi_2(n_1) = \eta a f(b^\pi_2(n_1)+n_1)$.

The resulting threshold above which covenant-based contract is preferred is given by:

$$\underline{a}^p(n_1, r)_H = \frac{(1-\delta)\theta^k_B}{\eta}\left(1 - \frac{(1-\delta)\theta^k_B}{1+r}\right)^{\alpha-1} n_1^{1-\alpha}. \tag{2.15}$$

Similarly, consider the case of $r < \underline{r}(k_2)$, i.e., nonbank investor participates in the loan transaction, and the bank originates-to-distribute. Resulting capital choice is given by:

$$k^*_{2,\text{distribute}}(n_1, r) = \min\left\{\left(\frac{\alpha a}{r+\delta}\right)^{\frac{1}{1-\alpha}}, \max\left\{\frac{1+r}{(1+r)-\theta^k_N(1-\delta)}\,(n_1 - C),\ b^\pi_2(n_1)+n_1\right\}\right\}, \tag{2.16}$$

where $b^\pi_2(n_1)$ solves $(1+r)b^\pi_2(n_1) = \eta a f(b^\pi_2(n_1)+n_1)$.

The resulting threshold above which covenant-based contract is preferred is given by:

$$\underline{a}^p(n_1, r)_D = \frac{1}{\eta}\,(1+r)^{1-\alpha}\left(1+r-(1-\delta)\theta^k_N\right)^{\alpha-1}\frac{(1-\delta)\theta^k_N\, n_1 - (1+r)C}{(n_1-C)^\alpha}. \tag{2.17}$$

The nonbank participation interest rate threshold is hence given by:

$$\underline{r}(n_1) = (1-\delta)\theta_B^k + \frac{(1-\delta)(\theta_N^k - \theta_B^k)}{C} n_1 - 1. \tag{2.18}$$

2.6.4 Model calibration

Table 2.5 presents value I set for structural parameters of the model. The first two parameters are standard in U.S. data. I set collateral constraint tightness for bank loans to match the average debt-to-asset ratio of borrowers facing collateral constraints in Compustat-DealScan data, and that for nonbank loan to match the nonbank-bank difference in loan loss given default at 4%. Nonbank's fixed cost is calibrated to match a 200 basis points spread in wholesale vs. retail funding cost when bank is indifferent between holding the loan to maturity and originating-to-distribute in equilibrium.

Table 2.5: 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
θ_B^k	Bank recovery rate	0.41	Avg. debt/asset ratio in Compustat-DealScan
θ_N^k	Nonbank recovery rate	0.45	Haque et al. (2024)
C	Nonbank's fixed cost disadvantage	0.05	Retail vs. wholesale funding spread

2.7 Bibliography

Becker, B. & Ivashina, V. (2014). Cyclicality of credit supply: Firm level evidence. *Journal of Monetary Economics*, 62, 76–93.

Begenau, J. & Landvoigt, T. (2022). Financial regulation in a quantitative model of the modern banking system. *The Review of Economic Studies*, 89, 1748–1784.

Bernanke, B., Gertler, M., & Gilchrist, S. (1996). The financial accelerator and the flight to quality. *The Review of Economics and Statistics*, 78, 1–15.

Buchak, G., Matvos, G., Piskorski, T., & Seru, A. (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics*, 130, 453–483.

Chava, S. & Roberts, M. R. (2008). How does financing impact investment? the role of debt covenants. *The Journal of Finance*, 63, 2085–2121.

Chernenko, S., Erel, I., & Prilmeier, R. (2022). Why do firms borrow directly from nonbanks? *The Review of Financial Studies*, 35, 4902–4947.

Chodorow-Reich, G. (2014). The employment effects of credit market disruptions: Firm-level evidence from the 2008–9 financial crisis. *The Quarterly Journal of Economics*, 129, 1–59.

Chodorow-Reich, G. & Falato, A. (2022). The loan covenant channel: How bank health transmits to the real economy. *The Journal of Finance*, 77, 85–128.

Degryse, H., Karapetyan, A., & Karmakar, S. (2021). To ask or not to ask? bank capital requirements and loan collateralization. *Journal of Financial Economics*, 142, 239–260.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The*

Review of Economic Studies, 51, 393–414.

Drechsel, T. (2023). Earnings-based borrowing constraints and macroeconomic fluctuations. *American Economic Journal: Macroeconomics*, 15, 1–34.

Farhi, E. & Tirole, J. (2021). Shadow banking and the four pillars of traditional financial intermediation. *The Review of Economic Studies*, 88, 2622–2653.

Fleckenstein, Q., Gopal, M., Gutiérrez, G., & Hillenbrand, S. (2025). Nonbank lending and credit cyclicality. *The Review of Financial Studies*, (pp. hhaf024).

Gopal, M. & Schnabl, P. (2022). The rise of finance companies and fintech lenders in small business lending. *The Review of Financial Studies*, 35, 4859–4901.

Greenwald, D. (2019). Firm debt covenants and the macroeconomy: The interest coverage channel. *SSRN Electronic Journal*.

Haque, S., Mayer, S., & Wang, T. (2024). How private equity fuels non-bank lending. *Finance and Economics Discussion Series*, Board of Governors of the Federal Reserve System (U.S.).

Hillenbrand, S. (2025). The fed and the secular decline in interest rates. *The Review of Financial Studies*, 38, 981–1013.

Hofmann, B., Li, Z., & Wu, S. P. Y. (2025). Monetary policy and the secular decline in long-term interest rates: A global perspective. *BIS Working Papers No.1252*, Bank for International Settlements.

Irani, R. M., Iyer, R., Meisenzahl, R. R., & Peydró, J.-L. (2021). The rise of shadow banking: Evidence from capital regulation. *The Review of Financial Studies*, 34, 2181–2235.

Ivashina, V. & Sun, Z. (2011). Institutional demand pressure and the cost of corporate loans. *Journal of Financial Economics*, 99, 500–522.

Ivashina, V. & Vallée, B. (2025). Weak credit covenants. *Management Science*, Forthcoming.

Jiménez, G., Ongena, S., Peydró, J.-L., & Saurina, J. (2017). Macroprudential policy, countercyclical bank capital buffers, and credit supply: Evidence from the spanish dynamic provisioning experiments. *Journal of Political Economy*, 125, 2126–2177.

Kiyotaki, N. & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, 105, 211–248.

Lian, C. & Ma, Y. (2021). Anatomy of corporate borrowing constraints. *The Quarterly Journal of Economics*, 136, 229–291.

Plantin, G. (2015). Shadow banking and bank capital regulation. *The Review of Financial Studies*, 28, 146–175.

Prilmeier, R. & Stulz, R. M. (2020). Securities laws and the choice between loans and bonds for highly levered firms. *SSRN Electronic Journal*.

Ramcharan, R. (2020). Banks' balance sheets and liquidation values: Evidence from real estate collateral. *The Review of Financial Studies*, 33, 504–535.

Sarto, A. & Wang, O. (2025). The secular decline in interest rates and the rise of shadow banks. *Journal of Financial Economics*, Forthcoming.

Schwert, M. (2018). Bank capital and lending relationships. *The Journal of Finance*, 73, 787–830.

Shivdasani, A. & Wang, Y. (2011). Did structured credit fuel the lbo boom? *The Journal of Finance*, 66, 1291–1328.

Winton, A. (1995). Delegated monitoring and bank structure in a finite economy.

Journal of Financial Intermediation, 4, 158–187.

Òscar Jordà, Richter, B., Schularick, M., & Taylor, A. M. (2021). Bank capital redux: Solvency, liquidity, and crisis. *The Review of Economic Studies*, 88, 260–286.

Chapter 3

Project Heterogeneity and Long-Term Credit Relationships

3.1 Introduction

Credit relationships are an important determinant of firms' access to external finance and investment opportunities (see, e.g. Petersen & Rajan, 1994; Berger & Udell, 1995). By facilitating monitoring and reducing information asymmetries between borrowers and lenders, stable relationships can help firms alleviate credit constraints and sustain investment. Consequently, the destruction of credit relationships, particularly during crisis episodes, can have adverse effects on firm investment and broader macroeconomic outcomes (Cohen et al., 2021; Bethune et al., 2022). The fragility of credit relationships can thus fuel financial instability and amplify macroeconomic fluctuations.

Not only small businesses, but also large publicly listed firms, rely on access to credit through stable credit relationships[1]. While a large body of research has studied how micro-level heterogeneity in firm characteristics affects the transmission of macroeconomic shocks and monetary policy (see e.g. Crouzet & Mehrotra, 2020; Ottonello & Winberry, 2020; Cloyne et al., 2023), relatively little attention

[1]The effects of credit relationships on small business lending have been well documented in the relationship lending literature, and Chapter 1 has documented that credit relationships are also prevalent in the syndicated loan market for U.S. nonfinancial corporations.

has been paid to how firm heterogeneity interacts with relationship-based financial frictions to shape aggregate dynamics. Motivated by the fragility of credit relationships and their prevalence across the firm size distribution, this paper studies how project heterogeneity affects investment dynamics and shock transmission in a dynamic equilibrium model of long-term credit relationships.

To study this, I build on the framework by den Haan et al. (2003), which incorporates matching frictions, liquidity allocation frictions, and contractual imperfections in dynamic credit relationships. This environment provides a natural setting to examine how credit relationship formation and separation amplify macroeconomic fluctuations. Their framework captures two widely documented stylized facts on credit relationships: first, most credit relationships between banks and firms are long-term and covenanted (e.g., Sufi, 2009; Roberts & Sufi, 2009; Acharya et al., 2014); and second, it is costly for borrowers to switch lenders, suggesting evidence of matching frictions in the credit market (e.g., Chava & Purnanandam, 2011; Chernenko & Sunderam, 2014; Chodorow-Reich, 2014). I extend their framework by introducing project heterogeneity, where entrepreneurs draw investment opportunities with different productivities. The extension is motivated by two additional stylized facts: different types of borrowers were heterogeneously affected during the 2008 financial crisis (e.g., Chodorow-Reich, 2014; Schwert, 2018; Berger et al., 2017); and different types of banks were also affected differently during the crisis (e.g., Chodorow-Reich, 2014; Chen et al., 2017; Begenau et al., 2025). These facts suggest that the formation, continuation, and separation of credit relationships are shaped by the characteristics of both borrowers and lenders. Consequently, the macroeconomic consequences of the fragility of relationships depend on the distribution of firm productivity and its interaction with financial frictions.

