Optimal Intermediary Contracts

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March 22, 2026

Abstract

We study the role of pledgeability in shaping optimal intermediary contracts. We develop a model in which financial intermediaries offer deposit contracts to partially insure lenders against idiosyncratic risks and extend collateralized loans to borrowers with limited commitment. The model shows that a nonmonotonic relationship between contract terms and pledgeability emerges in general equilibrium. The nonmonotonicity arises as the equilibrium contract terms depend on the elasticities of both loan demand and deposit supply. Our framework helps explain the puzzling response of corporate loans following the passage of the Bankruptcy Abuse Prevention and Consumer Protection Act. We also use the framework to investigate how unexpected shocks affect financial stability and how pledgeability influences welfare under the Glass-Steagall Act.

JEL Codes: E40, E61, E62, H21.

Keywords: optimal deposit contract, optimal loan contract, pledgeability, bank risk, Bankruptcy Abuse Prevention and Consumer Protection Act, Glass-Steagall Act.

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The authors wish to thank Phil Dybvig, Peter Haslag, David Skeie, Ping Wang, Cathy Zhang, and conference participants at the 2023 Midwest Macro meetings, the 2024 Costa Rica Search and Matching Conference, and the 2024 Summer Workshop on Money, Banking, Payments, and Finance for helpful comments and suggestions.

1 Introduction

Financial intermediaries accept deposits and allocate those deposits between loans and securities. They contract simultaneously with depositors and borrowers. Therefore, the optimal contracts reflect the composition of the intermediary's assets, the risks associated with its loans, and the extent of risk sharing among depositors. Given the financial intermediary's role, it is natural to wonder how financial frictions affect each of these three elements. By using a general-equilibrium model, we analyze how simultaneous interactions impact equilibrium contracts, loan risk, and risk sharing.

We study the optimal intermediary contract in an environment where borrowers have limited commitment. Models in partial equilibrium predict a monotonic relationship between limited commitment and loan rates. We see evidence of this conventional wisdom in debates over the effects of the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA). In 2005, BAPCPA imposed stricter qualifications for borrowers seeking to file under Chapter 7's "fresh start" provision.[1] For corporate bankruptcies, particularly under Chapter 11, BAPCPA enhanced creditor protections and improved the pledgeability of corporate bonds. As BAPCPA was being debated, Posner (2005) asserted that the law would reduce interest rates and make borrowers better off.[2] Posner's logic can be summarized as follows: by enacting BAPCPA, a larger fraction of the loan is pledged for debt repayment. With greater collateral, loan risk is considered lower. It follows that the loan rate should also be lower, as risk-averse lenders require less compensation for risk.[3]

We present regression results that contradict this conventional wisdom. After implementing BAPCPA, corporate loan spreads did not decline — neither immediately

[1]For the impact on consumers, see Gross et al. (2021) for a detailed discussion.

[2]See Posner (2005).

[3]See Gupta et al. (2022) for a description of changes in real estate values backing loans. Note that the legal change represents an *ex ante* change in the collateral value. With a different set of rules, new loans are subject to a different level of pledged collateral at the time the loan is made. In contrast, changing economic conditions are a kind of *ex-post* value change. After the loan was made, the collateral value unexpectedly changed.

nor over time. Instead, the data show that the pre-BAPCPA downward trend in loan spreads came to a halt after the law was enacted. In addition, BAPCPA led to a noticeable reduction in corporate loan sizes upon its enactment, and the previously increasing trend in loan size experienced a significant slowdown after the law's passage. These two puzzling responses, taken together, indicate that the predictions from the partial-equilibrium models are insufficient to fully capture the impact of improved pledgeability on loan contracts.

To study the equilibrium contracts, we modify the canonical Diamond-Dybvig (1983) model with banks providing deposit and loan contracts. Banks can invest in either collateralized loans or a safe technology.[4,5] Our first and foremost task is to fully characterize the contract terms and the bank's asset allocation and analyze how collateral pledgeability affects them. The loan rate is bounded below by the return on the risk-free technology and above by the return on the borrower's project. We show the lower (upper) bound is attained when pledgeability is below (above) a low (high) threshold. For intermediate levels, the loan rate increases with pledgeability because greater pledgeability relaxes borrowing constraints, expands loan demand, and intensifies competition for loans, thereby bidding up the rate.

Other contract terms, including loan size, collateral requirements, and the deposit rate, are nonmonotonic in pledgeability. Their equilibrium responses depend on the elasticities of loan demand and deposit supply, which in turn are determined by the elasticities of intertemporal substitution (EIS) of borrowers and depositors. For example, when the depositor's EIS is below one, the supply of loans decreases with a rate

[4]Our work builds on a long tradition of models analyzing the role of banks and secondary markets in providing partial insurance, including Bryant (1980), Jacklin (1987), Bhattacharya and Gale (1987), Hellwig (1994), Diamond (1997), Holmstrom and Tirole (1998), Von Thadden (1999), Allen and Gale (2003), Caballero and Krishnamurthy (2004), and Farhi et al. (2009).

[5]The risk-free asset could be interpreted as a direct-investment project undertaken by the bank. We mention the direct-investment interpretation because we extend the model with stochastic returns. As a direct investment, it is possible to study universal banking issues. In this way, our model builds on an extensive literature that analyzes optimal loan contracts under various information frictions. For a summary of the literature on collateral in loan contracts, see, for example, Williamson (1987), Besanko and Thakor (1987), Bernanke and Gertler (1990), Berger and Udell (1990), and Dowd (1992).

increase. With an increase in pledgeability, the loan rate is bid up, and the equilibrium loan size can decrease. When the borrower's EIS is high, higher borrowing costs can lead to borrowers substituting away from collateral production despite the relaxation of the pledgeability constraint.

Our results highlight the importance of a general-equilibrium approach. In a closely related paper, Kaplan and Zingales (1997) model the financing cost as a *reduced-form* function of the financing constraint. In their setup, the financing cost is captured by the wedge between a firm's internal and external financing rates. They derive conditions under which there is a nonmonotone relationship between loan-contract terms and financing constraints. Our model also generates nonmonotone patterns of contract terms by specifying the underlying friction directly as a loan-repayment constraint. Our approach *endogenizes* the interest-rate differential within a general-equilibrium framework. As a result, the wedge between internal and external financing costs can vary nonmonotonically with the tightness of the financial friction, which emerges in general equilibrium. This implies that the interest-rate differential used in Kaplan and Zingales (1997) is not a perfect mechanism that indicates tightness in the financial constraint. [6]

Second, we examine the relationship between diversification, pledgeability, and the bank's vulnerability to runs. We show that diversification reduces the risk of insolvency. When pledgeability is low and loan rates are correspondingly low, the bank holds some risk-free assets. We consider an unexpected, negative shock to the return on loans.[7] This diversified portfolio allows it to repay patient depositors when facing an unexpected negative interest-rate shock. With an increase in pledgeability, however, the bank's portfolio is weighted toward loans. In this setting, an unexpected, negative interest-rate shock means that banks are less capable of meeting payments to

[6] In Kaplan and Zingales (1997), "firm is considered more financially constrained as the wedge between its internal and external cost of funds increases." They are "agnostic on whether the wedge between the cost of internal and external funds is caused by hidden information problems,... or agency problems..."

[7] Borrowers use loan funds to fund a project. The experiment considers an unexpected reduction on the fundamental return to the project.

patient depositors and are therefore more exposed to runs.

Lastly, we extend the model to include a direct-investment technology with stochastic returns. Our results, therefore, can be used to assess whether a policy, like the Glass-Steagall Act, is welfare improving or not. Under the Act (separated banking), banks can only invest in a risk-free, low-return technology and in the loan market. Without the Act (unified banking), banks may invest in risky technology; with deposit insurance, the loan-rate floor increases but leads to overinvestment in risk and diversion of resources from production to insurance. Higher pledgeability increases profitability in both systems, but the welfare ranking depends on its level. When pledgeability rates are low, separated banking is preferable because limited loan size under unified banking encourages excessive risky investment. As pledgeability increases, more resources flow into productive lending, reducing diversion and making unified banking superior. Yet, further pledgeability increases eventually raise loan rates under separated banking, resulting in banks shifting assets into loans. Overall, we show that the Glass-Steagall Act has ambiguous effects on expected welfare.

Literature review

Our paper is related to several strands of literature. Following Diamond and Dybvig (1983), a vast body of work explores the role of banks in providing partial insurance to consumers facing idiosyncratic liquidity shocks (see footnote 4). Similarly, a substantial literature examines optimal loan contracts and credit rationing of different forms (e.g., Kiyotaki and Moore, 1997; Holmes and Tirole, 1998; Jermann and Quadrini, 2012, Bai et al., 2026, among others). Our paper bridges these two strands of research by studying an economy where deposit contracts and loan contracts are determined simultaneously in general equilibrium, allowing financial frictions on the lending side, specifically limited commitment by borrowers, to feed back into the contract terms.

There is a substantial body of literature modeling the limited commitment problem in the banking setup. Here we mention a few. In Antinolfi and Prasad (2008), collateral serves as a means of liquidity provision. By pooling collateral, banks allocate resources more efficiently than individuals. The debt repayment constraint may not bind for the bank, even though it would bind for individuals. A recent paper by Amador and Bianchi (2024) models banks as borrowers that acquire liquidity through bond issuance. Their framework includes a stochastic-return capital asset as an outside option in the bank's asset structure. Their work focuses on the bank's default decision, while ours examines the relationship between pledgeability and intermediary contracts. Regarding the literature on limited commitment and financing choice, our paper is closely related to Rocheteau et al.(2018). They study the transmission of nominal interest rates to real lending rates, focusing on the firm's financing choices, whereas we focus on the bank's portfolio choice.

There is a large empirical literature examining collateral in the optimal loan contract. Along the extensive margin, Hester (1972), Berger and Udell (1990,1995), and Klapper (1999) provide empirical support for the hypothesis that collateral is used by less creditworthy borrowers. John et al. (2003) present evidence that there is a positive, extensive relationship between collateral and loan rates. They explain how lenders price agency risk into the loan rate. Along the intensive margin, Benmelech and Bergman (2009) argue that the empirical work suffers from selection bias inherent in collateral's extensive margin. In their paper, collateral redeployability serves as a proxy for the intensity of collateral pledged. They present evidence that there is a negative relationship between collateral values on both loan rates and loan size.[8] In contrast to the empirical literature, our paper provides a general-equilibrium model in which the relationship between pledgeability and loan contract terms is nonmonotonic, potentially reconciling the conflicting findings across the extensive and intensive margin studies.

The rest of the paper is organized as follows. Section 2 presents the empirical motivation. Section 3 sets up the model environment. Section 4 derives the theoretical

[8]With both extensive and intensive margins, biased estimates are present if riskier firms are required to pledge more collateral. Because the quantity of collateral may be correlated with unobserved characteristics that affect loan rates, studies finding a positive relationship between loan rates and the presence of collateral are tainted by selection bias.

results in the competitive equilibrium. Section 5 considers two extensions: financial stability and the effect of the Glass-Steagall Act. Section 6 concludes.

2 Empirical Motivation

In this section, we examine how loan contract terms responded to BAPCPA. Our argument is that BAPCPA increased pledgeability, and we study changes in loan rates and loan sizes before and after its enactment. This legislative change is particularly useful because pledgeability is not directly observable. As we argue below, BAPCPA provides an event-study–type shift in pledgeability.

2.1 Bankruptcy Abuse Prevention and Consumer Protection Act

Passed and implemented in 2005, BAPCPA reformed the U.S. Bankruptcy Code. While primarily targeting consumer bankruptcies, BAPCPA also enhanced creditor protections in corporate bankruptcies. Specifically, BAPCPA improved the recovery of corporate bonds under Chapter 11, which is commonly used by firms seeking to reorganize. These enhancements are achieved through three main dimensions.[9]

First, BAPCPA imposed strict limits on the exclusivity period, during which only the debtor may propose a reorganization plan. Previously, courts could extend this period for several years, leading to prolonged delays in bankruptcy proceedings. Under BAPCPA, the exclusivity period is capped at 120 days, encouraging faster resolutions and protecting creditors from delays that diminish the value of their claims.

Second, BAPCPA imposed restrictions on executive compensation and bonuses for firms in bankruptcy to address perceived abuses. Previously, companies could offer substantial bonuses to retain executives, often diverting resources away from creditors. The new law allows such payments only if specific conditions are met, such as the

[9] Refer to Sprayregen et al. (2005) for a summary of all major corporate-side changes introduced by BAPCPA.

executive having a comparable job offer elsewhere, and it caps their size relative to payments made to non-management employees.

Third, BAPCPA introduced measures to strengthen oversight and improve creditor rights. It extended the look-back period for avoiding fraudulent transfers from one to two years, thereby increasing protections against improper asset transfers. Additionally, it expanded participation rights for noninstitutional creditors by granting them greater access to information and representation in committees. Lastly, BAPCPA requires the appointment of a trustee when there is suspicion of fraud or misconduct in the debtor's management, ensuring stronger oversight and accountability.

2.2 Data and Measures

Data Source. We use loan-level data from the Loan Pricing Corporation's (LPC) Dealscan database. Dealscan provides detailed information on the commercial loan market, including the dates and contractual terms associated with loan issuances. In our study, the unit of analysis is the loan (i.e., tranche), which is the most granular unit of observation in Dealscan. Our analysis focuses primarily on loan spreads and sizes, which are the key terms of loan contracts. Dealscan data are compiled from SEC filings, industry contacts, and lender reports (Chava and Roberts, 2008).

Sample Restriction. We apply four restrictions to our sample. First, as BAPCPA was signed on April 20, 2005, and implemented on October 17, 2005, we restrict the sample to loans with active dates between 2004 and 2007. This time frame allows us to analyze credit conditions during the relevant years surrounding the reform while avoiding the period of the global financial crisis, following Gross et al.(2021). Second, we include only loans originating in the United States that are subject to BAPCPA. We further restrict the sample to loans denominated in US dollars to exclude heterogeneity in currency risks. Third, we include only original loan issuance, excluding loans that are amendments to existing agreements. Fourth, we focus on corporate loans and exclude loans issued by banks, government entities, media and communications firms, non-bank financial institutions, and utilities.[10] Summary statistics for this sample are reported in Appendix D.

2.3 Aggregate Patterns

To examine changes in aggregate loan patterns following BAPCPA, we first consolidate loan-level data into aggregate time series for visualization.

Figure 1 plots the total number of loans (Panel A) and the total loan amounts (Panel B) recorded in Dealscan from 2004 to 2007. To reduce noise, the daily panel is aggregated into weekly frequencies based on active loan dates. The two vertical dashed gray lines mark the passage of BAPCPA on April 20, 2005, and its implementation on October 17, 2005. In each panel, we plot two red fitted lines: one for the period before BAPCPA was passed and another for the period after its implementation. These fitted lines are linear predictions of the variable of interest over time.

Panel A shows a noticeable shift in the number of loans issued before and after BAPCPA, while Panel B depicts corresponding changes in loan volumes. The evidence suggests that the growth rates of both loan issuances and volumes declined following the enactment of BAPCPA. Although Dealscan may not encompass the entire loan market, as long as BAPCPA does not significantly change Dealscan's coverage, its aggregate patterns remain informative.

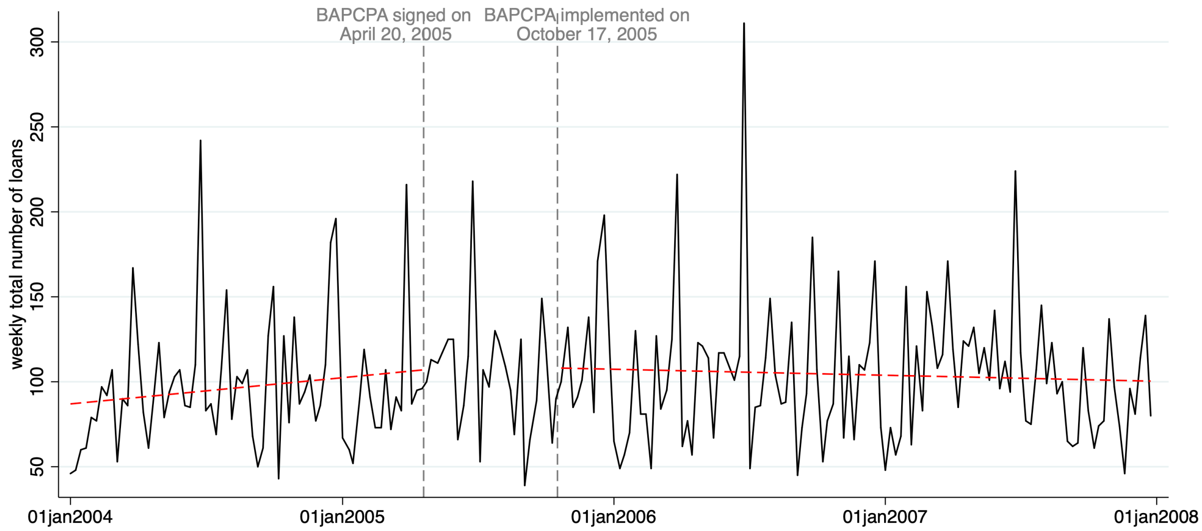
Figure 2 presents the time series of weighted average loan spreads (Panel A) and weighted average loan sizes (Panel B), with weights constructed using relative loan sizes.[11] We also aggregate the daily averages into a weekly frequency according to the active dates of the loans. Panel A shows a clear downward trend in (weighted) loan spreads before the passage of BAPCPA. However, upon BAPCPA's implementation, we do not observe a decrease in loan spreads. Instead, the data indicate that the decline in loan spreads came to a complete halt following the law's implementation.

Panel B of Figure 2 plots the weekly weighted average loan sizes. While the trends

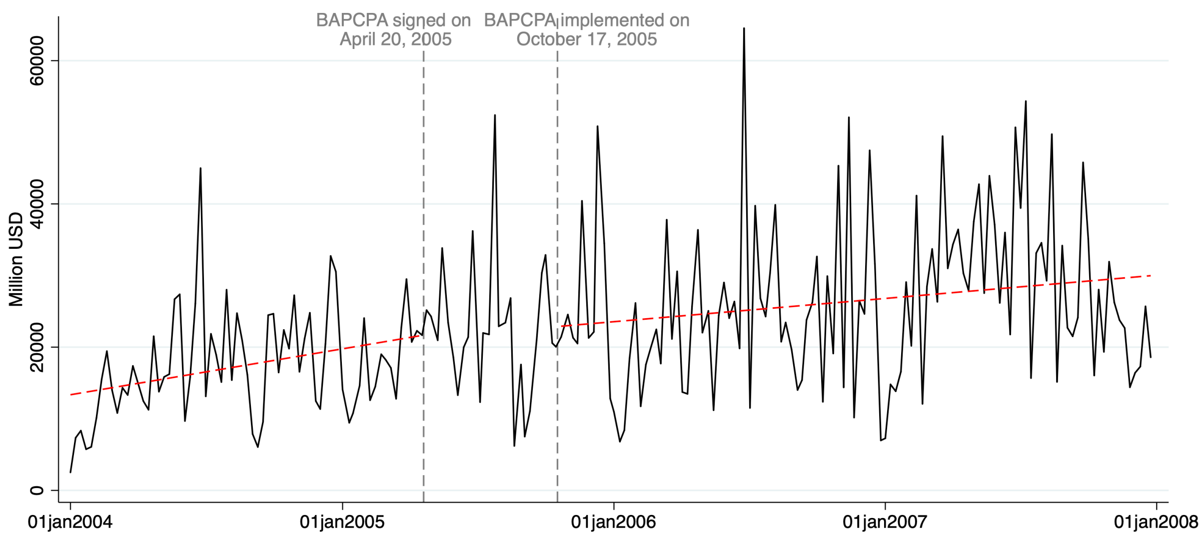
[10] Corporate loans comprise approximately 74.28% of all loan types in our dataset.
[11] Figure C.2 in the appendix plots the unweighted averages, which show similar patterns.

Figure 1: Weekly Time Series of Total Loans

Panel A. Total Number of Loans



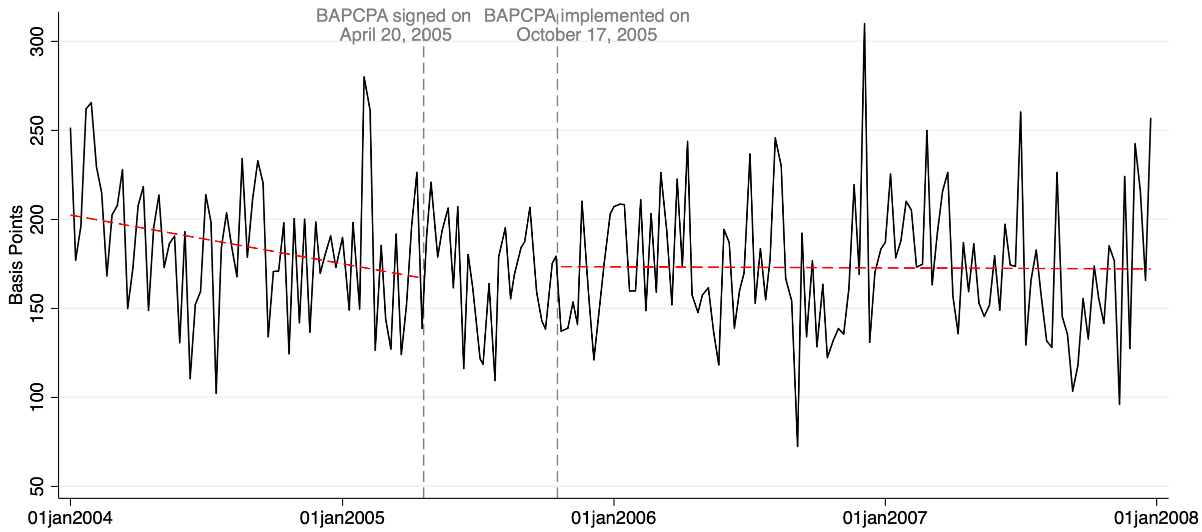
Panel B. Total Amount of Loans



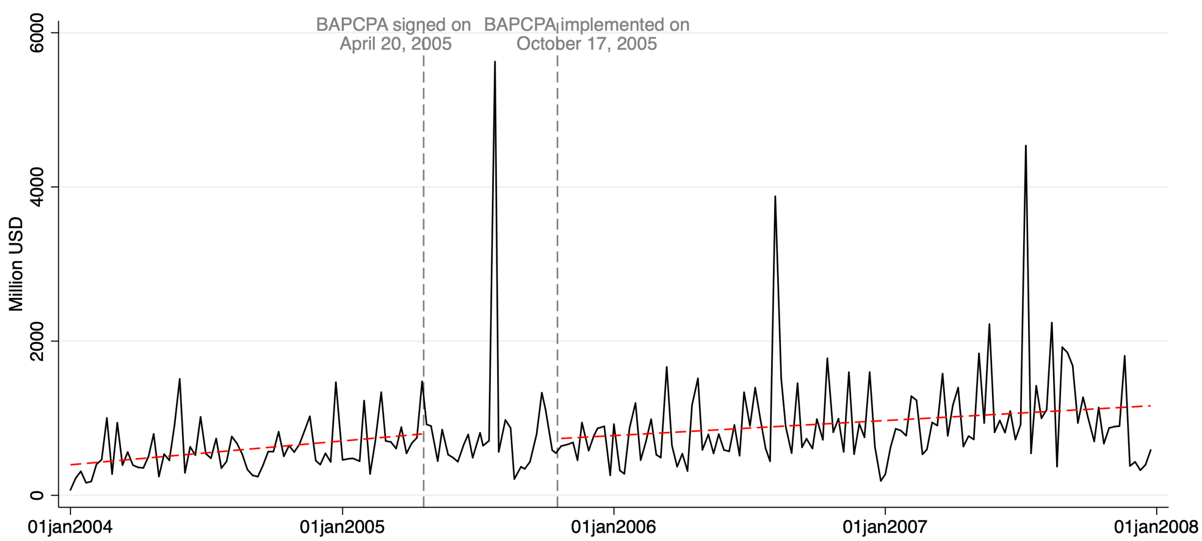
Note: This figure shows the total number of loans (Panel A) and the total loan amounts (Panel B) in Dealscan from 2004 to 2007. We aggregate the loan-level data into a weekly frequency based on the active dates of the loans. The two vertical dashed gray lines mark the passage of BAPCPA on April 20, 2005, and its implementation on October 17, 2005. In each panel, we plot two red fitted lines: one for the period before BAPCPA was passed and another for the period after its implementation. These fitted lines are linear predictions of the variable of interest over time.

Figure 2: Weekly Weighted Average Spreads and Sizes of Loans

Panel A. Weighted Average Spreads of Loans



Panel B. Weighted Average Sizes of Loans



Note: This figure shows the weighted average spreads of loans (Panel A) and the weighted average loan sizes (Panel B) in Dealscan from 2004 to 2007, with weights based on relative loan sizes. We aggregate the daily averages into a weekly frequency based on the active dates of the loans. The two vertical dashed gray lines mark the passage of BAPCPA on April 20, 2005, and its implementation on October 17, 2005. In each panel, we plot two red fitted lines: one for the period before BAPCPA was passed and another for the period after its implementation. These fitted lines are linear predictions of the variable of interest over time.

in weighted loan sizes remain positive before and after BAPCPA's implementation, the post-BAPCPA trend is consistently lower than the trajectory predicted by the pre-BAPCPA trend. This suggests a reduction in loan sizes following BAPCPA.[12]

These two patterns point to a significant shift in loan contracts, both in price and quantity, after the implementation of BAPCPA. The pattern is not consistent with the prediction that an increase in pledgeability should lead to lower loan spreads. Next, we conduct event-study regressions to test the statistical significance of these findings.

2.4 Event-Study Regressions

We proceed to a more formal statistical analysis. Specifically, we examine whether the differences in trends in loan spreads and loan sizes before and after BAPCPA are statistically significant. To do so, we estimate event-study regressions that test for changes following the passage of BAPCPA. Our identifying assumption is that, in the absence of the bankruptcy reform, both the level and the trend observed prior to the week of April 20, 2005, when BAPCPA passed, would have remained constant over time.

Consider the following regression specification:

$$y_{it} = \beta_0 + \beta_1(t - \bar{t}) + \beta_2 \mathbb{1}\{t \geq \bar{t}\} + \beta_3(t - \bar{t}) \times \mathbb{1}\{t \geq \bar{t}\} + \epsilon_{it}, \tag{1}$$

where the dependent variable y_{it} represents the characteristic of loan i issued at time t, which can be either the loan's spread or size. Here, $\bar{t}$ denotes April 20, 2005, the reference date that marks the passage of BAPCPA.[13] The term $t - \bar{t}$ captures the distance in time from this reference point, equal to zero on April 20, 2005; negative values before this date; and positive values afterward. To facilitate the interpretation of coefficients,

[12]Panel B of Figure C.2 in the appendix shows the unweighted average loan sizes, where the change is less pronounced, indicating that the reduction in loan sizes primarily exists among larger loans.