Introducing project heterogeneity alters the nature and consequences of the fragility of credit relationships. In equilibrium, lenders matched with low-productivity entrepreneurs have weaker incentives to continue the relationship, because the expected surplus from the match is lower and the possibility of rematching with a more productive entrepreneur. Such lenders require higher realizations of liquidity to sustain the relationship. By contrast, lenders matched with high-productivity entrepreneurs are more reluctant to separate, given the potential loss associated with rematching with a lower-productivity entrepreneur. These lenders are willing to accept lower payoffs in low-liquidity states to remain in the relationship. This asymmetric fragility across the productivity distribution gives rise to three key dynamics. First, relationship separations are driven by different mechanisms: separations with high-productivity entrepreneurs tend to be involuntary due to liquidity shortfalls, whereas those with low-productivity entrepreneurs are more likely to be voluntary, driven by upward matching incentives. Second, project heterogeneity contributes to capital misallocation: some low-productivity projects are over-funded, while high-productivity projects may be under-funded. Third, this misallocation amplifies the overall fragility of relationships by increasing the responsiveness of inefficient relationship separation to adverse shocks. Together, these forces lead to a lower level of aggregate investment in steady-state equilibrium and create an additional amplification mechanism beyond those identified in den Haan et al. (2003).

The prevalence of earnings-based loan contracts in corporate borrowing (e.g. Lian & Ma, 2021; Drechsel, 2023) suggests that contractual agreements often link entrepreneurial payoffs to project performance. Motivated by this, I extend the model by endogenizing agency frictions: instead of a fixed outside option, the entrepreneur can now walk away from the relationship with a fraction of the project output. This formulation links the entrepreneur's incentive compatibility to realized outcomes, effectively capturing the nature of performance-based contracts. This extension delivers two key results. First, it raises steady-state aggregate investment by improving the efficiency of match continuation: lenders no longer need to overcompensate entrepreneurs with low-productivity projects, mitigating capital misallocation. Second, increasing the share of divertible output strengthens the link between entrepreneurial payoffs and project outcomes, which enhances matching efficiency and raises aggregate investment in the medium run, despite short-run disruptions due to a higher incidence of relationship separation triggered by opportunistic exit behavior.

3.1.1 Related literature

This paper is related to the literature on long-term relationships in credit markets. An early approach by den Haan et al. (2003) establishes that complementarity between financial intermediation and investment gives rise to both equilibria with a functioning investment channel, and the collapse equilibria where such channel ceases to operate. This complementarity also serves as a mechanism for aggregate shock propagation. The contribution of my paper, which builds on the setting of theirs, is the introduction of project heterogeneity and endogenous agency frictions. The interaction between project heterogeneity and lender heterogeneity generates higher fragility of long-term credit relationships and liquidity misallocation, and hence lower aggregate investment. It also creates an amplification of the decline in investment during the crisis. Endogenous agency frictions give rise to limited enforceability, which generates a unique equilibrium. Several recent papers in the literature follow a similar path (e.g. Boualam, 2018; Payne, 2024), but with different implications. Unlike Payne (2024), in which project heterogeneity affects long-term relationships through innate higher risks associated with projects with higher level of productivity, project risks in my paper are endogenized and originate from the interaction between project heterogeneity and allocation frictions. The resulting implications are hence different: project heterogeneity amplifies distortions by other frictions, rather than the opposite. Furthermore, a shift towards performance-based contracts is associated with more stable credit relationships and a higher level of aggregate economic activity.

The paper also fits into the vast macro-finance literature on aggregate implications of financial frictions[2]. A large number of papers have examined how frictions on the supply of funds can create an amplification effect on the aggregate economy during a crisis (e.g. Gertler & Kiyotaki, 2010; Brunnermeier & Sannikov, 2014). The liquidity spirals in these papers are driven by falling prices of bank assets and deleveraging after an initial adverse shock. Instead, I focus on how frictions in the credit relationship between lenders and entrepreneurs can cause fragility in liquidity and therefore amplify adverse shocks during a crisis, complementing the literature on relationship banking (e.g. Sharpe, 1990). The fragility of relationships can cause costly credit disruptions, and hence the level of fragility determines the value of a relationship, which can be regarded as a part of the balance sheet of a lender, and in this sense this paper is indirectly linked to literature on bank balance sheet.

This paper is also part of the literature on search and matching frictions in credit markets. In particular, several papers have stressed the role of search and matching frictions in credit markets and in the transition dynamics of the aggregate economy (e.g. den Haan et al., 2003; Wasmer & Weil, 2004; Petrosky-Nadeau & Wasmer, 2013; Rocheteau et al., 2018). My paper focuses on the interaction between matching frictions and project heterogeneity. The adverse effects of matching frictions on the formation of credit relationships can be persistent in the presence of project heterogeneity and create liquidity misallocation due to upward matching incentives.

Finally, the paper is linked to the literature on allocative concerns on innovation. In particular, the rise of superstar firms (Autor et al., 2020) and the increasing skewness in firm size and productivity distributions have raised concerns on the macroeconomic consequences of such heterogeneity. This paper contributes by proposing a relationship channel: increased heterogeneity, potentially driven by innovation, can

[2]See Brunnermeier et al. (2013) for an excellent survey on this literature.

exacerbate financial frictions by amplifying the aggregate fragility of relationships and capital misallocation, generating adverse effects on aggregate outcomes.

3.1.2 Structure of the paper

The remainder of the paper is organized as follows. Section 3.2 presents the theoretical framework to analyze the effects of project heterogeneity. Section 3.3 calibrates the model and examines the quantitative implications of project heterogeneity. Section 3.4 shows an extension to the baseline model with endogenous agency frictions. Section 3.5 concludes.

3.2 Model

This section presents a dynamic equilibrium model of long-term credit relationships in an economy with heterogeneous entrepreneurial projects and multiple frictions in financial intermediation. Building on den Haan et al. (2003), the model introduces heterogeneity in project productivity and considers its interaction with frictions in liquidity allocation, matching, and contracting. These frictions jointly determine the formation and continuation of credit relationships and shape aggregate investment and macroeconomic dynamics. There are three types of agents: a representative household, a unit mass of financial intermediaries (lenders), and a continuum of entrepreneurs.

The representative household supplies liquidity to the financial system and consumes the returns from investments. In each period, the household chooses the level of savings to maximize lifetime utility, taking the aggregate return to savings as given. Let r denote the risk-free interest rate, and the household discounts future returns at rate $\beta = \frac{1}{1+r}$. The household supplies aggregate liquidity H_t to financial intermediaries (lenders) up to the point where $R_t = r$ in equilibrium, where R_t

denotes the expected return to liquidity at time t.

Lenders act as financial intermediaries and receive in aggregate H_t units of funds from households at the beginning of the period t. These funds are used to finance entrepreneurial projects through bilateral credit relationships. All lenders are eligible for access to these funds. Each lender receives an individual allocation of liquidity h_t that depends both on aggregate liquidity H_t and on a liquidity allocation rule that is subject to allocation frictions. When matched with an entrepreneur, a lender offers a take-it-or-leave-it contract that specifies the investment level and the payment to the entrepreneur contingent on realized project output. Upon agreement, the lender transfers funds for production. Income generated from these contracts is ultimately repaid to households.

Entrepreneurs are the only agents with access to productive technologies. At the start of the period t, an unmatched entrepreneur i randomly draws a productivity $A_{i,t}$ from distribution $\Omega(A)$, while an entrepreneur continuing from a previous credit relationship j continues to enjoy the prior productivity level $A_{j,t} = A_{j,t-1}$. This assumption reflects empirical observations that startup productivity is highly dispersed and that productive ideas tend to bring longer-term growth, and hence productivities persist. Entrepreneurs are not endowed with any financial wealth, and derive utilities solely from contractual payments received from lenders. Given a match and an investment of h_t, an entrepreneur with productivity $A_{i,t}$ produces output $A_{i,t}f(h_t)$, where $f(\cdot)$ is strictly increasing and concave, with $f(0) = 0$ and $f'(0) = \infty$. The market for new projects is perfectly competitive, and entrepreneurs accept any contract that yields a non-negative payoff relative to their outside option.

Each period is divided into four sub-periods:

1. **Realization period**: Lenders receive liquidity from household savings in the previous period, and each lender draws an idiosyncratic realization of available funds. Unmatched entrepreneurs draw a new project productivity level;

2. **Matching and contracting period**: Unmatched lenders and entrepreneurs enter the pool of matching. Newly matched pairs, as well as existing matches, engage in contract negotiations. Contracts specify the terms of investment and payment.

3. **Production period**: Entrepreneurs who accept a contract receive the agreed amount of liquidity, produce, and generate output. Payments are made based on contract terms;

4. **Decision period**: Households receive investment returns and make consumption and saving decisions. Entrepreneurs in ongoing relationships decide whether to continue the relationship or exit and re-enter the matching pool in the next period.

3.2.1 Frictions in the credit market

This section introduces the three main frictions that interact with project heterogeneity in affecting equilibrium outcomes in the model: frictions in the allocation of liquidity across lenders, frictions in the process of matching, and frictions arising from limited commitment in contracts. Together, these imperfections give rise to fragile credit relationships, capital misallocation, and amplification of macroeconomic shocks.

3.2.1.1 Liquidity Allocation Friction

Liquidity provided by households is not allocated uniformly across lenders. Following den Haan et al. (2003), I model liquidity allocation using a reduced-form stochastic rule: at the beginning of period t, each lender draws an individual liquidity realization h_t from a distribution $v(h_t \mid H_t)$ that depends on the aggregate supply of liquidity H_t. The distribution satisfies three properties: (i) $v(h_t \mid H_t)$ is continuous and increasing in H_t; (ii) the probability of receiving zero liquidity, $h_t = 0$, is strictly positive; and (iii) lenders do not have access to future liquidity flows. This liquidity rule generates ex-post heterogeneity across lenders and distorts efficient allocation of aggregate liquidity in the economy:

$$\int_0^\infty h_t \, dv(h_t \mid H_t) = H_t. \tag{3.1}$$

When liquidity is not efficiently allocated among lenders, project heterogeneity amplifies the consequences of misallocation. When high-productivity entrepreneurs are matched with lenders who receive low liquidity, their projects may be underfunded, and vice versa. This generates larger losses associated with capital misallocation than in an economy with homogeneous productivity.

3.2.1.2 Matching Friction

The market for credit relationships is subject to search and matching frictions. In each period, unmatched lenders enter a matching pool to search for entrepreneurs. Similarly, unmatched entrepreneurs enter the pool after observing their productivity draws and must pay a search cost c. Lenders that were previously matched may continue the existing relationship or opt to enter the matching pool.

Let U_t denote the mass of unmatched lenders and V_t the mass of unmatched entrepreneurs in period t. Define funding tightness as $\theta_t = \frac{V_t}{U_t}$. A higher θ_t indicates a greater shortage of liquidity relative to the number of new projects to be funded, and therefore a higher probability of matching with an entrepreneur for the lender. The probability that a lender is matched with an entrepreneur in the matching pool in period t is given by the matching probability function $\lambda(\theta_t)$, which is strictly increasing in θ_t, and follows $\lambda(0) = 0$ and $\lambda(\infty) = 1$. The implied probability that an unmatched entrepreneur is matched is $\frac{\lambda(\theta_t)}{\theta_t}$, which is strictly decreasing in θ_t. The total number of new relationships formed is thus $\lambda(\theta_t)U_t$.

Heterogeneous project values imply that matching has asymmetric payoffs. High-productivity entrepreneurs benefit more from being matched, but are also more likely to break relationships if continuation is uncertain. This creates endogenous fluctuations in matching efficiency over time.

3.2.1.3 Contracting Friction

Once matched, either newly matched or continuing from previous relationship, each lender proposes a take-it-or-leave-it contract to the matched entrepreneur. The contract specifies an investment amount h_t, output $A_{i,t}f(h_t)$, and a payment $p_{i,t}$ to the entrepreneur conditional on production. If accepted, production takes place in the same period; otherwise, the lender re-enters the matching pool, while the entrepreneur waits until the next period for a new productivity draw.

Unlike in den Haan et al. (2003), where contractual imperfection arises from moral hazard, contractual frictions in this model come from limited commitment. Entrepreneurs may walk away with part of the output at the end of the production period, particularly when their continuation value is low. This is captured by allowing entrepreneurs to retain an output amount x, which can be interpreted as divertible output. I assume that such concealment is eventually detectable (e.g., via auditing), and detected deviation leads to relationship termination. Later in the paper, I endogenize this friction by modeling $x_{i,t} = \rho A_{i,t}f(h_t)$, where $\rho \in [0, 1]$ captures the degree of contract enforceability. A higher ρ reflects weaker enforcement and a greater ability of the entrepreneur to divert output upon exiting the relationship.

Contractual imperfections are amplified when the option to sever relationships is more attractive for relationships with low-productivity projects. Project heterogeneity induces more frequent ex-post breakups, further exacerbating the fragility of credit relationships and reducing aggregate investments.

3.2.2 Lender-entrepreneur contracting

Consider a matched relationship in period t between a lender with liquidity h_t and an entrepreneur with productivity $A_{i,t}$, either drawn in the current period or carried over from a previous realization. The lender chooses to offer a production contract if the expected value from continuing the relationship exceeds that from rematching. Formally, the lender's participation constraint is:

$$A_{i,t}f(h_t) - p_{i,t} + g_{i,t} - g^e_{i,t} \geq w_t, \tag{3.2}$$

where $p_{i,t}$ is the payment to the entrepreneur i with productivity $A_{i,t}$ in period t, $g_{i,t}$ is the present value of joint future expected cash flows from continuing the relationship, $g^e_{i,t}$ is the present value of future expected payment to the entrepreneur i (and hence the present value of the future expected cash flow of the entrepreneur), w_t is the lender's expected cash flow from rematching in the current period. $A_{i,t}f(h_t) - p_{i,t}$ and $g_{i,t} - g^e_{i,t}$ are the current and future expected cash flows from the contract to the lender, respectively.

Because lenders cannot borrow against future income, they must also satisfy a liquidity constraint when designing the contract:

$$p_{i,t} \leq A_{i,t}f(h_t) + h_t. \tag{3.3}$$

I make a further assumption that if participation constraint (3.2) is satisfied, the lender is still willing to propose a contract to the entrepreneur even when facing the risk of diversion of output by the entrepreneur and relationship termination:

$$A_{i,t}f(h_t) - x + \beta\mathbb{E}(w_{t+1}) \geq w_t,$$

where x is the amount of output that the entrepreneur can divert. This condition implies that the present cash flows from the project to the lender plus the present value of the future expected cash flow from entering the matching pool in the next period is greater than the expected cash flow from re-entering the matching pool. This ensures that the lender is willing to extend liquidity and continue to the production stage even when separation is inevitable. It is automatically satisfied for sufficiently small x or sufficiently high β.

From the entrepreneur's perspective, accepting a contract is strictly preferred to rejection, since rejecting yields zero current payoff and requires waiting for a new match. The worst-case scenario under a contract is to produce, divert x, and reenter the matching pool in the next period. Hence, the entrepreneur accepts any offer and decides whether to continue the relationship after production. The relationship continues if:

$$p_{i,t} + g^e_{i,t} \geq x, \tag{3.4}$$

which states that the sum of current and future expected cash flows exceeds the outside option from severing the relationship and waiting for matching in subsequent periods. Because the market for new projects is competitive, the entrepreneur's value of being unmatched is zero.

Anticipating this, the lender seeks to minimize the payment to the entrepreneur to maximize its own cash flows, subject to the continuation constraint of the entrepreneur (3.4). Thus, the entrepreneur's continuation constraint binds in equilibrium. Furthermore, since entrepreneurs are assumed not to have any financial asset that can be used as part of the transfer in the contract, the payment to entrepreneurs cannot be negative, i.e., lenders are unable to 'penalize' entrepreneurs. Thus, combining this condition with the binding continuation constraint yields the following:

$$p_{i,t} = \max\left\{0, x - g^e_{i,t}\right\}. \tag{3.5}$$

A relationship continues under this contract if conditions (3.2), (3.3), and (3.5) are satisfied.

3.2.3 Endogenous relationship separation

If any of the conditions (3.2), (3.3), or (3.4) is not satisfied, the credit relationship between the lender and the entrepreneur will terminate. Breakup may occur in two forms, which I refer to as *ex-ante* and *ex-post*. Ex-ante breakup arises when the lender realizes insufficient liquidity at the start of the period, such that it cannot provide sufficient compensation for the entrepreneur to continue the relationship. In this case, the lender chooses not to offer a contract and the relationship terminates immediately, in line with den Haan et al. (2003). Ex-post breakup arises due to project heterogeneity, and occurs when the entrepreneur draws a low level of productivity, resulting in a relatively low continuation value. Intuitively, the entrepreneur may still accept a contract to produce in the current period, but the lender and the entrepreneur may prefer to break up and match again in the next period, hoping to draw a higher productivity or to be matched with an entrepreneur with high productivity.

Hence, there exists a productivity-specific liquidity threshold $\underline{h}_t(A_{i,t}) \geq 0$, below which the relationship terminates. To characterize this threshold, I substitute (3.5) into (3.2) and (3.3), and solve for the point at which either constraint binds. The resulting threshold can be expressed as:

$$A_{i,t} f(\underline{h}_t(A_{i,t})) + \min\left\{\underline{h}_t(A_{i,t}) - \max\{0, x - g^e_{i,t}\},\ g_{i,t} - w_t - \max\{g^e_{i,t}, x\}\right\} = 0. \tag{3.6}$$

3.2.4 Values of continuing relationships

If an endogenous breakup, either ex-ante or ex-post, does not occur in the current period, a lender matched with an entrepreneur of productivity $A_{i,t}$ expects to extend a contract to the entrepreneur in the next period, provided that the realization of $h_{t+1} \geq \underline{h}_{t+1}(A_{i,t+1}) = \underline{h}_{t+1}(A_{i,t})$, since productivity is carried over in a continuing relationship. The resulting expected output in the next period is given by:

$$\mu(\underline{h}_{t+1}(A_{i,t+1}) \mid H_{t+1}) = \int_{\underline{h}_{t+1}(A_{i,t+1})}^{\infty} A_{i,t+1} f(h_{t+1})\, dv(h_{t+1} \mid H_{t+1}). \tag{3.7}$$

The present value of expected future joint cash flows for a continuing pair with $A_{i,t} = A_{i,t+1}$, denoted by $g_{i,t}$, is given by the discounted value of expected future production, conditional on continuation:

$$g_{i,t} = \beta \left\{ \mu(\underline{h}_{t+1}(A_{i,t+1}) \mid H_{t+1}) + v(\underline{h}_{t+1}(A_{i,t+1}) \mid H_{t+1}) w_{t+1} + \left[1 - v(\underline{h}_{t+1}(A_{i,t+1}) \mid H_{t+1})\right] g_{i,t+1} \right\}. \tag{3.8}$$

The present value of expected future cash flows to the entrepreneur, $g^e_{i,t}$, consists of the discounted expected payment and the continuation value:

$$g^e_{i,t} = \beta \int_{\underline{h}_{t+1}(A_{i,t+1})}^{\infty} \left(p_{i,t+1} + g^e_{i,t+1}\right)\, dv(h_{t+1} \mid H_{t+1}). \tag{3.9}$$

Proposition 3.1. *In any equilibrium, $g^e_{i,t} \leq \beta x$ for any $A_{i,t}$ realized, in every period t.*

Proposition 3.1 states that the entrepreneur's expected continuation value must not exceed the maximum amount that can be retained by severing the relationship. The proof is provided in the Appendix. Intuitively, any contract offering more than the outside option would be suboptimal from the lender's perspective, as payments to the entrepreneur could be reduced without violating the entrepreneur's incentive compatibility (continuation) constraint.