[13]We follow Gross et al. (2021) in using the passage of BAPCPA as the cutoff. As they point out, under the bankruptcy code, debts incurred in the months leading up to a filing are not eligible for discharge. As a result, loans issued between passage and implementation were unlikely to be discharged under the old, more lenient rules.

Table 1: Event Study for Loan Spreads and Sizes

	Spread		log(Size)	
	(1)	(2)	(3)	(4)
$\hat{\beta}_0 : 1$	244.60***	168.64***	4.42***	6.00***
	(4.32)	(7.47)	(0.04)	(0.07)
$\hat{\beta}_1 : t - \bar{t}$	-13.40**	-25.54**	0.12**	0.58***
	(5.86)	(10.80)	(0.05)	(0.10)
$\hat{\beta}_2 : 1\{t \geq \bar{t}\}$	-7.50	0.07	-0.07	-0.23**
	(5.14)	(9.02)	(0.05)	(0.09)
$\hat{\beta}_3 : (t - \bar{t}) \times 1\{t \geq \bar{t}\}$	12.61**	28.39**	-0.03	-0.45***
	(6.13)	(11.28)	(0.06)	(0.11)
Observations	18070	18070	18070	18070
R^2	0.003	0.003	0.003	0.024
Wald test p-value for $\beta_1 + \beta_3 = 0$	0.66	0.38	0.00	0.00
Weighted by loan size	×	✓	×	✓

Note: This table presents the event study results for the following regression specification: $y_{it} = \beta_0 + \beta_1(t - \bar{t}) + \beta_2 \mathbb{1}\{t \geq \bar{t}\} + \beta_3(t - \bar{t}) \times \mathbb{1}\{t \geq \bar{t}\} + \epsilon_{it}$, where the dependent variable y_{it} represents the characteristic of loan i issued at time t, which can be either the loan's spreads (Columns 1 and 2) or size (Columns 3 and 4). The unit for loan spreads is basis points. The explanatory variable $\bar{t}$ denotes April 20, 2005, the reference date marking the passage of BAPCPA. The term $t - \bar{t}$ captures the distance in time from this reference point, and we annualize it by dividing by 365. The indicator function $\mathbb{1}\{t \geq \bar{t}\}$ equals one if the loan is issued post-BAPCPA. The residual term is denoted as ϵ_{it}. The second-to-last row displays the p-values from the Wald test for $\beta_1 + \beta_3 = 0$, which assesses the growth rate of loan spreads after the passage of BAPCPA. Regressions in Columns 1 and 3 are unweighted, while those in Columns 2 and 4 are weighted by loan sizes. Standard errors, shown in parentheses, are robust. Statistical significance is indicated by stars: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

we annualize $t - \bar{t}$ by dividing it by 365. The indicator function $\mathbb{1}\{t \geq \bar{t}\}$ equals one if the loan is issued post-BAPCPA. The residual term is denoted as ϵ_{it}. In this model, β_2 measures the immediate change in the loan terms on the day BAPCPA was passed, while β_3 indicates the change in trend following the passage of the reform.

Table 1 presents the results of the event-study regressions, which are consistent with the aggregate patterns observed in Figure 2.[14] In the first two columns, the dependent variable is the loan spread measured in basis points. Column 1 reports the results from an unweighted regression. The estimated coefficient of $t - \bar{t}$ is significantly negative, indicating that loan spreads decreased, on average, by 13.40 basis points per year prior to the passage of BAPCPA. In contrast, the estimated coefficient of $\mathbb{1}\{t \geq \bar{t}\}$ is statistically insignificant, suggesting that loan spreads did not decline after BAPCPA was implemented. Importantly, this lack of impact cannot be attributed to lagged effects, as the coefficient of the interaction term $(t - \bar{t}) \times \mathbb{1}\{t \geq \bar{t}\}$ is significantly positive, with a sizable magnitude of 12.61. This indicates that loan spreads, in fact, had an increasing trend over time after BAPCPA became law.

Column 2 presents results from regressions weighted by loan spreads. It also suggests that there is no significant decline in loan spreads at the time of BAPCPA implementation. The coefficient, β_2, is statistically indistinguishable from zero. Regarding the post-BAPCPA trend, the second-to-last row shows the p-values from the Wald test for $\beta_1 + \beta_3 = 0$, which assesses the growth rate of loan spreads after the passage of BAPCPA. The large p-values indicate that this growth rate is statistically insignificant from zero, suggesting that the previously declining trend in loan spreads effectively ceased following the passage of BAPCPA.

In Columns 3 and 4, the dependent variable is the logged loan size. Both the unweighted regression (Column 3) and the weighted regression (Column 4) show significant and positive coefficients for $t - \bar{t}$, indicating an increase in the average loan sizes prior to the reform. Specifically, the unweighted pre-BAPCPA growth rate is 12% per year, and the weighted pre-BAPCPA growth rate is even higher at 58% per year. These results highlight the expansion of the loan market prior to BAPCPA.

However, the passage of BAPCPA disrupted this upward trend, particularly for larger loans. In the weighted regression (Column 4), the estimated coefficient β_2 is significantly negative, suggesting that the loan sizes immediately decreased by 23%

[14]See also Figure C.2 in the Appendix.

upon the passage of BAPCPA. Furthermore, the significantly negative coefficient of -0.45 for the interaction term $(t-\bar{t})\times\mathbb{1}\{t\geq\bar{t}\}$ indicates a 45% slowdown in the growth rate of loan sizes after the reform. Since the unweighted regression does not show significant changes (Column 3), these findings imply that the discontinuity is primarily concentrated among the larger loans.

The results of the event study reject the null hypothesis of no structural break in the loan market following the passage of BAPCPA. More importantly, the direction of the changes runs counter to the conventional prediction: an increase in pledgeability is predicted to reduce loan rates. In what follows, we develop a model with limited commitment that can account for the observed patterns.

3 The Model

3.1 Environment

The model environment is based on Diamond and Dybvig (1983) with the introduction of an additional type of agent: borrowers. There are three time periods indexed by $t=0,1,2$. There are two types of agents in this economy: depositors and borrowers. The measure of depositors is normalized to 1 while the measure of borrowers is n.

Each depositor is endowed with one unit of capital in $t=0$ and nothing in periods $t=1,2$. Depositors have access to a long-term investment technology that turns 1 unit of capital at $t=0$ into $\underline{R}>1$ units of consumption good at $t=2$ or 1 unit of consumption good at $t=1$. There is also a storage technology that can transform capital into consumption good at a one-for-one rate in either period.

Depositors are identical in period 0. At date $t=1$, each depositor receives an idiosyncratic preference shock. With probability λ, the depositor is impatient, meaning he derives utility exclusively from consuming in $t=1$. With probability $1-\lambda$, the depositor is patient, meaning he values consumption in $t=2$.

Let $u(x_t)$ denote the utility function of the depositor, where x_t is the consumption in period t. The utility function is strictly increasing, strictly concave, and normalized to $u(0) = 0$. Whether a depositor is patient or impatient is his private information. By the law of large numbers, λ is also the fraction of depositors in the population who are impatient.

Borrowers have access to a technology that turns 1 unit of capital at $t = 0$ into $\bar{R} > \underline{R}$ units of consumption good at $t = 2$ or one unit of consumption good at $t = 1$. They are not endowed with capital. However, they can produce capital by incurring a utility cost at $t = 0$. Let $c(k)$ be the cost function of producing k units of capital at $t = 0$, where $c', c'' > 0$ and $c'(0) = 0$. Borrowers consume at $t = 2$ with utility function $v(x)$, where $v' > 0 > v''$.

Following Diamond-Dybvig, depositors have the incentive to form a coalition that acts as a bank by providing themselves with a deposit contract to insure against the consumption shock. The borrowers have access to better technology. So, if there is no further friction, banks should lend their capital to borrowers in $t = 0$ and get a higher return. However, borrowers lack commitment. When a borrower receives a loan, he can liquidate the investment at $t = 1$, transforming the capital into the consumption good at a one-for-one rate, repaying only the pledged fraction of the collateral posted. Here, posted collateral consists of the sum of loans and the borrower's capital. For simplicity, we assume that if the borrower reneges on the loan, he absconds with the unpledgeable collateral.[15] Let χ be the fraction of the collateral collected by the bank, so $1 - \chi$ is the fraction consumed by the borrower if he reneges on the loan.[16]

3.2 Benchmark: No Loan Market

To set up a benchmark for comparison, we first calculate the payoffs of banks and borrowers without the loan market. As a coalition of depositors, the bank seeks to

[15]Boot et al. (1991) explain the use of collateral by the borrower's hidden action and hidden information.

[16]This is modeled as cash diversion in Biais et al. (2007) and DeMarzo and Fishman (2007).

maximize the expected welfare of its depositors. Formally, the deposit contract solves

$$\hat{W}_D = \max_{x_1, x_2} \left[\lambda u\left(x_1\right) + (1-\lambda) u\left(x_2\right)\right] \tag{2}$$

$$\text{s.t. } \left(1 - \lambda x_1\right) \underline{R} = (1-\lambda) x_2 \tag{3}$$

$$x_2 \geq x_1 \tag{4}$$

where (3) is the resource constraint and (4) is the incentive constraint for late depositors to wait until $t = 2$ to withdraw. The bank liquidates λx_1 from its investment in $t = 1$ to pay impatient depositors and leave the rest until $t = 2$ with return $\underline{R}$ to pay patient ones. As standard, the solution to (2), denoted by $(\hat{x}_1, \hat{x}_2)$ satisfies the first-order condition $u'\left(x_1\right) = \underline{R} u'\left(x_2\right)$ and (3). At $(\hat{x}_1, \hat{x}_2)$, (4) does not bind.

Unlike much of the literature following Diamond-Dybvig (1983), we do not impose the assumption that the coefficient of relative risk aversion (CRRA), defined as $-xu''/u'$, is greater than 1. The inverse of CRRA, $-u'/xu''$, is the elasticity of intertemporal substitution (EIS). A higher CRRA means that depositors are more risk averse. It also means the EIS is low. The assumption that CRRA > 1 results in $1 < \hat{x}_1 < \hat{x}_2 < \underline{R}$, meaning the depositors prefer a smoother consumption profile than what they can have in autarky. However, if $0 <$ CRRA < 1, the contract specifies $\hat{x}_1 < 1 < \underline{R} < \hat{x}_2$, indicating that depositors prefer a more volatile consumption profile than under autarky. This does not mean depositors are not risk averse. They are. However, since the technology yields a higher return, the depositors prefer to substitute away from early consumption toward higher late consumption.

Without the loan market, borrowers solve:

$$\hat{W}_B = \max_{k} \left[-c\left(k\right) + v\left(\bar{R}k\right)\right]$$

The first-order condition is $c'\left(k\right) = \bar{R} v'\left(\bar{R}k\right)$. Let the solution for capital be denoted by $\hat{k}$. Borrowers consume $\hat{x}_B = \bar{R}\hat{k}$.

3.3 Competitive Loan Market

Next, we set up the problem in a competitive loan market. Both banks and borrowers take the market loan rate as given and choose the size of the loan to maximize their expected utility. The bank's problem is

$$\max_{x_1, x_2, a} \left[\lambda u\left(x_1\right) + (1-\lambda)\, u\left(x_2\right)\right]$$
$$\text{s.t. } (1-\lambda)\, x_2 = \left(1 - \lambda x_1 - a\right) r + a\underline{R} \tag{5}$$

and (4), where r is the market loan rate. The bank keeps λx_1 in storage and invests a in its own long-term technology.[17] Thus, $1 - \lambda x_1 - a$ is the amount of the loan extended to the borrowers. Equation (5) is the resource constraint for the bank. The bank expects the loan to be paid at $t = 2$ with the interest rate r. From its own production, the bank pays impatient depositors λx_1 at $t = 1$ and the safe-haven investment a, matures with return $\underline{R}$. With these resources, the bank pays the patient depositors at $t = 2$.

The first-order condition with respect to x_1 is

$$u'\left(x_1\right) - r u'\left(x_2\right) = 0 \tag{6}$$

By (5), $a = 0$ if $r > \underline{R}$, $0 < a < 1 - \lambda x_1$ if $r = \underline{R}$, and $a = 1 - \lambda x_1$ if $r < \underline{R}$. Next, take the derivative of (6) with respect to r for $r > \underline{R}$, we get the slope of the loan supply curve as

$$\frac{d\ell^s}{dr} = \frac{d\left(1 - \lambda x_1\right)}{dr} = \frac{-\lambda\left[u'(x_2) + x_2 u''(x_2)\right]}{u''(x_1) + \frac{\lambda r^2 u''(x_2)}{1-\lambda}} \tag{7}$$

where ℓ^s denotes the supply of loans. The denominator is negative and the numerator depends on the intertemporal marginal rate of substitution at x_2. With the assumption that EIS < 1 in the literature following Diamond and Dybvig (1983), the numerator is positive. Hence, the supply of loans, $1 - \lambda x_1$, decreases in r. If EIS > 1, the numerator of (7) is negative, which means the supply of loans is increasing in r. A more general

[17] It does not matter whether the bank keeps λx_1 in storage or in its own long-term technology because these two options yield the same return at $t = 1$.

case is that EIS moves above and below 1 as x_2 changes, so the supply curve is non-monotone. Figure 3 shows two monotonic cases of the loan supply curve for $\underline{R} < r \leq \bar{R}$. The vertical segment of the supply curve represents the quantities at which depositors are indifferent, as the return on the loan is the same as that of their own safe investment.