The expected output from a project before the realization of liquidity and matching in period t is given by:

$$\bar{\mu}(\underline{h}_t(A) \mid H_t) = \int \mu(\underline{h}_t(A) \mid H_t) \, d\Omega(A). \tag{3.10}$$

The expected probability of breakup is:

$$\bar{v}(\underline{h}_t(A) \mid H_t) = \int v(\underline{h}_t(A) \mid H_t) \, d\Omega(A). \tag{3.11}$$

The present value of future expected joint cash flows from a newly matched project in the next period, g_t, is given by:

$$g_t = \beta \left\{ \bar{\mu}(\underline{h}_{t+1}(A) \mid H_{t+1}) + \bar{v}(\underline{h}_{t+1}(A) \mid H_{t+1}) w_{t+1} + \left[1 - \bar{v}(\underline{h}_{t+1}(A) \mid H_{t+1})\right] g_{t+1} \right\}. \tag{3.12}$$

The corresponding present value of expected payments to the entrepreneur under a new match is:

$$g_t^e = \int g_{i,t}^e \, d\Omega(A). \tag{3.13}$$

Finally, the present value of the expected cash flow to a lender from entering the matching pool, w_t, is:

$$w_t = \lambda(\theta_t)(g_t - g_t^e) + (1 - \lambda(\theta_t))\beta w_{t+1}, \tag{3.14}$$

which reflects the weighted average of the value of being matched with a new project and the continuation value of remaining unmatched.

3.2.5 Relationships and matching market dynamics

Denote by U_t the mass of lenders in the pool of matching in period t, and by N_t the mass of lenders matched with entrepreneurs at the start of period t. The mass of matched lenders in the next period, N_{t+1}, includes relationships that continue from the previous period and those formed through new matches. The law of motion for N_t is given by:

$$N_{t+1} = (1 - \bar{v}(\underline{h}_t(A) \mid H_t))N_t + \lambda(\theta_t)U_t. \tag{3.15}$$

The mass of lenders in the matching pool at time t, U_t, consists of those who begin the period in relationships but separate endogenously, and those who are unmatched at the beginning of the period:

$$U_t = \bar{v}(\underline{h}_t(A) \mid H_t)N_t + (1 - N_t). \tag{3.16}$$

Since the market for new projects is competitive, the free-entry condition ensures that entrepreneurs' expected gains from entering the matching pool equal the cost of entry. That is, the expected cash flow from matching must equal the matching cost:

$$\frac{\lambda(\theta_t)}{\theta_t} g_t^e - c = 0. \tag{3.17}$$

This condition is satisfied for sufficiently small c such that $\frac{c}{g_t^e} \leq 1$; otherwise, no entry occurs, and $\theta_t = 0$.

A recursive equilibrium is a collection of value functions $\{g_{i,t}, g_{i,t}^e, g_t, g_t^e, w_t\}_{t=0}^{\infty}$, liquidity threshold $\{\underline{h}_t(A)\}_{t=0}^{\infty}$, and aggregate variables $\{N_t, U_t, \theta_t, H_t\}_{t=0}^{\infty}$, such that given an initial number of relationships:

1. Given liquidity h_t and productivity $A_{i,t}$, the contract between a matched lender-entrepreneur pair satisfies the lender's participation constraint (3.2), liquidity constraint (3.3), and entrepreneur's continuation constraint (3.4);

2. The productivity-specific liquidity threshold $\underline{h}_t(A)$ in (3.6) determines whether a relationship continues;

3. Value functions evolve recursively according to (3.8), (3.9), (3.12), (3.13), and

(3.14);

4. Matching market dynamics follow (3.15) and (3.16), and the free-entry condition (3.17) holds;

5. The market for liquidity clears.

3.2.6 Implications of project heterogeneity

Let $\underline{A}$ be the lowest productivity level in the support of the productivity distribution $\Omega(A)$. Consider a counterfactual economy in which project heterogeneity is eliminated, and all entrepreneurs draw the same productivity level $\underline{A}$. Denote the degenerate productivity distribution in this counterfactual by $\Phi(A) = \{\underline{A}\}$.

To understand how project heterogeneity affects the fragility of credit relationships and liquidity allocation, I compare relationship outcomes under Ω and Φ for a lender matched with an entrepreneur of productivity $\underline{A}$. The contract structure, liquidity allocation rule, and matching frictions are held fixed. Since the project market is perfectly competitive, the net expected payoff from a new match for the entrepreneur is zero. The only difference lies in the lender's expectation of matching with an entrepreneur with higher productivity conditional on breakup and rematching.

Denote the liquidity threshold under the heterogeneous distribution Ω by $\underline{h}_t^{\Omega}(\underline{A})$, and under the homogeneous distribution Φ by $\underline{h}_t^{\Phi}(\underline{A})$. The thresholds are analogous to the one derived in (3.6).

Lemma 3.1. $\underline{h}_t^{\Omega}(\underline{A}) > \underline{h}_t^{\Phi}(\underline{A})$.

Proof: Under both the heterogeneous case $\Omega(A)$ and the homogeneous counterfactual $\Phi(A) = \{\underline{A}\}$, the value of a continuing relationship $g_{i,t}$ and the entrepreneur's continuation value $g_{i,t}^e$ at $A = \underline{A}$ are identical by construction. However, the value of reentering the matching pool w_t differs: under $\Omega(A)$, lenders may match with higher-productivity entrepreneurs in the future, whereas under $\Phi(A)$, all entrepreneurs have productivity $\underline{A}$. It follows from equation (3.14) that $w_t^{\Omega} > w_t^{\Phi}$. Now consider the lender's participation constraint in equation (3.2) evaluated at $A = \underline{A}$. Since $g_{i,t}$ and $g_{i,t}^{e}$ are identical across the two distributions, a higher w_t under Ω implies that the required cash flow from the project, $\underline{A}f(h_t) - p_{i,t}$, must be higher to satisfy the constraint. By equation (3.5), the payment to the entrepreneur is identical in both environments. Because $f(\cdot)$ is strictly increasing, the only way to raise $\underline{A}f(h_t)$ is to increase h_t. Therefore, the minimum liquidity h_t that supports the continuation of the relationship is strictly higher under Ω than under Φ.

This result shows that under Ω, a lender who exits a relationship anticipates the possibility of rematching with a higher-productivity entrepreneur in the future. This results in an expected value of re-entering the matching pool. In contrast, under Φ, all entrepreneurs are identical, and rematching provides no opportunity for better matches. As a result, the relative value of rematching and hence the opportunity cost of continuing with a low-productivity match is strictly higher under heterogeneity. Intuitively, when lenders expect to match with better projects in the future, they are more likely to terminate relationships with low-productivity entrepreneurs. Heterogeneity increases the continuation threshold and thus makes relationships more fragile in the left tail of the project productivity distribution.

Similarly, let $\bar{A}$ be the lowest productivity level in the support of the productivity distribution $\Omega(A)$. Consider another counterfactual economy in which project heterogeneity is eliminated, and all entrepreneurs draw the same productivity level $\bar{A}$. Denote the degenerate productivity distribution in this counterfactual by $\chi(A) = \{\bar{A}\}$. Denote the liquidity threshold under the heterogeneous distribution Ω by $\underline{h}_t^{\Omega}(\bar{A})$, and under the homogeneous distribution χ by $\underline{h}_t^{\chi}(\bar{A})$.

Corollary 3.1. $\underline{h}_t^{\Omega}(\bar{A}) < \underline{h}_t^{\chi}(\bar{A})$.

Corollary 3.1 follows the same logic as Lemma 3.1, and indicates that project heterogeneity makes relationships less fragile in the right tail of the project productivity distribution. When lenders expect that matches may be worse in the future, they are less likely to terminate the current relationship with a high-productivity entrepreneur. Thus, they are willing to continue such a relationship at lower liquidity realizations compared to the case with homogeneous productivity.

Proposition 3.2. *Project heterogeneity exacerbates liquidity misallocation.*

Proposition 3.2 follows from Lemma 3.1 and Corollary 3.1, which show that, relative to the homogeneous case, low-productivity projects require higher liquidity realizations to sustain relationships, while high-productivity projects are sustained with lower liquidity. Heterogeneity in productivity thus introduces a mismatch between project quality and liquidity allocation, amplifying distortions in capital allocation arising from liquidity allocation.

Proposition 3.3. *If the productivity distribution is right-skewed, project heterogeneity increases the fragility of relationships.*

Proposition 3.3 generalizes Lemma 3.1 and Corollary 3.1. When the productivity distribution exhibits right-skewness, a higher concentration of low-productivity projects implies that the adverse effect of project heterogeneity on relationship fragility becomes more pronounced. This result highlights a potential downside of innovation: by increasing the dispersion and right-skewness of project productivity, it can inadvertently raise the fragility of credit relationships, thereby exacerbating capital misallocation through the financial intermediation channel.

3.3 Quantitative implications of project heterogeneity

This section characterizes the model's steady state, calibrates the model, and reports quantitative results. The model is calibrated to assess how project heterogeneity interacts with allocation and matching frictions to shape aggregate outcomes. Then I examine the dynamic responses of the economy to aggregate shocks, highlighting how project heterogeneity amplifies the transmission of shocks through the credit relationship channel.

3.3.1 Steady states

Proposition 3.1 allows us to derive the following steady-state equilibrium conditions:

$$A_i f(\underline{h}(A_i)) + \min\{\underline{h}(A_i) - x + g_i^e,\ g_i - w - x\} = 0, \quad \forall i \tag{3.18}$$

$$g_i = \beta\big\{\mu(\underline{h}(A_i) \mid H) + v(\underline{h}(A_i) \mid H)\, w + \big[1 - v(\underline{h}(A_i) \mid H)\big]\, g_i\big\}\,, \quad \forall i \tag{3.19}$$

$$g_i^e = \beta\big(1 - v(\underline{h}(A_i) \mid H)\big)\, x, \quad \forall i \tag{3.20}$$

$$g = \beta\big\{\bar{\mu}(\underline{h}(A) \mid H) + \bar{v}(\underline{h}(A) \mid H)\, w + \big[1 - \bar{v}(\underline{h}(A) \mid H)\big]\, g\big\}\,, \tag{3.21}$$

$$g^e = \beta\big(1 - \bar{v}(\underline{h}(A) \mid H)\big)\, x, \tag{3.22}$$

$$w = \lambda(\theta)\,\big(g - g^e\big) + \big(1 - \lambda(\theta)\big)\,\beta w, \tag{3.23}$$

$$N = \big(1 - \bar{v}(\underline{h}(A) \mid H)\big)N + \lambda(\theta)U, \tag{3.24}$$

$$U = \bar{v}(\underline{h}(A) \mid H)\, N + (1 - N), \tag{3.25}$$

$$\frac{\lambda(\theta)}{\theta} = \frac{c}{g^e} \quad \text{if } \frac{c}{g^e} \leq 1, \quad \text{and} \quad \theta = 0 \text{ otherwise.} \tag{3.26}$$

Aggregate returns to liquidity provided by households in equilibrium can hence be characterized by aggregate production less aggregate payment to entrepreneurs:

$$R(H) = \frac{N\big(\bar{\mu}(\underline{h}(A) \mid H) - \big(1 - \bar{v}(\underline{h}(A) \mid H)\big)\big(x - g^e\big)\big)}{H}. \tag{3.27}$$

In equilibrium, the household supplies $H > 0$ such that $R(H) = r$ (with $\beta = 1/(1+r)$); if $R(H) < r$ for all $H > 0$, there is a collapse equilibrium with $H = 0$.

Since g^e is a function of x, the divertible output of the entrepreneur when terminating the relationship, and is strictly less than x, the aggregate return R is decreasing in x. Thus, for small x, there exists a steady-state equilibrium with positive investment. For sufficiently large x, $R(H) < r$ and the economy collapses. In the interest of the role that multiple frictions play, I focus on the steady-state equilibrium with positive investment.

3.3.2 Steady-state effects of project heterogeneity

Figures 3.1 and 3.2 illustrate aggregate investment, relationship dynamics, and returns to investments in the steady state under project heterogeneity. These results are obtained from the steady-state system (3.18) to (3.26)[3].

Figure 3.1 demonstrates the relationship between aggregate investment H and steady-state average returns R. The dotted line represents the value of interest rate

[3]To illustrate the effects of project heterogeneity its interaction with other frictions, the examples follow similar simulation specifications as in den Haan et al. (2003) in order to show a direct comparison. Specifically, I assume that the production function $f(h_t) = h_t^{\alpha}$, and productivity draw follows $A_i \in \{A_h, A_l\}$, in which A_h is drawn with probability p_h, and A_l is drawn with probability $1 - p_h$. The matching function is assumed to be $m(U_t, V_t) = \xi U_t^{\zeta} V_t^{1-\zeta}$. The liquidity allocation rule $v(h_t \mid H_t)$ has three support points, 0, $h_t^l(H_t)$, and $h_t^h(H_t)$, where $v(h_t^l(H_t) \mid H_t) = v(h_t^h(H_t) \mid H_t) = \gamma H_t^{\eta}$, $h_t^l(H_t) = H_t/(3v(h_t^l(H_t) \mid H_t))$, and $h_t^h(H_t) = (2H_t)/(3v(h_t^h(H_t) \mid H_t))$. Entrepreneurs with productivity A_l would want to be in a relationship with lenders with investable fund $h_t^l(H_t)$ and above, and those with productivity A_h would want to be in a relationship only if lenders realize $h_t^h(H_t)$. The parameters in the model take the following values: $\alpha = 0.3$, $A_h = 2$, $A_l = 1$, $p_h = 0.1$, $\beta = 0.96$, $\xi = 0.25$, $\zeta = 0.5$, $\gamma = 0.2$, $\eta = 0.2$, and $x = 3$. Given the assumptions and parameter values, steady-state values of variables yield an implied value of entrepreneur's cost of matching $c = 0.277$.

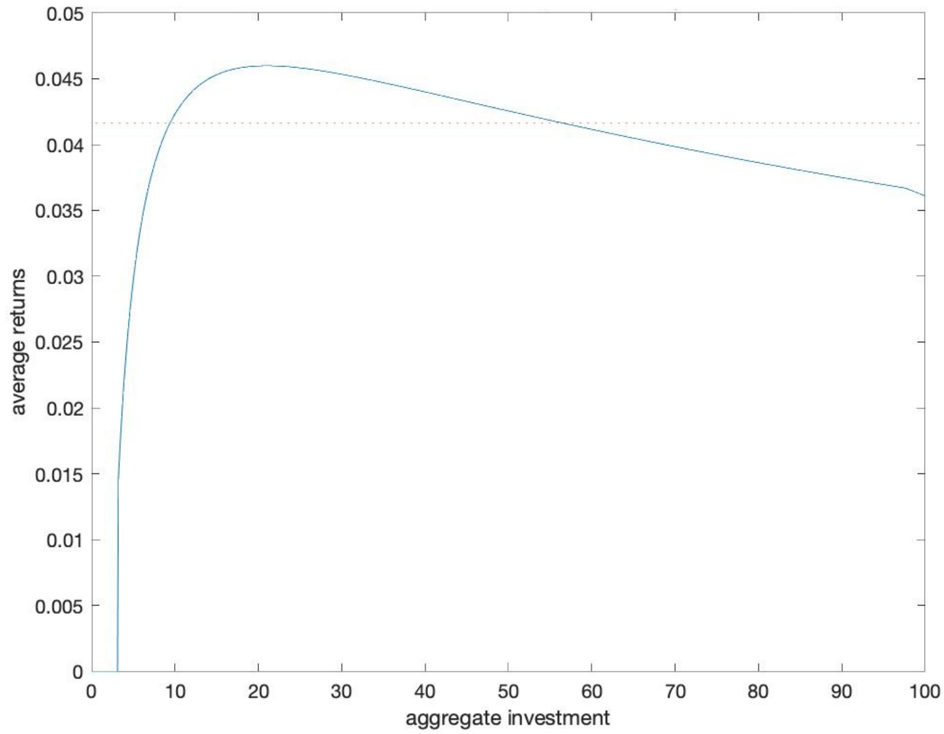
r.

For low levels of aggregate investment H, production and payments to entrepreneurs are insufficient to sustain relationships, resulting in zero matches and no production. As H increases beyond this threshold, the marginal return to investment increases because additional liquidity supports more relationships, and the gains from financial intermediation outweighs the diminishing returns to production. Thus, investment exhibits increasing returns to scale for a low-to-medium range of H. At higher H, the number of relationships continues to grow, but the mismatch between liquidity and productivity is creating more distortions. Diminishing returns to production dominate, and investment exhibits decreasing returns to scale. This yields two positive-investment steady states: one unstable (low H) and one stable (high H).

Relative to the homogeneous productivity benchmark in den Haan et al. (2003), introducing heterogeneity does not increase steady-state returns. In fact, the steady-state level of aggregate investments is lower. Two mechanisms drive this result. First, liquidity misallocation is more costly in the presence of project heterogeneity, especially when high (low)-productivity entrepreneurs are matched with low (high)-liquidity lenders. Therefore, output loss associated with capital misallocation is amplified. Second, lenders matched with low-productivity entrepreneurs require a higher liquidity realizations to sustain a credit relationship when they expect a potentially better rematch. This increases the fragility of credit relationships for projects with lower productivity, thereby reducing aggregate returns to investment.

Figure 3.2 decomposes these effects by showing steady-state relationships between H and the number of active relationships N, breakup probability $\bar{v}(\underline{h}(A) \mid H)$, and matching probability $\lambda(\theta)$. For low H, insufficient liquidity prevents matching and relationship formation. As H rises, N and $\lambda(\theta)$ increase concavely while breakup probability falls convexly, raising returns and supporting positive-investment equilibria. At high levels of H, there are a limited number of lenders with sufficient liquidity

Figure 3.1: Aggregate Investment and Returns in Steady State

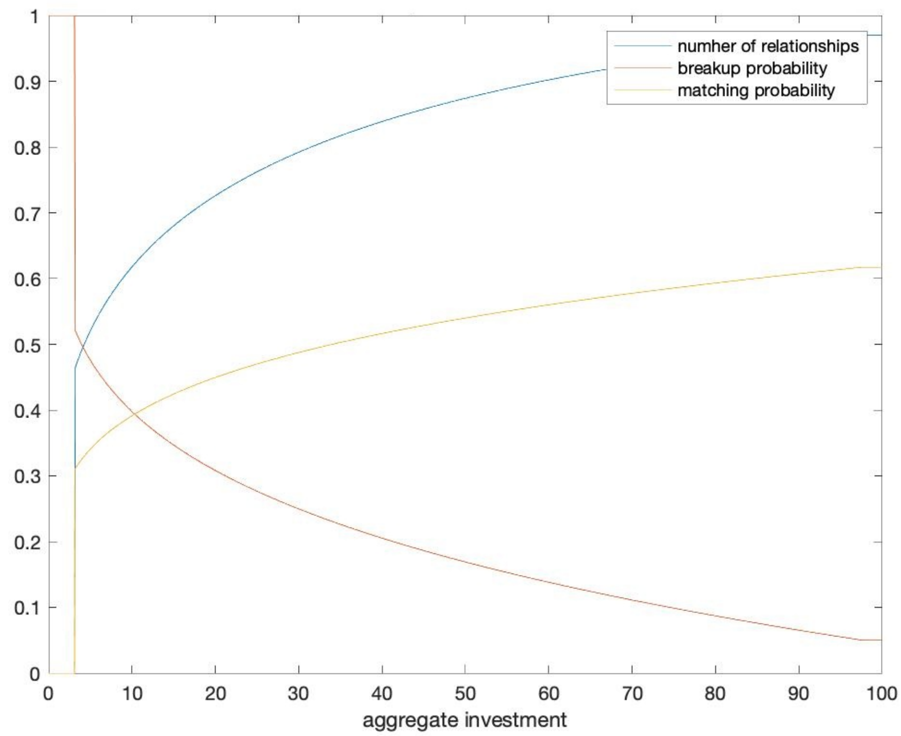


Notes: This figure shows the relationship between aggregate investment (aggregate liquidity H, horizontal axis) and the aggregate returns to investment (R, vertical axis), compared to the interest rate (r, dotted horizontal line).

and a potentially infinite amount of high-productivity projects. As a result, further increases H yield smaller gains in the number of relationships.