The borrower's problem is

$$\max_{k,\ell,x_B} \left[-c\left(k\right) + v\left(x_B\right)\right]$$

$$\text{st } x_B = \left(\bar{R} - r\right)\ell + \bar{R}k \tag{8}$$

$$x_B \geq \left(1 - \chi\right)\left(\ell + k\right) \tag{9}$$

where ℓ is the loan amount. Equation (8) is the borrower's resource constraint. His consumption is financed by two sources: he borrows ℓ from the bank, invests it, gets a return of $\bar{R}$ and pays r; in addition, his own capital yields $\bar{R}$. The borrower's repayment constraint is described by (9). The borrower can abscond with $1 - \chi$ fraction of the investment, and the bank recovers χ fraction of it. The contract must ensure that the borrower's equilibrium payoff cannot be less than the deviation payoff.

The first-order conditions are

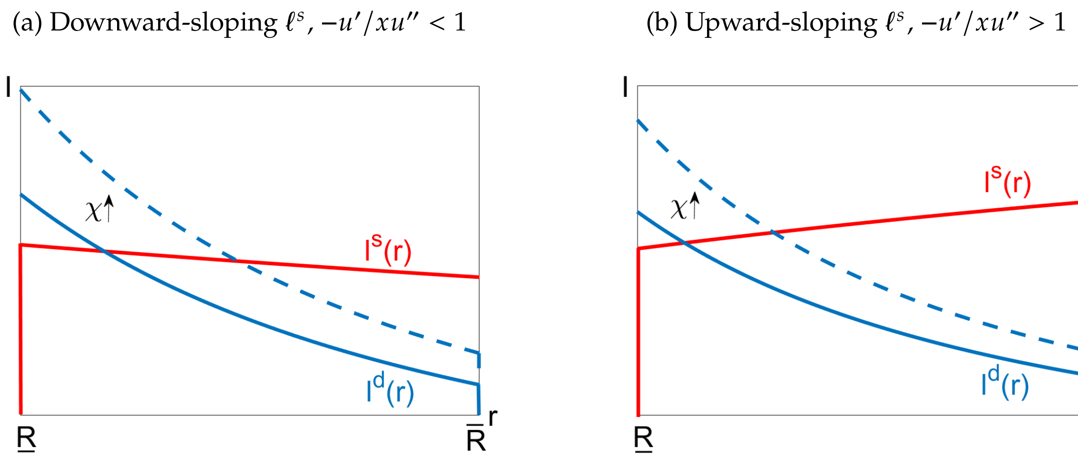
$$-\left(r - \bar{R} + 1 - \chi\right)c'\left(k\right) + r\left(1 - \chi\right)v'\left(x_B\right) = 0 \tag{10}$$

$$\eta - \frac{\left(\bar{R} - r\right)v'\left(x_B\right)}{r - \bar{R} + 1 - \chi} = 0 \tag{11}$$

where η is the Lagrangian multiplier associated with (9); in other words, the shadow value of the borrower's repayment constraint. Note that for $r < \bar{R} - 1 + \chi$, there will be infinite demand for ℓ. So r cannot be lower than $\bar{R}-1+\chi$. There are two cases, depending on whether (9) binds. First, with $r = \bar{R}$, then $k = \hat{k}$ and $\ell < \left(\bar{R} - 1 + \chi\right)\hat{k}/(1 - \chi)$. This is represented by the vertical part of the blue curve in Figure 3. Second, with $\bar{R} - 1 + \chi \leq r < \bar{R}$, the demand for loans is solved from (10) with binding (9). That is,

$$\left(r - \bar{R} + 1 - \chi\right)c'\left(\frac{r - \bar{R} + 1 - \chi}{\bar{R} - 1 + \chi}\ell\right) = r\left(1 - \chi\right)v'\left(\frac{r\left(1 - \chi\right)}{\bar{R} - 1 + \chi}\ell\right) \tag{12}$$

Figure 3: Competitive Loan Market Equilibrium



Note: The figure illustrates equilibrium in the competitive loan market. The red curve represents the supply of loans from banks, $\ell^s(r)$. The left panel shows that when the elasticity of intertemporal substitution (EIS) < 1, the supply of loans decreases in the loan rate r. The right panel shows that when EIS > 1, loan supply increases in r. The vertical segment of the supply curve is the range of loan quantities for which banks are indifferent between lending and investing in their own safe technology yielding return $\underline{R}$. The blue curve represents the demand for loans by borrowers, $\ell^d(r)$, which is downward sloping in both panels. The blue dashed curve is the upward shift in the original loan demand curve when pledgeability χ increases.

Taking the derivative of (12) with respect to r, we get the slope of the loan demand curve:

$$\frac{d\ell^d}{dr} = \frac{-\frac{\left(\bar{R}-1+\chi\right)^2}{r}c' - \left(r-\bar{R}+1-\chi\right)\ell c'' + (1-\chi)\, r\ell v''}{\left(r-\bar{R}+1-\chi\right)^2 c'' - r^2 (1-\chi)^2 v''} \tag{13}$$

As $c', c'' > 0 > v''$, (13) is negative. Hence, the demand for loans decreases in r, as shown in Figure 3.

Taking the derivative of (12) with respect to χ, we get

$$\frac{d\ell^d}{d\chi} = \frac{-\frac{\left(\bar{R}-r\right)\left(\bar{R}-1+\chi\right)}{1-\chi}c' - rkc'' + x_B r\bar{R}v''}{r^2 (1-\chi)^2 v'' - \left(r-\bar{R}+1-\chi\right)^2 c''}$$

which is positive. This implies that when χ increases, the demand curve shifts up. See the blue dashed lines in Figure 3.

Finally, the loan-market clearing condition is

$$1 - \lambda x_1 - a = n\ell \tag{14}$$

which solves for equilibrium r.

4 Results

4.1 Theoretical Results

There are three cases for equilibrium contracts, depending on whether eq. (9) binds and whether $a > 0$ or $a = 0$. We refer to the High-pledgeability Region as the range of χ values where eq. (9) does not bind, the Medium-pledgeability Region where eq. (9) binds and $a = 0$, and the Low-credibility Region where eq. (9) binds and $a > 0$.

If the loan supply curve is upward sloping, it is obvious that the intersection of ℓ^s and ℓ^d is unique (see Figure 3b). An increase in χ shifts up ℓ^d but does not affect ℓ^s. For a high value χ, ℓ^d and ℓ^s intersect at $r = \bar{R}$, where (9) does not bind. For low value χ, they intersect at $r = \underline{R}$, where (9) binds and $a > 0$. For intermediate value, they intersect at r between $\underline{R}$ and $\bar{R}$, where (9) binds and $a = 0$. Hence, there are two cutoffs of χ, labeled $\bar{\chi}$ and $\underline{\chi}$, $\bar{\chi} > \underline{\chi}$.

However, if ℓ^s is downward sloping or nonmonotone, it is less clear if the equilibrium is unique and if there are only two cutoffs. In Appendix A, we verify that ℓ^s is flatter than ℓ^d in the Medium Region whenever the two curves intersect. Thus, ℓ^s and ℓ^d cross at most once in the Medium Region, and the equilibrium is indeed unique. The upshot is that there are two cutoffs for three distinct regions. In any case, we have the following proposition.

Proposition 1 *Consider a perfectly competitive loan market. There exist $\underline{\chi}$ and $\bar{\chi}$, with $\underline{\chi} < \bar{\chi}$ such that (1) if $\chi \geq \bar{\chi}$, the equilibrium is in the High-pledgeability Region; (2) if $\underline{\chi} \leq \chi < \bar{\chi}$, the equilibrium is in the Medium-pledgeability Region; (3) if $\chi < \underline{\chi}$, the equilibrium is in the Low-pledgeability Region.*

The proof is provided in Appendix A. We discuss each case in detail below.

High-pledgeability Region: With $\eta = 0$, we solve (5)-(14) to get $a = 0$, $r = \bar{R}$, $k = \hat{k}$, $x_1 = x_1^*$ and $x_2 = x_2^*$, where $\left(x_1^*, x_2^*\right)$satisfies $u'(x_1) = \bar{R}u'(x_2)$ and $(1 - \lambda x_1)\bar{R} = (1 - \lambda)x_2$. The aggregate loan size is $1 - \lambda x_1^*$. Each borrower gets $\ell^* = \left(1 - \lambda x_1^*\right)/n$. The economy is in this region if and only if $\chi \geq \bar{\chi} \equiv 1 - \hat{k}\bar{R}/\left(\ell^* + \hat{k}\right)$.

In the High-pledgeability Region, the bank takes full advantage of the borrower's technology. The marginal rate of substitution between x_1 and x_2 equals the marginal rate of transformation of the borrower's technology. The borrower's capital production and consumption are the same as in autarky.

Medium-pledgeability Region: Medium-pledgeability Region: With $\eta > 0$ and $a = 0$, the Medium Region is associated with values of $\underline{\chi} \leq \chi < \bar{\chi}$, where $\underline{\chi}$ is defined in the proof of Proposition 1 in the Appendix. In this region, $\underline{R} \leq r < \bar{R}$.

In the Medium Region, r and χ are positively related. When χ increases, borrowers are able to borrow more, which intensifies competition for loans. This competition drives up the interest rate. Whether the loan size increases depends on the slope of ℓ^s. If ℓ^s is downward sloping, the equilibrium loan size decreases with χ, and vice versa.

It is ambiguous whether borrowers produce more capital compared to the High-pledgeability Region. Two countervailing forces are at work. On the one hand, as assets become less pledgeable, the loan contract requires more collateral to induce the borrower to repay the loan. On the other hand, since r is lower in the Medium Region, the unit repayment cost is smaller, which helps relax the repayment constraint.

We find that, when the depositor's EIS is low, the borrower's EIS, $-v'/xv''$, determines the sign of the overall effect. With a high elasticity, borrowers reduce the production of collateral as the opportunity cost becomes higher when r increases; the opposite occurs when elasticity is low. However, when depositor's elasticity is high, the overall effect is indeterminate. For the same reason, x_B is not necessarily monotone in χ.

Low-pledgeability Region: Low-pledgeability Region: With $\eta > 0$ and $a > 0$, we have

Table 2: Comparative Statics, Competitive Market

	$dx_1/d\chi$	$dx_2/d\chi$	$dx_B/d\chi$	$dk/d\chi$	$dr/d\chi$	$d\ell/d\chi$	$da/d\chi$
High	0	0	0	0	0	0	N.A.
Medium ($-u'/xu'' < 1$)	+	+	±	±	+	−	N.A.
Medium ($-u'/xu'' > 1$)	−	+	±	±	+	+	N.A.
Low	0	0	+	±	0	+	−

Note: The table reports the comparative statics of the equilibrium with respect to pledgeability χ in competitive loan and deposit markets. The three rows correspond to the High-, Medium-, and Low-pledgeability Regions characterized in Proposition 1. In the Medium Region, the sign of several comparative statics depends on the depositor's elasticity of intertemporal substitution, $-u'/xu''$. The signs +, −, and 0 indicate whether the variable increases, decreases, or remains unchanged as χ increases. The symbol ± indicates that the sign is ambiguous and depends on parameter values, while N.A. denotes that the variable is not defined in that region.

that $r = \underline{R}$. It follows immediately that $x_1 = \hat{x}_1$ and $x_2 = \hat{x}_2$, as in autarky. Borrowers take full advantage of the loan market as they pay the bank's reservation rate. This region arises when $\chi < \underline{\chi}$. In the Low-pledgeability Region, ℓ and x_B are both strictly increasing in χ, while a is strictly decreasing. Again, we find that whether k increases or decreases depends on $-v'/xv''$.

The comparative statics for each of the three regions are summarized in Table 2. In the Low Region, the sign of $dk/d\chi$ follows $dk/d\chi \doteq -(v'/v''x + 1)$, where $\doteq$ indicates that the derivative has the same sign as the expression on the right-hand side. In the Medium Region, if $u'/u''x + 1 > 0$, then $dk/d\chi \doteq v'/v''x + 1$.

To illustrate the economic intuition, consider the case in which χ increases from zero. The borrowing conditions change in several dimensions: collateral, loan rate, and loan size. As pledgeability rises, borrowers become less constrained and can borrow more. In the Low-pledgeability Region, banks still invest in the low-return technology, so the loan rate remains at $r = \underline{R}$.[18]

As χ increases within this region, borrowers become less constrained and borrow more. Banks gradually reduce direct investment while lending expands. The loan rate

[18]Note that even when $\chi = 0$, banks can still lend a positive amount to borrowers because the borrower would have to give up the return on his own capital if he absconds.

remains at $\underline{R}$, which equals the return on direct investment. The effect on the borrower's capital production, k, depends on the borrower's EIS.

When χ crosses $\underline{\chi}$, the economy enters the Medium Region. Banks no longer invest in the low-return technology, and competition for loans eventually raises the loan rate. The long-term deposit rate, measured by x_2, reflects the investment return. Naturally, it increases with the loan rate and consequently χ. In contrast, the short-term deposit rate x_1 depends on depositors' EIS: it rises when EIS is low and falls when EIS is high. The response of loan size also depends on the depositors' EIS, while the relationship between k and χ depends on the elasticities on both sides of the market.

As χ increases further and crosses $\bar{\chi}$, the repayment constraint no longer binds. The loan rate reaches $r = \bar{R}$, the loan size remains constant, and k stays at $\hat{k}$.

4.2 Numerical Results

To illustrate the equilibrium outcomes for different values of collateral pledgeability, we turn to numerical analysis. The following functional forms and parameter values are used in the numerical experiments. The results are plotted in Figure 4.

Let

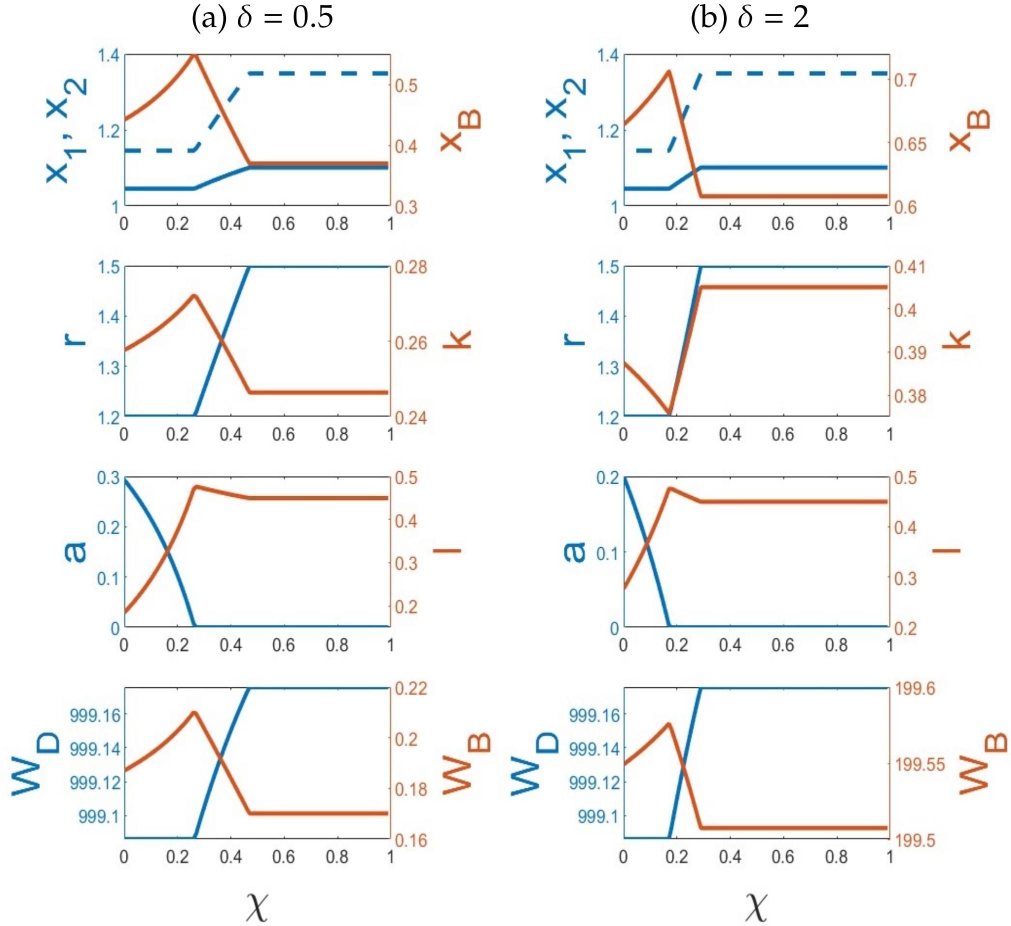
$$u(x) = \frac{(x+b)^{1-\gamma} - b^{1-\gamma}}{1-\gamma}, \quad c(k) = Bk^{\alpha}, \quad v(x) = A\frac{(x+b)^{1-\delta} - b^{1-\delta}}{1-\delta},$$

where $b = 0.001$, $\gamma = 2$, $B = 1$, $\alpha = 2$ and $A = 0.2$. Other parameters are $\bar{R} = 1.5$, $\underline{R} = 1.2$, $\lambda = 0.5$, and $n = 1$. In the figure, the left column uses $\delta = 0.5$, and the right column uses $\delta = 2$.

The parameters γ and δ determine the EIS of depositors and borrowers, respectively. If $\gamma > 1$, depositor's EIS < 1. If $\gamma < 1$, their EIS > 1. The same relationship applies to borrowers through δ. Given $\gamma > 1$, the adjustment in k depends on the borrower's EIS. With $\delta = 0.5$, capital initially increases in the Low Region and then decreases in the Medium Region. Conversely, when $\delta = 2$, the adjustment follows the opposite pattern.

In both examples, loan size, borrower's consumption, and borrower's welfare first

Figure 4: Competitive Equilibrium ($\gamma = 2$)

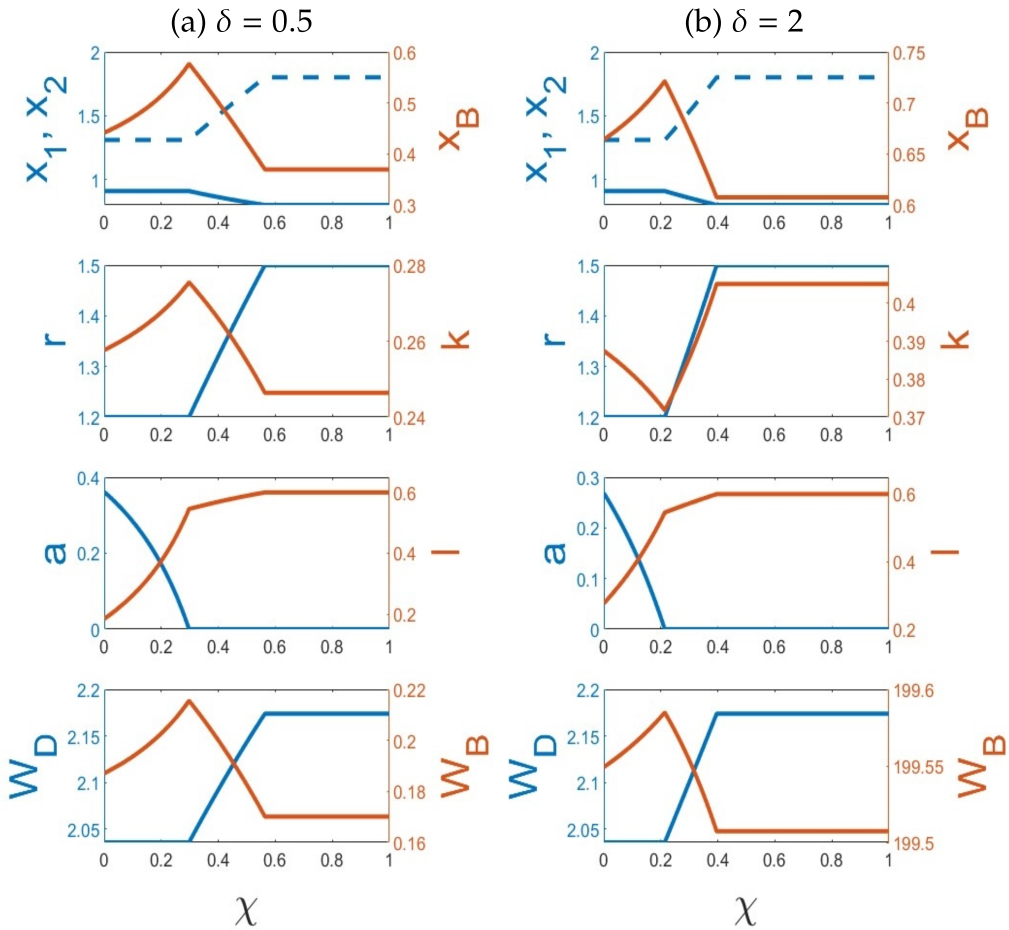


Note: The figure shows equilibrium outcomes as collateral pledgeability χ varies, with the depositor's EIS parameter set to $\gamma = 2$. Panel (a) sets the borrower's EIS $\delta = 0.5$ and panel (b) sets $\delta = 2$. Blue lines correspond to variables measured on the left vertical axis, including impatient depositors' consumption x_1, patient depositors' consumption x_2 (dashed blue line), the loan rate r, the bank's investment in the safe technology a, and depositor welfare W_D. Red lines correspond to variables measured on the right vertical axis, including borrower consumption x_B, the borrower's capital production k, the loan size ℓ, and borrower welfare W_B.

increase, then decrease, and eventually stay constant. In particular, the right panel shows a case where collateral intensity (i.e., k/ℓ ratio) rises as assets become more pledgeable in the Medium Region. The loan rate is constant in the Low and High Regions and strictly increasing in the Medium Region.

On the deposit side, both types of depositors consume more as χ increases, but patient depositors' consumption x_2 increases faster than impatient depositors' con-

Figure 5: Competitive Equilibrium ($\gamma = 0.5$)



Note: The figure shows equilibrium outcomes as collateral pledgeability χ varies, with the depositor's EIS parameter set to $\gamma = 0.5$. Panel (a) sets the borrower's EIS $\delta = 0.5$ and panel (b) sets $\delta = 2$. Blue lines correspond to variables measured on the left vertical axis, including impatient depositors' consumption x_1, patient depositors' consumption x_2 (dashed blue line), the loan rate r, the bank's investment in the safe technology a, and depositor welfare W_D. Red lines correspond to variables measured on the right vertical axis, including borrower consumption x_B, the borrower's capital production k, the loan size ℓ, and borrower welfare W_B.

sumption x_1. As a result, risk sharing is weaker, but the overall welfare of depositors W_D improves.

Figure 5 plots examples using the same parameter values as in Figure 4, except that $\gamma = 0.5$. As χ increases, depositors consume less x_1 and more x_2 in the Medium Region, and the loan size increases monotonically across Regions.

Our numerical experiments are not intended as a kind of quantitative identification.

In particular, the cut-off points for the different regions should not be interpreted literally. Nevertheless, even this simple numerical exercise provides useful qualitative insights.

Specifically, the Medium Region offers an explanation for the events following BAPCPA's passage. One key feature of BAPCPA is that the law increases loan pledgeability. Our model accounts for the shift in loan-rate trend as the result of intensified competition for loans. When the intertemporal elasticity of substitution is sufficiently low, the loan supply curve is downward sloping. When the equilibrium lies in the Medium Region, the model predicts that greater pledgeability results in a contraction in loan size.

The last row of Figure 4 shows that borrowers can in fact be worse off as pledgeability increases. Under these conditions present in the Medium Region, borrowers are worse off due to smaller loans. In contrast, lenders (depositors) are better off as loan rates increase with pledgeability. Indeed, the top row of Figure 4 shows that the consumption of both impatient and patient depositors increases with pledgeability.

To compare our results with Kaplan and Zingales (1997), we use the marginal cost of producing k as the rate of internal financing and the loan rate r as the external financing rate. The difference, $c' - r$, increases in the Low Region and decreases in the Medium Region in the numerical examples above with $\delta = 0.5$, whereas it decreases in both regions when $\delta = 2$. This shows that interest rate differentials are not reliable indicators of underlying frictions. Even if other contract terms are nonmonotonic in interest rate differentials, this does not imply that they are nonmonotonic in the underlying frictions.

The non-monotonicity results are robust to alternative market structures where banks have market power, modeled through bilateral trading with Nash bargaining or directed search (see Appendix B).[19] The underlying mechanism differs from that in

[19]See Drechsler, Savov and Schnabl (2017). They consider a model in which banks have market power over deposits whereas we focus on the market power over loans. In their paper, the federal funds rate is used as a measure of the risk-free rate. When monetary policy tightens, the spread between the federal funds rate and the deposit rate widens. Although we do not analyze changes in the return on the risk-free

the competitive equilibrium: agents can adjust multiple elements of the contracts, each operating on different margins when the repayment constraint binds. Thus, changes in pledgeability do not necessarily cause all terms to move uniformly in magnitude or even direction. Despite these complexities, a common feature emerges across market structures: investment in the low-return, safe asset falls with pledgeability in the Low-pledgeability Region and becomes zero once the economy enters the Medium Region. In other words, using the low-return technology is the last resort under the worst credit conditions. This is because the production frontier is invariant to small changes in contract terms, whereas investing in the low-return asset shrinks the production set.

5 Extensions

In this section, we extend the baseline framework to explore additional implications of the model. We first examine how unexpected shocks to borrowers' productivity affect financial stability and the likelihood of bank runs. We then study how pledgeability interacts with banking regulation by comparing separated and unified banking systems, motivated by the restrictions imposed under the Glass-Steagall Act.

5.1 Financial Stability

In the first extension, we examine how collateral pledgeability affects the stability of the banking system in the presence of unexpected shocks. To connect the analysis with the bank-run literature, we follow the conventional assumption in Diamond and Dybvig (1983) that depositors have CRRA > 1 (equivalently, EIS < 1). The optimal deposit contract specifies $1 < x_1 < x_2 < \bar{R}$ and is prone to panic bank runs.

Given that there is no aggregate uncertainty in the model, a demand deposit with suspension clauses can strongly implement the "no run" equilibrium. To provide

asset, deposit rates in our model respond to changes in pledgeability. So, we could analyze movements in the spread between the risk-free good and deposit rates. The risk-free-to-deposit rate spread is not monotonically related to changes in pledgeability in our framework, suggesting that future work could explore how this limited commitment affects the deposit channel.

insight into financial stability, we consider an unexpected negative productivity shock to the borrower's technology. Depositors observe the decline at $t = 1$. Denote the return by $\tilde{R}$, where $\tilde{R} < \bar{R}$. The borrower honors the repayment if

$$\ell\left(\tilde{R} - r\right) + k\tilde{R} \geq (1 - \chi)(\ell + k)\,. \tag{15}$$

Otherwise, he defaults.