Project heterogeneity shapes these dynamics differently across H: at low H, competition for entrepreneurs is weak, and the possibility of drawing high productivity increases entry, and hence $\lambda(\theta)$ and N are higher relative to the homogeneous case; at high H, competition among projects is intense, and sustaining high-productivity relationships requires high liquidity. As a result, N remains below 1 and breakup probability above 0, even with abundant aggregate liquidity.

Figure 3.2: Relationship Dynamics in Steady State



Notes: This figure shows the relationship between aggregate investment (aggregate liquidity H, horizontal axis) and the steady-state values of financial intermediation (vertical axis), including number of relationships (as a fraction of total number of projects), matching and breakup probabilities.

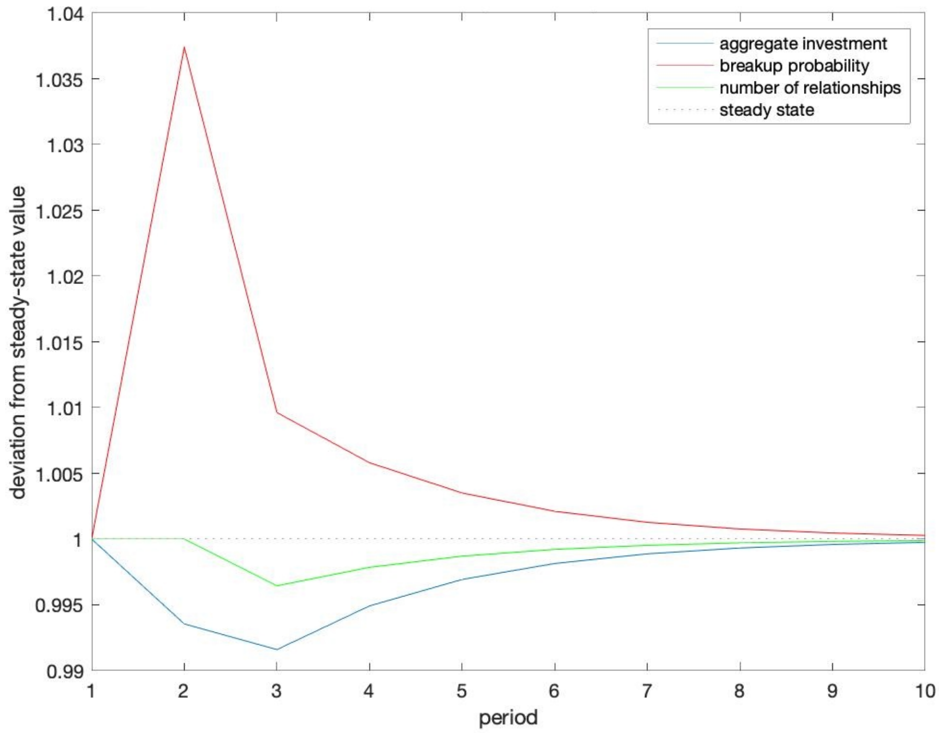
3.3.3 Propagation of shocks

This subsection examines how the interaction of matching and liquidity allocation frictions amplifies the effects of aggregate shocks in the presence of project heterogeneity. First, I consider a project heterogeneity shock, modeled as a temporary shift in the productivity distribution that increases the probability of drawing a high-productivity project. This can be interpreted as a temporary increase in demand for projects with higher returns. However, such a shock may not be equivalent to a positive productivity shock in production, since in the presence of matching and allocation frictions, the effect of a surprise increase in realization of productivity may be offset by the increase in probability of breakup due to a higher liquidity requirement for production. The economy starts period 1 in steady-state equilibrium with positive investment. The shock to the productivity distribution hits at the end of period 1, after realization of liquidity and productivity for period 1 matching, contracting and production, but before the continuation decision.

Figure 3.3 shows the responses of aggregate investment, breakup probability, and the number of relationships to the project heterogeneity shock. Breakup probability spikes immediately, as sustaining relationships now requires higher liquidity per project. The number of relationships is predetermined in the shock period, but falls in the following period as the higher breakup rate takes effect. Over time, relationships are rebuilt through matching, and the economy returns to steady state. Aggregate investment falls in the first period after the shock due to lower returns, and can decline further in the next period as relationship numbers drop. With allocation and matching frictions, one-off productivity shocks that have heterogeneous effects on entrepreneurial project opportunities can have adverse and persistent effects on aggregate economic activities in the presence of project heterogeneity. If the shock is sufficiently large, or the aggregate investment is low, the shock can push the economy into a collapse equilibrium with no investment activity.

Second, I replicate a one-time negative shock to the number of relationships and Figure 3.4 reports the responses of the aggregate investment, the probability of breakup and the number of relationships following such a shock. Instead of interpreting this as a negative productivity shock (den Haan et al., 2003), such a shock can be regarded more precisely as an exogenous separation shock, for example, due to a temporary change in household preference such that lenders are requested not to continue lending to certain entrepreneurs. Although the shock led to deviations from the steady-state equilibrium for an extended period of time, contrary to den Haan et al. (2003), such an effect is not persistent in the long run, and the economy will eventually return to steady-state equilibrium. Relationships that were disrupted

Figure 3.3: Impulse Response Functions: Project Heterogeneity Shock



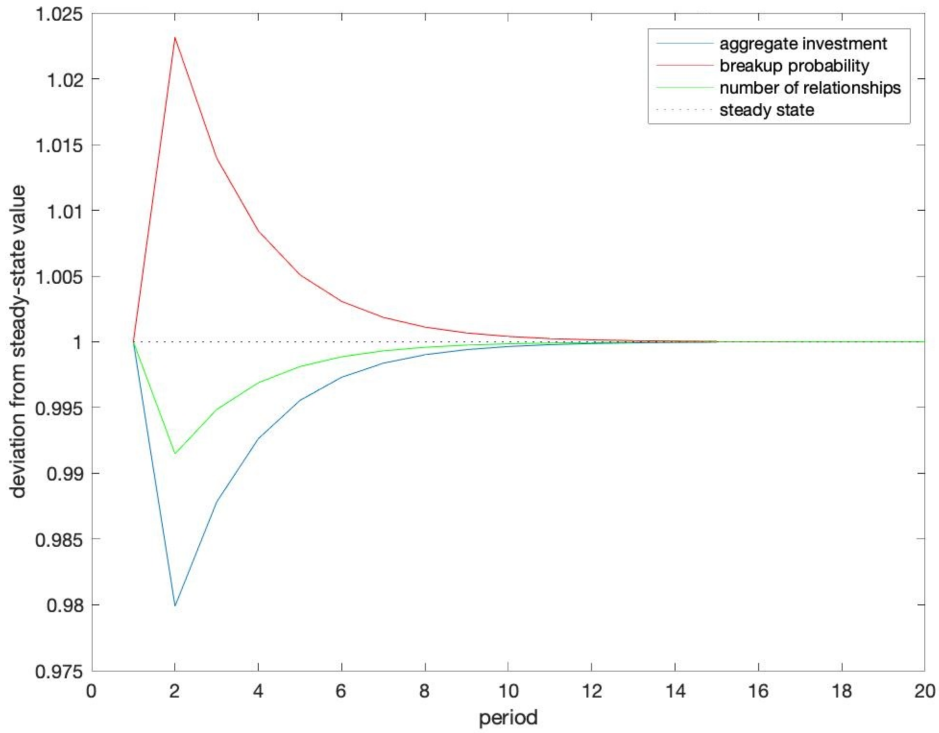
Notes: This figure shows the impulse responses of aggregate investment, breakup probability, and number of relationships to a one percentage point increase in the probability of realizing higher productivity for new projects. The economy is assumed to be at steady-state in period 1, and the project heterogeneity shock hits at the end of period 1 before relationship continuation choice is made.

due to the shock will be restored via matching in the long run, although recovery is slow.

3.4 Endogenous agency frictions

This section extends the baseline model with endogenous agency friction, and analyzes the case that entrepreneurs are now able to leave the relationship while 'hiding' a fraction of output, $x_{i,t} = \rho A_{i,t} f(h_t)$, instead of a fixed amount x. The microfoundation is that due to asymmetric information, lenders may not be able to perfectly observe the productivity of entrepreneurs during the contract negotiation

Figure 3.4: Impulse Response Functions: Relationship Separation Shock



Notes: This figure shows the impulse responses of aggregate investment, breakup probability, and number of relationships to a one percentage point decrease in the fraction of the number of relationships to total number of entrepreneurs. The economy is assumed to be at steady-state in period 1, and the relationship separation shock hits at the end of period 1 before relationship continuation choice is made.

process. Entrepreneurs are thus able to either truly report their levels of productivity, produce, and receive payments if offered an optimal contract, leading to ex post continuation of the relationship, or underreport its productivity when offered a suboptimal contract. Underreporting can be detected during the ex post auditing process, and would lead to termination of the relationship. $\rho \in [0, 1]$ is a parameter of contract enforceability that states the maximum fraction of output that an underreporting entrepreneur will be able to take away upon termination of the contract.

Intuitively, this extension means that the current payment to the entrepreneur, $p_{i,t} = \max\{0, x_{i,t} - g^e_{i,t}\}$, is linked to the output of the project in the current period. This is analogous to a performance-based contract in which the entrepreneur's outside option is endogenous to realized project outcomes. Since the outside option now depends on the productivity realization $A_{i,t}$ and the liquidity draw h_t, entrepreneurs with high realized output have stronger incentives to walk away if not properly compensated. As a result, the optimal contract must adjust payments to entrepreneurs in response to project performance, introducing an additional endogenous margin into the contract design problem.