Because the productivity shock is unexpected, contracts do not accommodate such an event. The bank may fail to fulfill its promise to pay patient depositors x_2. If $a > 0$, the bank can still make some payment at $t = 2$, but the payment may fall short of x_1. We assume that the depositors learn the borrower's repayment decision and then decide whether to withdraw at $t = 1$. Even with a suspension clause, knowing that fewer resources will be available at $t = 2$ encourages early withdrawals.

In the High-pledgeability Region, eq. (21) does not bind. As long as the fall in return is "small," borrowers honor the debt. However, in the Medium and Low Regions, the repayment constraint binds. A decrease in the borrower's return violates eq. (21) and triggers a default. In the Medium Region, banks allocate all long-term investments to borrowers' projects. With all-the-eggs-in-one-basket, the bank will have no resources to pay the depositors at $t = 2$. Thus, default by borrowers triggers a bank run. In the Low-pledgeability Region, the bank invests some resources in the safe project, which yields $a\underline{R}$. Consequently, the bank can pay each patient consumer $a\underline{R}/(1-\lambda)$ in $t = 2$. If $a\underline{R}/(1-\lambda) < x_1$, a bank run follows. However, if $a\underline{R}/(1-\lambda) \geq x_1$, it is incentive compatible for patient depositors not to withdraw at $t = 1$.

The implication is clear: through this extensive margin, banks are able to diversify their portfolios. In the presence of unanticipated shocks, the Medium-pledgeability Region and the lower portion of the High-pledgeability Region are more fragile than the Low-pledgeability Region. When χ falls below a critical threshold, the Low-pledgeability Region implements a diversified portfolio that reduces the chance of a bank run.

We extend the numerical analysis in Figure 4 with $\bar{R} = 1.25$, $\lambda = 0.4$, $\gamma = 1.2$, and $\delta = 0.1$. The cutoffs are $\underline{\chi} = 0.69$ and $\bar{\chi} = 0.75$. For $\chi \geq 0.75$, higher pledgeability allows the system to absorb larger negative shocks. In the Low-pledgeability Region, for $\chi < 0.18$, the condition $a\underline{R} > (1 - \lambda)\, x_1$ is satisfied, indicating that even if the borrowers default, bank failure does not occur.

5.2 Separated vs Unified Banking

The Glass-Steagall Act of 1933 distinguishes between loans and direct investments by restricting commercial banks from participating in securities underwriting.[20] Our goal in this section is to assess the impact of the Act on depositors' welfare. To adapt our model for this task, we assume that the return on banks' direct investment technology is stochastic. It yields $\underline{R}$, where $1 < \underline{R} < \bar{R}$, with probability ρ, and 0 with probability $1 - \rho$. Yields are bank specific, and depositors cannot diversify across banks due to, for example, geographic or legal restrictions.

Without the Act, banks can choose portfolios consisting of storage, risky direct investments, and loans to external borrowers. We refer to this as a "unified banking system." Under the Act, banks are limited to storage or loans, creating a "separated banking system." Thus, we interpret the direct investment asset as the key feature distinguishing the unified banking system from the separated one.

As risks are idiosyncratic across banks, we introduce a deposit insurance program that guarantees the same return for all banks in all states. Banks pay a premium ψ at $t = 0$. This insurance program provides subsidies to banks experiencing adverse

[20] Kroszner and Rajan (1994) examine the performance of commercial banks, comparing those constrained from direct investment with investment banks. Investment banks are free to invest directly. They present evidence consistent with the notion that there is no substantial difference between the quality of securities underwritten by investment banks and the loans made by commercial banks. Gorton and Schmid (2000) study the German banking environment. They argue that unified banking results in better returns for firms receiving direct investment from banks. Berlin and Meister (1999) examine the potential contributions of bank equity investments in addressing the challenges faced by financially distressed businesses. Additionally, Santos (1998) delved into the welfare implications of restrictions on banks' direct investments in non-financial enterprises.

shocks from direct investments.[21]

A deposit contract under separated banking solves the following:

$$
\begin{aligned}
W_D^S = \max_{x_1,x_2,s} \; & \lambda u(x_1) + (1-\lambda) u(x_2) \\
\text{s.t.} \;\; & (1-\lambda) x_2 = (1 - \lambda x_1 - s) r + s \\
& x_2 \geq x_1,
\end{aligned}
$$

where s is the investment in storage. The first-order condition with respect to x_1 is given by eq. (6). The optimal choice of s is $s = 0$ if $r > 1$, and $s > 0$ if $r = 1$. The equilibrium r can vary between 1 and $\bar{R}$. The borrower's problem remains the same as in Section 4. The market clearing condition is $1 - \lambda x_1 - s = n_B \ell$. The equilibrium under the separated banking can be viewed as a special case of Section 4 with $\underline{R} = 1$. As there is no risk in investment, the insurance program is not active.

Under the unified banking system, the deposit contract solves:

$$
\begin{aligned}
W_D^U(\psi) = \max_{x_1,x_2,a} \; & \lambda u(x_1) + (1-\lambda) u(x_2) \\
\text{s.t.} \;\; & (1-\lambda) x_2 = (1 - \psi - \lambda x_1 - a) r + a\underline{R} \qquad (16) \\
& x_2 \geq x_1. \qquad (17)
\end{aligned}
$$

Depositors are shielded from uncertainty by the insurance program, so they treat the return on direct investment as $\underline{R}$ with probability 1. The first-order condition with respect to x_1 remains eq. (6). If $r > \underline{R}$, then $a = 0$. If $r = \underline{R}$, then $a \in (0, 1 - \psi - \lambda x_1)$. If $r < \underline{R}$, then $a = 1 - \psi - \lambda x_1$. The borrower's problem remains the same as in Section 4. The market clearing condition is (14). Because $1 - \rho$ is the fraction of banks realizing no return on the direct investment, an actuarially fair insurance premium is $\psi = a(1-\rho)\underline{R}$. This closes the model.

Note that the insurance program has several opposite effects on welfare. On the one

[21] The deposit insurance policy is exogenously set by the government. Deposit insurance is not the solution to a Ramsey problem. See Davila and Goldstein (2023) for a modified version of Diamond-Dybvig in which the optimal deposit insurance is derived.

hand, since it provides a lower bound on direct investment, it raises the market loan rate and allows banks to earn a higher return on loans. On the other hand, it diverts resources from investments to rescue failed banks and encourages excessive investment in risky technology. The overall effect is ambiguous and can vary with pledgeability.

To begin, consider how separated and unified banking interacts with pledgeability. To illustrate, let $\underline{\chi}^U$ be the cutoff χ between the Low and Medium Regions defined in Section 4 with $\psi = 0$. From Proposition 1, we know that if $\chi \geq \underline{\chi}^U$, then $r \geq \underline{R}$ and $a = 0$. For high enough values of pledgeability, banks do not allocate resources to direct investment, and the equilibrium is invariant to separate and unified banking policies. The economic intuition is straightforward: when the loan market friction is minimal, the Glass-Steagall Act has no effect.

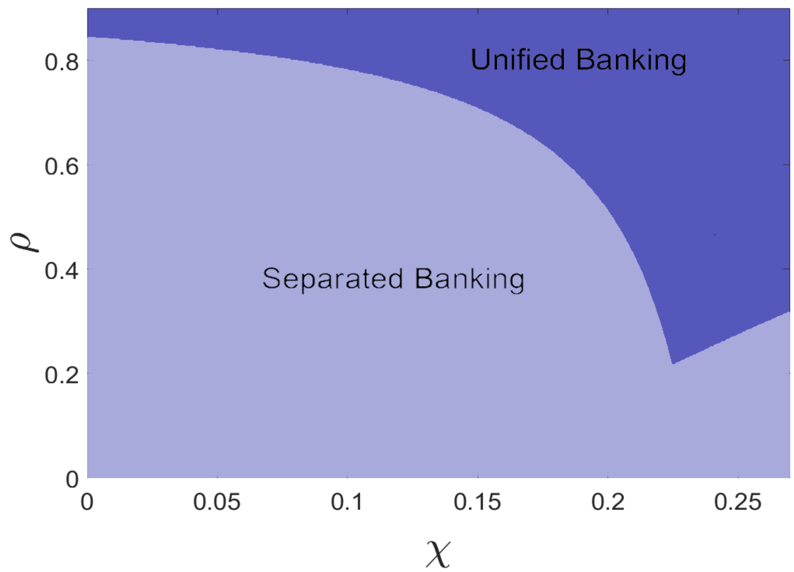
Next, consider the case of low pledgeability, specifically $\chi < \underline{\chi}^U$. It is straightforward to show that $\partial W_D^U / \partial \rho > 0$. As direct investment becomes less risky, the bank's portfolio options improve. Under Glass-Steagall, the depositor's welfare, W_D^S, does not change with ρ. Therefore, there exists a cutoff ρ above which the Act harms the economy and below which it does not.

Now fix ρ and examine how changes in pledgeability affect welfare under the two policy regimes. What if χ changes in the interval of $\left[0, \underline{\chi}^U\right]$? First, consider the case of separated banking. Suppose χ increases from 0. According to the comparative statics in Table 2, depositor's welfare stays constant in the Low-pledgeability Region.[22] Next, consider unified banking. For $\chi < \underline{\chi}^U$, banks invest in the risky technology, and the return is constant at $\underline{R}$. Since some banks fail in direct investment, the insurance premium is positive. By paying these premiums, resources are diverted from production, and excessive investment is made in risky technology. Therefore, as χ increases, less investment is diverted, and welfare rises. Consequently, it is not straightforward to determine whether the Act improves welfare.

We use a numerical example to illustrate the result. Let the parameter values be the

[22] As a reminder, expected welfare increases with χ for $\chi \in [\underline{\chi}^N, \underline{\chi}^U]$.

Figure 6: Universal Banking vs Narrow Banking



Note: The figure plots the iso-welfare frontier in the (χ, ρ) space at which depositor welfare is identical under unified and separated banking systems. The horizontal axis shows collateral pledgeability χ, and the vertical axis shows the probability of success of the direct investment technology ρ. The dark-shaded region indicates parameter values for which unified banking yields higher depositor welfare, while the light-shaded region indicates where separated banking dominates.

same as those used in Figure 4; that is, $\alpha = 1$, $\underline{R} = 1.1$, $\lambda = 0.3$, and $\delta = 2$. Figure 6 plots the frontier in the (χ, ρ) space where the depositor's welfare is the same under both systems. The dark-shaded area represents the region in which unified banking dominates separated banking, while the light-shaded area indicates the region in which separated banking outperforms unified banking.

The boundary is nonmonotonic in χ. For a given χ, depositor welfare is greater for high values of ρ, but lower for low values of ρ. Alternatively, for a given ρ, the non-monotonicity means that it is not clear which policy setting is preferred as χ changes. In Figure 6, the kink in the iso-welfare frontier illustrates this feature: for some values of ρ, separated banking becomes the preferred policy even when unified banking dominates for nearby levels of pledgeability.

The numerical results show that, for a given probability of success in the direct investment project, Glass-Steagall is the expected welfare maximizing policy when pledgeability is extremely low. However, for intermediate levels of pledgeability, Glass-Steagall can reduce expected welfare for the same probability of success. Thus, separated banking dominates unified banking for both low and high values of χ. It is the "in-between" values of χ in which separated banking can actually reduce depositor's welfare. Hence, whether Glass-Steagall is the preferred policy or not depends on both the riskiness of direct investment *and* the friction in the loan market. In general equilibrium, there is no single measure that definitively determines whether Glass-Steagall improves welfare.

6 Conclusion

Banking policies and financial indicators are often constructed and interpreted based on conventional wisdom. Specifically, interest rates on debt instruments are inversely related to the fraction of debt that borrowers can promise to repay. The intuition comes from a partial-equilibrium perspective in which lenders' supply increases in response to greater loan pledgeability. Indeed, both the BAPCPA and the Federal Reserve Bank of Chicago's National Financial Conditions Index (NFCI) interpret increases in interest rate spreads as signs of tighter credit conditions.[23] However, we present evidence suggesting that the effects associated with the passage of BAPCPA run in the opposite direction.

We re-examine the predictions of the partial-equilibrium analysis in an economy in which deposit contracts and loan contracts are determined simultaneously and borrowers have limited commitment. The general-equilibrium effects are important. We derive conditions under which the financial friction overturns the conventional prediction. The implication is clear: once general-equilibrium interactions are taken into account, commonly used interpretations of credit conditions warrant closer scrutiny. In our model, contract terms exhibit complex, interactive patterns with changes in

[23]See Brave and Kelly (2017) for details. The NFCI is constructed from 105 variables, including 30 different interest rate spreads and 28 measures of quantities or ratios. See also Boot et al. (1991).

pledgeability.

Because our framework incorporates both deposit and loan markets, the equilibrium intermediary contracts shed light on these interactions through the composition of intermediaries' assets, loan risk, and risk sharing. The model is easily extended to analyze banking issues and policies under shifting loan market conditions. We apply it to two key topics: financial fragility and the Glass-Steagall Act. In both cases, the model offers new insights. Economies with low pledgeability may be more stable since banks diversify their portfolios; and the welfare effects of the Glass-Steagall Act depend on both investment riskiness and frictions in markets other than the deposit market.

Our future work includes extending the model to incorporate dynamics to better understand the differences in trends before and after BAPCPA, as well as examining stochastic pledgeability at growth and business-cycle frequencies. Furthermore, we aim to explore how systemic changes in credit conditions affect heterogeneous agents and to revisit the data to further validate our theoretical framework.

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Appendix

A Proofs

Proof of Proposition 1: First, we show the uniqueness of the equilibrium. Rewrite the slope of the loan supply curve in the Medium Region, given by (7), as

$$\frac{d\ell^s}{dr} = \frac{u'(x_2) + x_2 u''(x_2)}{-\frac{u''(x_1)}{\lambda} - \frac{r^2 u''(x_2)}{1-\lambda}} > \frac{x_2 u''(x_2)}{-\frac{u''(x_1)}{\lambda} - \frac{r^2 u''(x_2)}{1-\lambda}} > \frac{x_2 u''(x_2)}{-\frac{r^2 u''(x_2)}{1-\lambda}} = -\frac{\ell}{r}$$

The first inequality follows from the fact that $u' > 0 > u''$, the second is by the fact that $-u_1''/\lambda$ is positive and u_2'' is negative, and the last equality holds because $(1-\lambda)\, x_2 = \ell r$ in the Medium Region. This implies that if ℓ^s is decreasing, the absolute value of its slope is less than ℓ/r.

Similarly, rewrite the slope of the loan demand curve, given by (13) as

$$\begin{aligned}
\frac{d\ell^d}{dr} &= \frac{\ell}{r}\frac{-\frac{\left(\bar{R}-1+\chi\right)^2}{\ell}c' - r\left(r-\bar{R}+1-\chi\right)c'' + r^2\left(1-\chi\right)v''}{\left(r-\bar{R}+1-\chi\right)^2 c'' - r^2\left(1-\chi\right)^2 v''} \\
&< \frac{\ell}{r}\frac{-r\left(r-\bar{R}+1-\chi\right)c'' + r^2\left(1-\chi\right)v''}{\left(r-\bar{R}+1-\chi\right)^2 c'' - r^2\left(1-\chi\right)^2 v''} \\
&= \frac{\ell}{r}\frac{-r\left(r-\bar{R}+1-\chi\right)c'' + r^2\left(1-\chi\right)v''}{r\left(r-\bar{R}+1-\chi\right)c'' - \left(\bar{R}-1+\chi\right)\left(r-\bar{R}+1-\chi\right)c'' - r^2\left(1-\chi\right)^2 v''} \\
&< -\frac{\ell}{r}
\end{aligned}$$

The first inequality follows from the fact that $c', c'' > 0 > v''$ and the second inequality follows from the fact that $c'' > 0$. This implies that the demand curve is downward-sloping and the absolute value of the slope is bigger than ℓ/r.

Hence, if the demand and supply curves intersect in the Medium Region, the demand curve must cut through the supply curve from above. If multiple intersections exist, the supply curve would have to cross the demand curve from above at least once. A contradiction. Therefore, the equilibrium in the Medium Region is unique.

If there is an equilibrium in the Medium Region, then $\ell^d > \ell^s$ at $r = \underline{R}$, and $\ell^d < \ell^s$ at $r = \bar{R}$, which means the equilibrium is unique. If ℓ^d and ℓ^s intersect at $r = \underline{R}$, it must be that $\ell^d \leq 1 - \lambda \hat{x}_1$. To get another equilibrium in the Medium or High Region, ℓ^d has to cross ℓ^s from below. A contradiction. Similar argument applies to the case where ℓ^d and ℓ^s intersect at $r = \bar{R}$. Therefore, the equilibrium is unique.

Next, we show there are only two cutoffs between Regions. It is straight-forward to show that if $\chi \geq \bar{\chi}$, the equilibrium in the High Region and the solution entails $\eta = 0$. Now consider $\chi < \bar{\chi}$ with $\eta > 0$. In the Low Region $a > 0$ and $r = \underline{R}$. By (6), $x_1 = \hat{x}_1$ and $x_2 = \hat{x}_2$. By (8)-(10), the demand for ℓ is characterized by

$$-c'\left(\frac{1-\chi+\underline{R}-\bar{R}}{\bar{R}-1+\chi}\ell\right)\left(1-\chi+\underline{R}-\bar{R}\right)+(1-\chi)\,\underline{R}v'\left(\frac{1-\chi}{\bar{R}-1+\chi}\ell\right)=0 \tag{18}$$

Take derivative wrt χ to get

$$\frac{d\ell}{d\chi}=-\frac{c'\left(\bar{R}-\underline{R}\right)\left(\bar{R}-1+\chi\right)^2+\ell\underline{R}\,(1-\chi)\left[c''\left(1-\chi+\underline{R}-\bar{R}\right)-v''\underline{R}\bar{R}\right]}{(1-\chi)\left(\bar{R}-1+\chi\right)\left[\underline{R}^2(1-\chi)^2v''-\left(1-\chi+\underline{R}-\bar{R}\right)^2c''\right]}>0$$

By (14) and since x_1 is constant, $da/d\chi < 0$. Thus, the cutoff of $\underline{\chi}$ between the Medium and Low Regions is unique. ■

B Market Power

To test the robustness of the non-monotonicity results, we examine the market response to changes in pledgeability under different loan market structures. Here, we use search frictions as a way to incorporate market power into the loan market. First, consider bilateral matches in the loan market. Banks and borrowers meet bilaterally to decide the terms of the loan contract. If they do not agree on the terms of trade, there is no trade and the payoffs are $\hat{W}_D$ and $\hat{W}_B$, respectively. Otherwise, they jointly determine the contract terms according to the generalized Nash bargaining solution. Let θ be the bargaining, or market, power of the bank. The generalized Nash problem is

$$\max_{x_1, x_2, x_B, r, k, a} \left[\lambda u(x_1) + (1-\lambda) u(x_2) - \hat{W}_D\right]^{\theta} \left[-c(k) + v(x_B) - \hat{W}_B\right]^{1-\theta} \tag{19}$$

$$\text{st (4), (5)}$$

$$x_B = (1 - \lambda x_1 - a)\left(\bar{R} - r\right) + k\bar{R} \tag{20}$$

$$x_B \geq (1-\chi)(1 - \lambda x_1 - a + k) \tag{21}$$

The first-order conditions with respect to (x_1, r, k, a) simplify to

$$u'(x_1)\left[c'(k) - (1-\chi) v'(x_B)\right] - \left(\bar{R} - 1 + \chi\right) u'(x_2) c'(k) = 0 \tag{22}$$

$$a\left[-u'(x_1) + \underline{R} u'(x_2)\right] = 0 \tag{23}$$

$$\theta u'(x_1) S_B - (1-\theta) c'(k) S_D = 0 \tag{24}$$

$$(1-\chi)\eta - \frac{(1-\theta) S_D c'(k)}{u'(x_1)}\left[\bar{R} u'(x_2) - u'(x_1)\right] = 0 \tag{25}$$

where the bank's trade surplus is $S_D \equiv \lambda u(x_1) + (1-\lambda) u(x_2) - \hat{W}_D$, the borrower's trade surplus is $S_B \equiv -c(k) + v(x_B) - \hat{W}_B$, and η is the Lagrangian multiplier associated with (21). As we found in the competitive market, there are three regions divided according to χ. Abusing notation, we use $\underline{\chi}$ and $\bar{\chi}$ to denote the cutoffs between the regions.

High-pledgeability Region: With $\eta = 0$ and $a = 0$, this region is characterized by $u'(x_1)/u'(x_2) = c'(k)/v'(x_B) = \bar{R}$, which implies that only borrower's higher-return technology is used and that the allocation is efficient. However, as $\theta \in (0,1)$, the bank does not get all surplus. Thus, $r < \bar{R}$. Denote the solution by $\left(\tilde{x}_1, \tilde{k}, \tilde{r}\right)$. The contract is in the High Region if and only if $\chi \geq \bar{\chi} \equiv 1 - \bar{R} + \tilde{r}(1 - \lambda\tilde{x}_1)/\left(1 - \lambda\tilde{x}_1 + \tilde{k}\right)$.

Medium-pledgeability Region: With $\eta > 0$ and $a = 0$, the contract is in the Medium Region if and only if $\underline{\chi} \leq \chi < \bar{\chi}$. Here, $\underline{R} \leq u'(x_1)/u'(x_2) < \bar{R}$, which implies the bank also undertakes the cost of twisting the investment in k by reducing the loan size and/or the rate. On the borrower's side, $c'(k) > \bar{R} v'(x_B)$, which implies that the marginal investment in k relaxes the borrowing constraint.

Low-pledgeability Region: With $\eta > 0$ and $a > 0$, the loan contract is in this Region if and only if $\chi < \underline{\chi}$. Again, $c'(k) > \bar{R}v'(x_B)$. On the bank's side, $u'(x_1) = \underline{R}u'(x_2)$ as the marginal investment of the bank yields $\underline{R}$.

Loan terms again exhibit non-monotonic patterns, but for a different reason. In a bilateral negotiation, both parties fully internalize all terms of the contract, including r, to adapt to changes in χ. The marginal value of each term is different when the repayment constraint binds. Consequently, the loan terms may not change in the same magnitude or even in the same direction with χ. Furthermore, one's surplus does not necessarily increase with the expansion of the Nash bargaining set (Kalai, 1977).

There is one clear comparative static. The quantity of direct investment is inversely related to pledgeability in the Low Region. Because the borrower's project return dominates the risk-free rate, the safe asset is the last tool that the bank uses to cope with the deteriorating pledgeability.

We continue the numerical analysis in Figure 4 and set $\theta = 0.5$. Figure B.1 presents the equilibrium contracts.

We can endogenize the bargaining power by considering competitive search. Suppose a bank can open a loan market by posting the terms of borrowing $(x_1, x_2, x_B, r, k, \ell)$. Borrowers observe the terms and pay an entry cost, denoted by ϕ, choosing to go to a specific market. In a market, banks and borrowers are matched according to the matching function $M(n_D, n_B)$, where n_D and n_B are the measures of banks and borrowers, respectively. Assume M is strictly increasing, strictly concave, and homogeneous of degree 1 in both arguments. Let $\tau = n_B/n_D$ be the market tightness. The probability that a bank meets a borrower is $\sigma(\tau) \equiv M(1, \tau)$ and the probability that a borrower meets a bank is $\sigma(\tau)/\tau$. Banks post terms of trade to solve the following problem:

$$\max_{x_1,x_2,x_B,r,k,a,\tau} \sigma(\tau)\left[\lambda u(x_1) + (1-\lambda) u(x_2)\right] + \left[1-\sigma(\tau)\right]\hat{W}_D \tag{26}$$

$$\text{st (4), (5), (20), (21)}$$

$$\frac{\sigma(\tau)}{\tau}\left\{-c(k) + v\left[(1-\lambda x_1 - a)\left(\bar{R}-r\right) + k\bar{R}\right]\right\} + \left[1-\frac{\sigma(\tau)}{\tau}\right]\hat{W}_B - \phi = \hat{W}_B \tag{27}$$

The LHS of (27) is the expected utility of a borrower if he enters the market, and the RHS is his payoff if he does not.

The first-order conditions are given by (22), (23) and

$$\left[1-\varepsilon(\tau)\right] u'(x_1) S_B - \varepsilon(\tau) c'(k) S_D = 0 \tag{28}$$

$$\eta - \frac{\sigma(\tau) u_2'(x_2)}{c'(k) - \chi v'(x_B)}\left[c'(k) - \bar{R} v'(x_B)\right] = 0 \tag{29}$$

where $\varepsilon(\tau) = \sigma'(\tau)\tau/\sigma(\tau)$ is the elasticity of the matching function and η is the Lagrangian multiplier associated with (21). With competitive search, the power is endogenized by the elasticity of the matching function. Note that if the matching elasticity is constant, the solution is the same as under Nash bargaining.

The equilibrium again falls into one of three regions associated with pledgeability. The comparative statics depend on the matching function and are generally ambiguous. The numerical analysis uses the same parameters as in Figure 4. Let $M(n_D, n_B) = n_D n_B/(n_D + n_B)$ and $\phi = 0.01$.

Figure B.2 plots the equilibrium contract terms, which are qualitatively similar to what we observed under Nash bargaining. Here the loan rate may rise with pledgeability in the entire range (the left column). The market gets tighter when χ increases from 0, but gets looser in the Medium Region and stays constant in the High Region. The ex-ante welfare of the borrowers is ϕ by the free entry condition, while the welfare of banks strictly increases for $\chi \leq \bar{\chi}$, despite the non-monotone matching probability. For matched borrowers, welfare follows a pattern similar to that in Figure B.1. Using parameters in Figure 5 produces the same patterns.