The breakup threshold in equation (3.6) can now be rewritten as:

$$A_{i,t}f(\underline{h}_t(A_{i,t})) + \min\left\{\underline{h}_t(A_{i,t}) - \max\{0, x_{i,t} - g^e_{i,t}\}, g_{i,t} - w_t - \max\{g^e_{i,t}, x_{i,t}\}\right\} = 0. \tag{3.28}$$

Proposition 3.4. *In any equilibrium, $g^e_{i,t} \leq \beta\hat{x}_{i,t}$ for any $A_{i,t}$ realized in every period t, where $\hat{x}_{i,t} = \mathbb{E}[\rho A_{i,t+1}f(h_{t+1}) \mid h_{t+1} \geq \underline{h}_{t+1}(A_{i,t+1})]$.*

Proposition 3.4 states that in any equilibrium, the entrepreneur's future value of a continuing relationship must not exceed the future expected value of the outside option, conditional on the future realization of sufficient liquidity by the lender to sustain the relationship. The proof is provided in the Appendix. Intuitively, when any future value of a continuing relationship exceeds benefits from voluntary termination of the relationship by the entrepreneur, the lender can always lower payment to the entrepreneur to further maximize its gains without violating the entrepreneur's incentive compatibility constraint.

Steady-state equations (3.18), (3.20), (3.22), and (3.27) are now modified as:

$$A_i f(\underline{h}(A_i)) + \min\left\{\underline{h}(A_i) - x_i + g^e_i, g_i - w - x_i\right\} = 0, \quad \forall i \tag{3.29}$$

$$g^e_i = \beta(1 - v(\underline{h}(A_i) \mid H))\hat{x}_i, \quad \forall i \tag{3.30}$$

$$g^e = \beta(1 - \bar{v}(\underline{h}(A) \mid H))\hat{x}, \tag{3.31}$$

$$R = \frac{N(\bar{\mu}(\underline{h}(A) \mid H) - (1 - \bar{v}(\underline{h}(A) \mid H))(\hat{x} - g^e))}{H}, \tag{3.32}$$

where $\hat{x} = \int \hat{x}_i d\Omega(A)$.

Lemma 3.2. $\frac{\partial p_i}{\partial \rho} \geq 0 \quad \forall i.$

Lemma 3.2 follows from equation (3.30) and the steady-state payment $p_i = \max\{0, x_i - g_i^e\}$ that since x_i and g_i^e are both functions of ρ, if $x_i - g_i^e > 0$ then p_i is increasing in ρ; otherwise if $x_i - g_i^e \leq 0$, $p_i = 0$.

Proposition 3.5. *In equilibrium, higher ρ, or weaker contract enforcement, contracts that sustain a credit relationship are more incentive-compatible for entrepreneurs.*

Proposition 3.5 directly follows from Lemma 3.2. Intuitively, weaker contract enforcement increases the entrepreneur's outside option and thus tightens the incentive compatibility constraint. As a result, the payment to the entrepreneur must be more closely linked to project performance to sustain the relationship, making it more incentive compatible for continuing entrepreneurs.

Figure 3.5 plots the relationship between aggregate investment and steady-state average returns to investment using steady-state conditions characterized by equations (3.19), (3.21), (3.23)-(3.26), and (3.29)-(3.32)[4]. First, with performance-based contracting, there exists a unique steady-state equilibrium with strictly positive aggregate investment, and the aggregate investment exhibits decreasing returns to H across the entire range, in contrast to the non-monotonic pattern observed in Figure 3.1. Under endogenous agency frictions, the entrepreneur's outside option depends on project output, which varies with liquidity allocation. As a result, the continuation value of a relationship becomes more closely linked to the entrepreneur's productivity draw. In low-productivity matches, the incentive to sever the relationship and seek a better match increases with H, as larger liquidity allocations increase

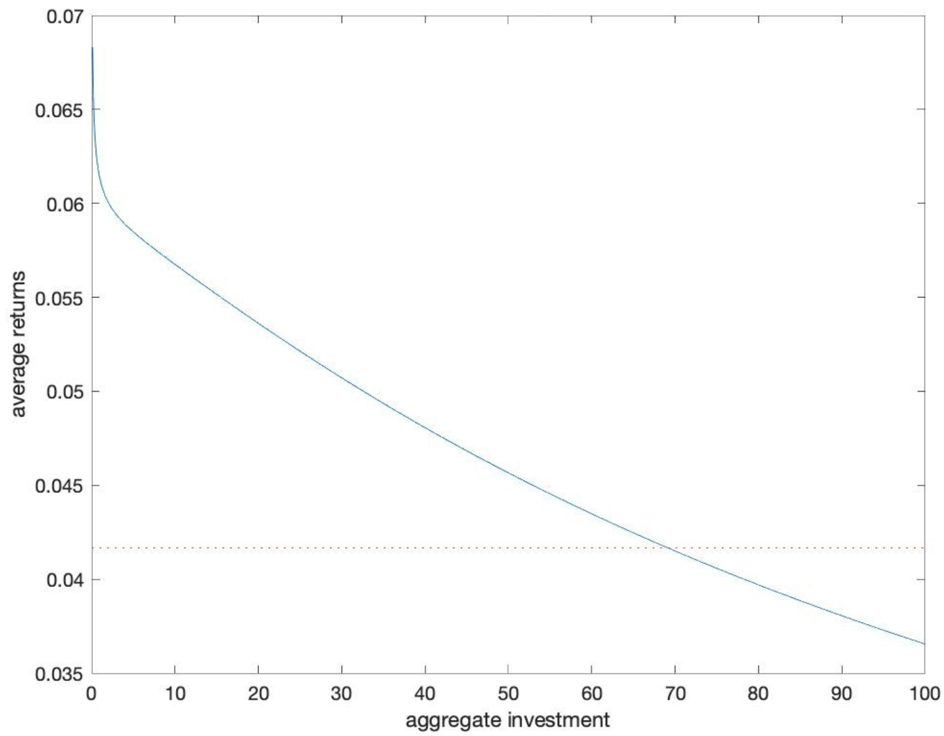
[4]The examples use additional assumptions including $x_{i,t} = \rho A_{i,t} f(h_t)$ where $\rho = 0.10$, $\gamma = 0.193$, and implied $c = 0.0358$, such that implied steady-state equilibrium liquidity allocation is same as in the baseline model.

the opportunity cost of inefficient matches. This leads to higher breakup probabilities even when liquidity is abundant. In high-productivity matches, continuation values rise only modestly because of the diminishing marginal return to additional liquidity with a concave production function. Together, these dynamics generate diminishing marginal returns to liquidity as H increases, producing a strictly decreasing relationship between aggregate investment returns and liquidity in steady state.

Figure 3.5 also shows that the aggregate investment in steady state is higher under performance-based contracting compared to the benchmark case with fixed outside options. This increase arises from the improved alignment of incentives in performance-based contracts, in which entrepreneurial payoffs are tied to realized project output. This structure relaxes the lender's participation constraint by reducing the need to overcompensate entrepreneurs, particularly in low-productivity matches. As a result, relationships with low-productivity projects are more likely to be sustained even when liquidity realization remains low, since entrepreneurs in these matches are willing to accept lower payments to continue. At the same time, the higher payments required to sustain a relationship with high-productivity entrepreneurs strengthens assortative matching between liquidity and productivity, ensuring that more productive projects are financed by lenders with sufficient liquidity. Together, these forces improve capital misallocation associated with project heterogeneity, and raise the equilibrium level of aggregate investment.

Then, I analyze how a shock to contract enforceability propagates in the presence of matching and allocation frictions. The shock takes the form of a one-time shock that increases the fraction of output that entrepreneurs can take away when terminating the relationship after production, ρ. The economy is assumed to enter period 1 in the steady-state equilibrium, and the shock hits the economy at the end of the period.

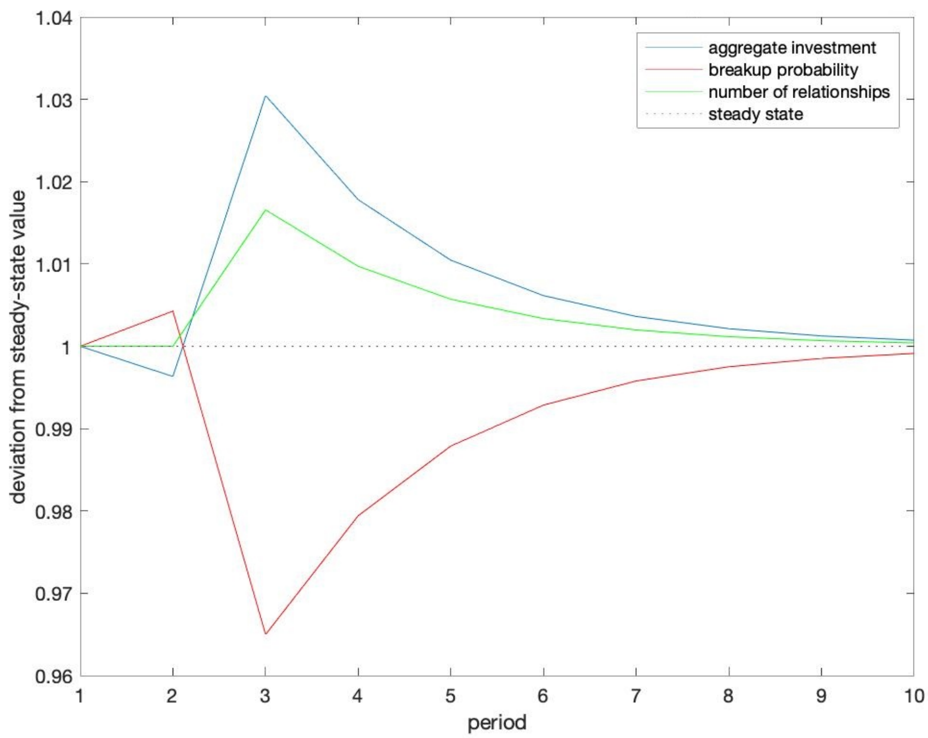
Figure 3.5: Effect of Aggregate Investment on Aggregate Returns (Extension)



Notes: This figure shows the relationship between aggregate investment (aggregate liquidity H, horizontal axis) and the aggregate returns to investment (R, vertical axis), compared to the interest rate (r, dotted horizontal line), in the presence of endogenous agency frictions.

Figure 3.6 illustrates the responses of aggregate investment, the probability of breakup and the number of relationships to the shock. Immediately after the shock, aggregate investment declines due to weakened contract enforceability. Lenders face higher compensation demands from entrepreneurs, leading to a spike in relationship separations and a fall in the returns to investment. However, this initial contraction is followed by a pronounced recovery in investment. The surge reflects a rise in entrepreneur entry, as the temporarily higher ρ makes the payment more closely linked to project performance, encouraging new participation. The resulting increase in the entrepreneur pool improves matching probabilities and lowers the threshold liquidity required to sustain a relationship. These dynamic adjustments persist even after the enforceability shock fades, leading to a medium-run expansion in investment and a decline in breakup probabilities. This highlights how transitory disruptions in contract parameters can induce persistent changes in entry and matching dynamics, with meaningful aggregate consequences.

Figure 3.6: Impulse Response Functions: Contract Enforceability Shock



Notes: This figure shows the impulse responses of aggregate investment, breakup probability, and number of relationships to a one percentage point increase in the fraction of output that entrepreneurs can take away when terminating the relationship after production, ρ. The economy is assumed to be at steady-state in period 1, and the relationship separation shock hits at the end of period 1 before relationship continuation choice is made.

3.5 Conclusion

This paper studies how project heterogeneity interacts with financial frictions in long-term credit relationships and the effects on aggregate investment and the transmission of macroeconomic shocks. I build on the framework of den Haan et al. (2003), and extend their dynamic equilibrium model of credit relationships to allow for heterogeneity in entrepreneurial project productivity. The results of the model show that the introduction of project heterogeneity alters both the nature and the consequences of the fragility of credit relationships. In equilibrium, the incentives to continue or sever a credit relationship differ across the productivity distribution, leading to distinct mechanisms of relationship separation: matches with low-productivity projects are more likely to end voluntarily due to upward matching incentives, while high-productivity matches may break down involuntarily due to liquidity constraints. These asymmetric dynamics lead to capital misallocation: high-productivity projects are more likely to be underfunded, while low-productivity ones may receive excessive funding. As a result, aggregate investment in steady state is lower, and project heterogeneity generates additional shock amplification.

Importantly, the amplification mechanism operates along both the extensive margin of relationship continuation and the intensive margin of liquidity allocation. Project heterogeneity exacerbates the mismatch between liquidity allocation and productive opportunities, increasing the fragility of credit relationships and the economy. This effect is particularly pronounced during downturns, when limited liquidity flows lead to inefficient separations and underinvestment. As the economy recovers, matching frictions slow the reallocation process, leading to a persistently low level of output and investment. These dynamics suggest that even economies with ample aggregate liquidity may remain constrained if credit relationships are not efficiently allocated across heterogeneous projects.

Overall, these findings underscore the importance of considering firm-level heterogeneity in theories of credit market imperfections and macroeconomic fluctuations. By studying the interaction between project heterogeneity and the fragility of credit relationships, this paper contributes to a deeper understanding of how innovation may lead to increased vulnerability through the credit channel. More broadly, the results shed light on how the increasing dispersion in firm productivity and the fragility of financial intermediation channels that depend on stable long-term credit relationships.

3.6 Appendix: proofs

3.6.1 Proof of Proposition 3.1

Suppose instead that $g^e_{i,t} > \beta x$, then from condition (3.9), it should follow that there exists a continuum of h_{t+1}, such that $p_{i,t+1} + g^e_{i,t+1} > x$ occurs with a positive possibility. If $p_{i,t+1} > 0$, this contradicts the optimal contracting decision of the lender stated in equation (3.5), and therefore is not an equilibrium. If $p_{i,t+1} = 0$, then we have $g^e_{i,t+1} > x$. By iterating the same argument, we can deduce $g^e_{i,t+2} > \beta^{-1}x$, $g^e_{i,t+3} > \beta^{-2}x$,..., and $g^e_{i,t+n} > \beta^{-n+1}x$. From equation (3.4) we can see that the maximum amount that an entrepreneur can take away each period is x, and hence it must hold in an equilibrium that:

$$g^e_{i,t} \leq \sum_{k=1}^{\infty} \beta^k x = \frac{\beta}{1-\beta} x \quad \forall t.$$

For sufficiently large n, we have:

$$g^e_{i,t+n} > \beta^{-n+1} x > \frac{\beta}{1-\beta} x,$$

and hence a contradiction. Thus, it is proved by contradiction that $g^e_{it} \leq \beta x$.

3.6.2 Proof of Proposition 3.4

Observe that the maximum amount that an entrepreneur with productivity $A_i t$ can take away from the relationship in the subsequent period is characterized by the expected value of a fraction of production in the future $\hat{x}_{i,t}$. In equilibrium $\hat{x}_{i,t} = \hat{x}_i$, and the proof follows from above by replacing x by $\hat{x}_i$.

3.7 Bibliography

Acharya, V., Almeida, H., Ippolito, F., & Perez, A. (2014). Credit lines as monitored liquidity insurance: Theory and evidence. *Journal of Financial Economics*, 112, 287–319.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., & Reenen, J. V. (2020). The fall of the labor share and the rise of superstar firms*. *The Quarterly Journal of Economics*, 135, 645–709.

Begenau, J., Bigio, S., Majerovitz, J., & Vieyra, M. (2025). A q-theory of banks. *The Review of Economic Studies*, (pp. rdaf035).

Berger, A. N., Bouwman, C. H. S., & Kim, D. (2017). Small bank comparative advantages in alleviating financial constraints and providing liquidity insurance over time. *The Review of Financial Studies*, 30, 3416–3454.

Berger, A. N. & Udell, G. F. (1995). Relationship lending and lines of credit in small firm finance. *The Journal of Business*, 68, 351–381.

Bethune, Z., Rocheteau, G., Wong, T.-N., & Zhang, C. (2022). Lending relationships and optimal monetary policy. *The Review of Economic Studies*, 89, 1833–1872.

Boualam, Y. (2018). Credit markets and relationship capital.

Brunnermeier, M. K., Eisenbach, T. M., & Sannikov, Y. (2013). *Macroeconomics with Financial Frictions: A Survey*, volume 2, (pp. 3–94). Cambridge University Press.

Brunnermeier, M. K. & Sannikov, Y. (2014). A macroeconomic model with a financial sector. *American Economic Review*, 104, 379–421.

Chava, S. & Purnanandam, A. (2011). The effect of banking crisis on bank-dependent borrowers. *Journal of Financial Economics*, 99, 116–135.

Chen, B. S., Hanson, S. G., & Stein, J. C. (2017). The decline of big-bank lending to small business: Dynamic impacts on local credit and labor markets. *National Bureau of Economic Research Working Paper Series*, No. 23843.

Chernenko, S. & Sunderam, A. (2014). Frictions in shadow banking: Evidence from the lending behavior of money market mutual funds. *The Review of Financial Studies*, 27, 1717–1750.

Chodorow-Reich, G. (2014). The employment effects of credit market disruptions: Firm-level evidence from the 2008–9 financial crisis. *The Quarterly Journal of Economics*, 129, 1–59.

Cloyne, J., Ferreira, C., Froemel, M., & Surico, P. (2023). Monetary policy, corporate finance, and investment. *Journal of the European Economic Association*, 21, 2586–2634.

Cohen, J., Hachem, K., & Richardson, G. (2021). Relationship lending and the great depression. *The Review of Economics and Statistics*, 103, 505–520.

Crouzet, N. & Mehrotra, N. R. (2020). Small and large firms over the business cycle. *American Economic Review*, 110, 3549–3601.

den Haan, W. J., Ramey, G., & Watson, J. (2003). Liquidity flows and fragility of business enterprises. *Journal of Monetary Economics*, 50, 1215–1241.

Drechsel, T. (2023). Earnings-based borrowing constraints and macroeconomic fluctuations. *American Economic Journal: Macroeconomics*, 15, 1–34.

Gertler, M. & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. *Handbook of Monetary Economics*, 3, 547–599.

Lian, C. & Ma, Y. (2021). Anatomy of corporate borrowing constraints. *The Quarterly Journal of Economics*, 136, 229–291.

Ottonello, P. & Winberry, T. (2020). Financial heterogeneity and the investment channel of monetary policy. *Econometrica*, 88, 2473–2502.

Payne, J. (2024). The disruption of long term bank credit.

Petersen, M. A. & Rajan, R. G. (1994). The benefits of lending relationships: Evidence from small business data. *The Journal of Finance*, 49, 3–37.

Petrosky-Nadeau, N. & Wasmer, E. (2013). The cyclical volatility of labor markets under frictional financial markets. *American Economic Journal: Macroeconomics*, 5, 193–221.

Roberts, M. R. & Sufi, A. (2009). Renegotiation of financial contracts: Evidence from private credit agreements. *Journal of Financial Economics*, 93, 159–184.

Rocheteau, G., Wright, R., & Zhang, C. (2018). Corporate finance and monetary policy. *American Economic Review*, 108, 1147–1186.

Schwert, M. (2018). Bank capital and lending relationships. *The Journal of Finance*, 73, 787–830.

Sharpe, S. A. (1990). Asymmetric information, bank lending and implicit contracts: A stylized model of customer relationships. *The Journal of Finance*, 45, 1069–1087.

Sufi, A. (2009). Bank lines of credit in corporate finance: An empirical analysis. *The Review of Financial Studies*, 22, 1057–1088.

Wasmer, E. & Weil, P. (2004). The macroeconomics of labor and credit market imperfections. *American Economic Review*, 94, 944–963.