Table B.1: Comparative Statics, Competitive Search, $\varepsilon' < 0$, Entry Cost

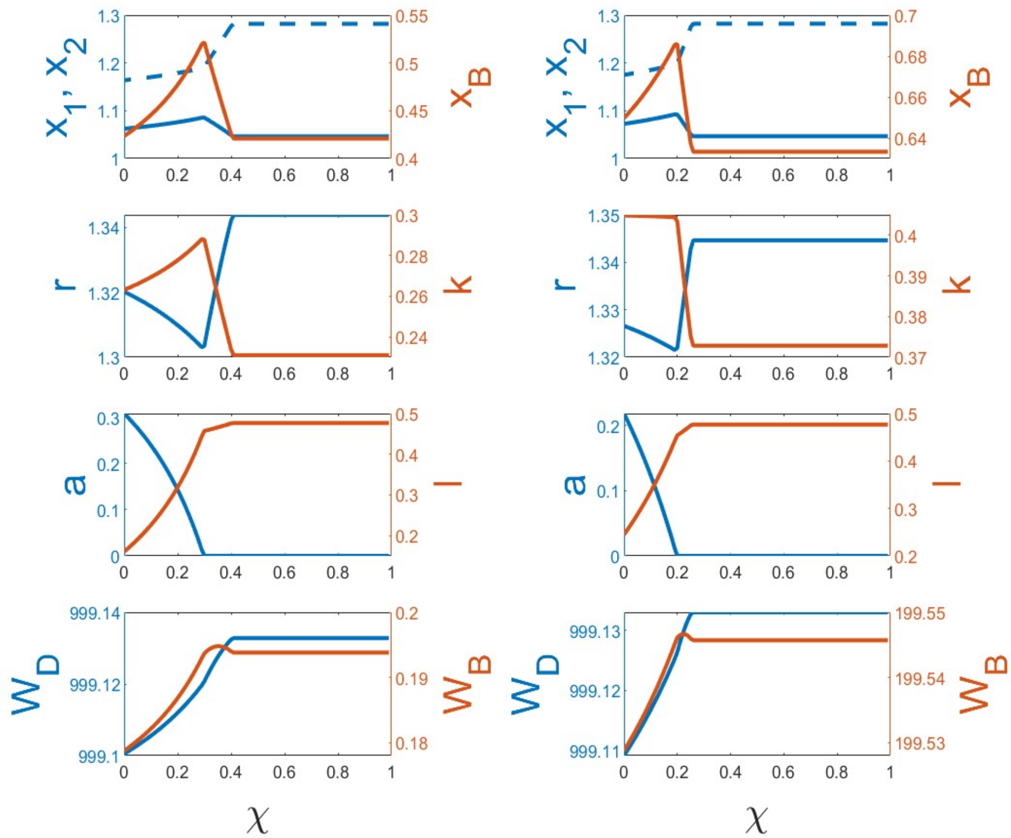
	$dx_1/d\phi$	$dx_2/d\phi$	$dx_B/d\phi$	$dk/d\phi$	$dr/d\phi$	$d\ell/d\phi$	$da/d\phi$
High	$-$	$-$	$+$	$-$	$-$	$+$	N.A.
Medium	$\pm$	$\pm$	$\pm$	$-$	$-$	$\pm$	N.A.
Low	$-$	$-$	$+$	$-$	$-$	$+$	$-$

Suppose the entry cost rises. If $\varepsilon' < 0$, we can show that $\underline{\chi}$ and $\bar{\chi}$ strictly decrease in ϕ. A high entry cost discourages borrowers from entering the loan market, and the market becomes less tight. So banks offer more favorable terms to the borrowers, and the borrowers are more willing to pay off loans rather than default. Hence, the repayment constraint is relaxed, the High-region expands, and the Low-Region contracts.

Table B.1 presents the comparative statics. As ϕ increases, from the perspective of credit market indicators, credit conditions appear to improve, reflected in lower interest rates and reduced collateral requirements. However, aggregate welfare declines as depositors are worse off by offering more favorable terms to borrowers.

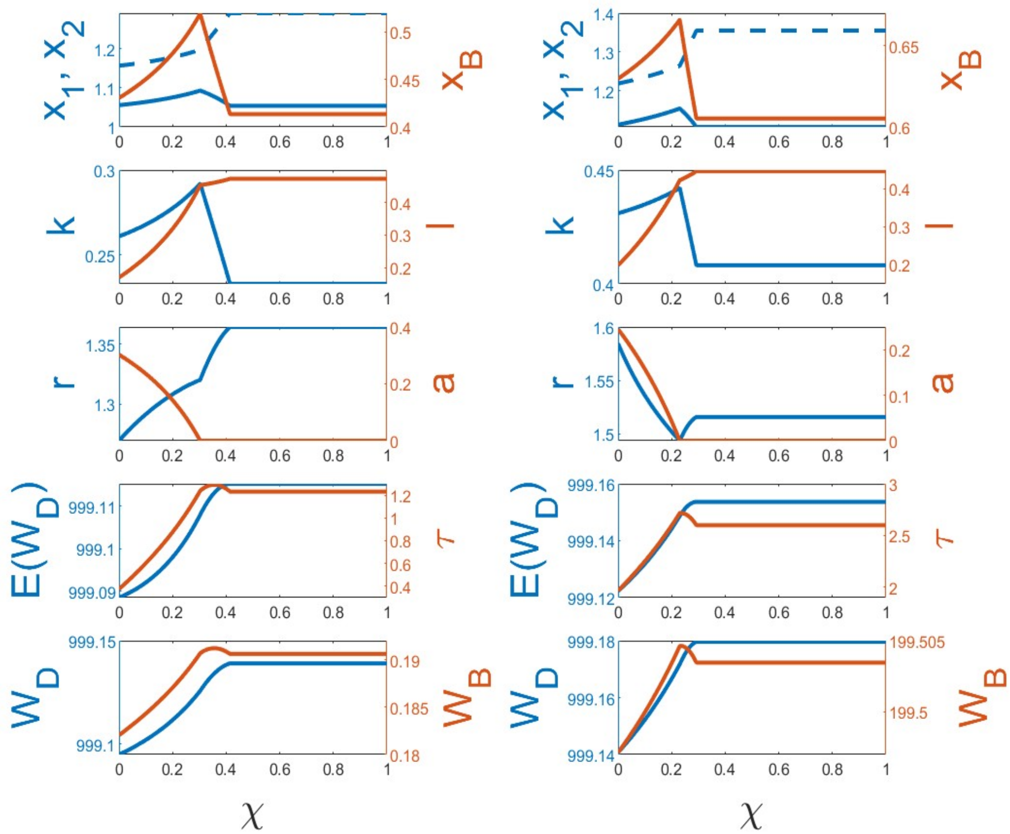
We continue the numerical example in Figure B.2. Set $\chi = 0.3$ for the left column and $\chi = 0.23$ for the right. Then, let ϕ vary. Figure B.3 plots the contract terms. Notice that with a higher ϕ, impatient depositors are worse off than patient depositors, implying that partial insurance is also weaker.

Figure B.1: Nash Bargaining. Left: $\delta = 0.5$; Right: $\delta = 2$



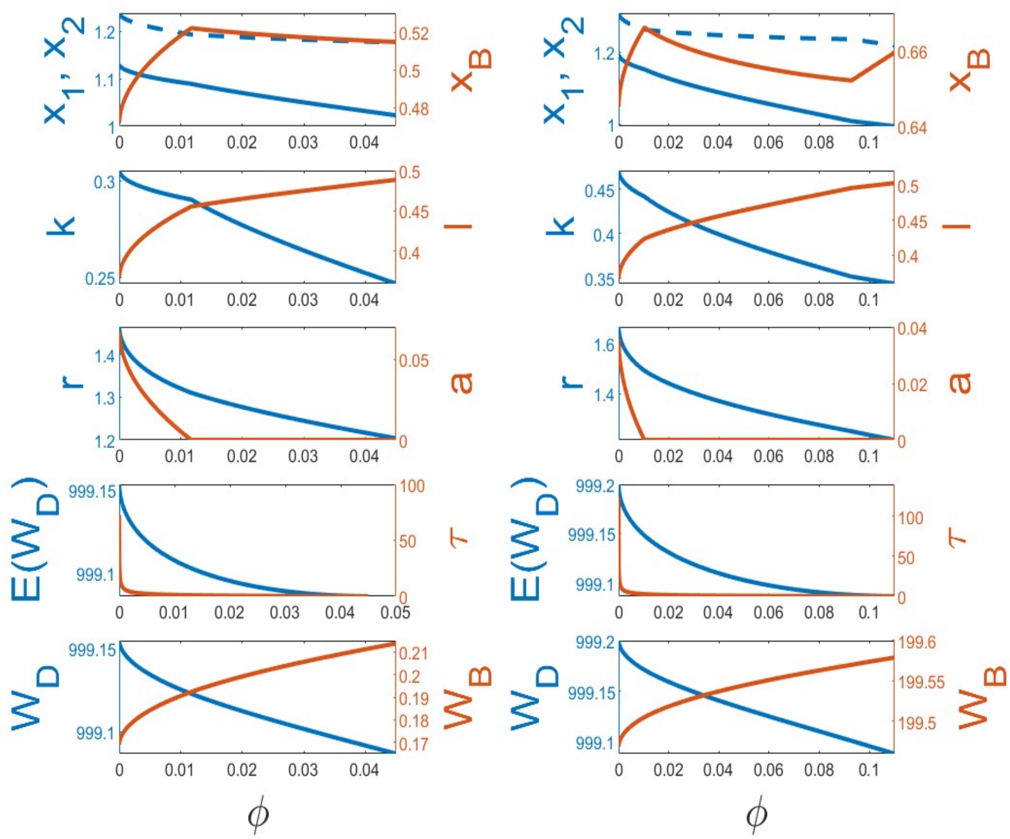
Note: The figure shows Nash bargaining outcomes as collateral pledgeability χ varies, with the depositor's EIS parameter set to $\gamma = 2$. Panel (a) sets the borrower's EIS $\delta = 0.5$ and panel (b) sets $\delta = 2$. Blue lines correspond to variables measured on the left vertical axis, including impatient depositors' consumption x_1, patient depositors' consumption x_2 (dashed blue line), the loan rate r, the bank's investment in the safe technology a, and depositor welfare W_D. Red lines correspond to variables measured on the right vertical axis, including borrower consumption x_B, the borrower's capital production k, the loan size ℓ, and borrower welfare W_B.

Figure B.2: Competitive Search. Left: $\delta = 0.5$; Right: $\delta = 2$



Note: The figure shows the equilibrium outcome with competitive search loan market as collateral pledgeability χ varies, with the depositor's EIS parameter set to $\gamma = 2$. Panel (a) sets the borrower's EIS $\delta = 0.5$ and panel (b) sets $\delta = 2$. Blue lines correspond to variables measured on the left vertical axis, including impatient depositors' consumption x_1, patient depositors' consumption x_2 (dashed blue line), the borrower's capital production k, the loan rate r, depositiors' ex-ante welfare $E(W_D)$, and ex post welfare W_D. Red lines correspond to variables measured on the right vertical axis, including borrowers' consumption x_B, the loan size ℓ, the bank's investment in the safe technology a, market tightness τ, and borrowers' ex-post welfare W_B.

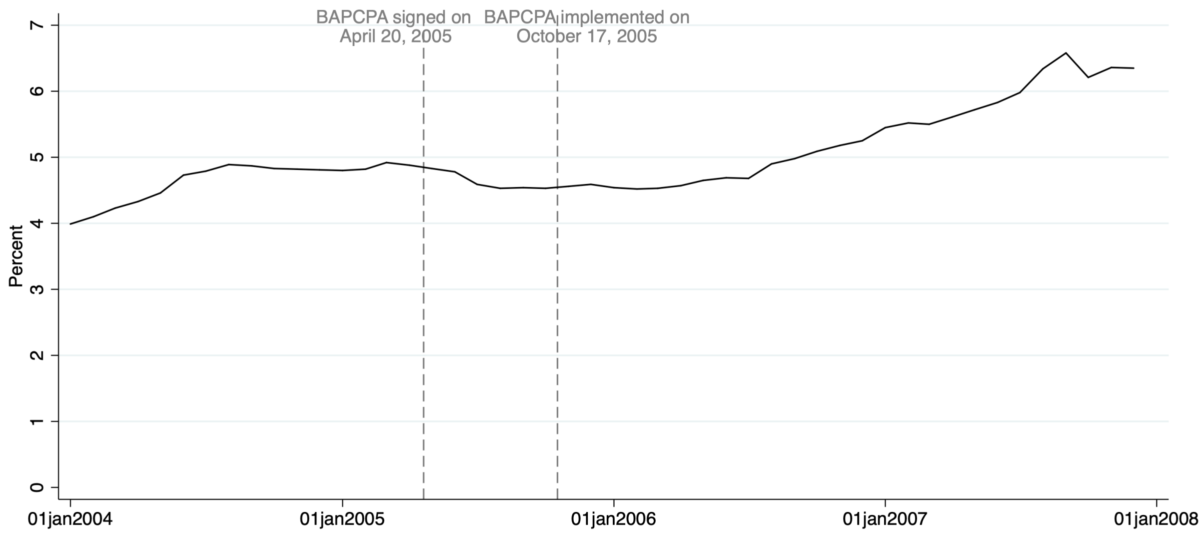
Figure B.3: Optimal Contracts with different entry costs



Note: The figure shows the equilibrium outcome with competitive search loan market as borrowers' entry cost ϕ varies, with the depositor's EIS parameter set to $\gamma = 2$. Panel (a) sets the borrower's EIS $\delta = 0.5$ and panel (b) sets $\delta = 2$. Blue lines correspond to variables measured on the left vertical axis, including impatient depositors' consumption x_1, patient depositors' consumption x_2 (dashed blue line), the borrower's capital production k, the loan rate r, depositiors' ex-ante welfare $E(W_D)$, and ex post welfare W_D. Red lines correspond to variables measured on the right vertical axis, including borrowers' consumption x_B, the loan size ℓ, the bank's investment in the safe technology a, market tightness τ, and borrowers' ex-post welfare W_B.

C Section 2 Supplementary Figures

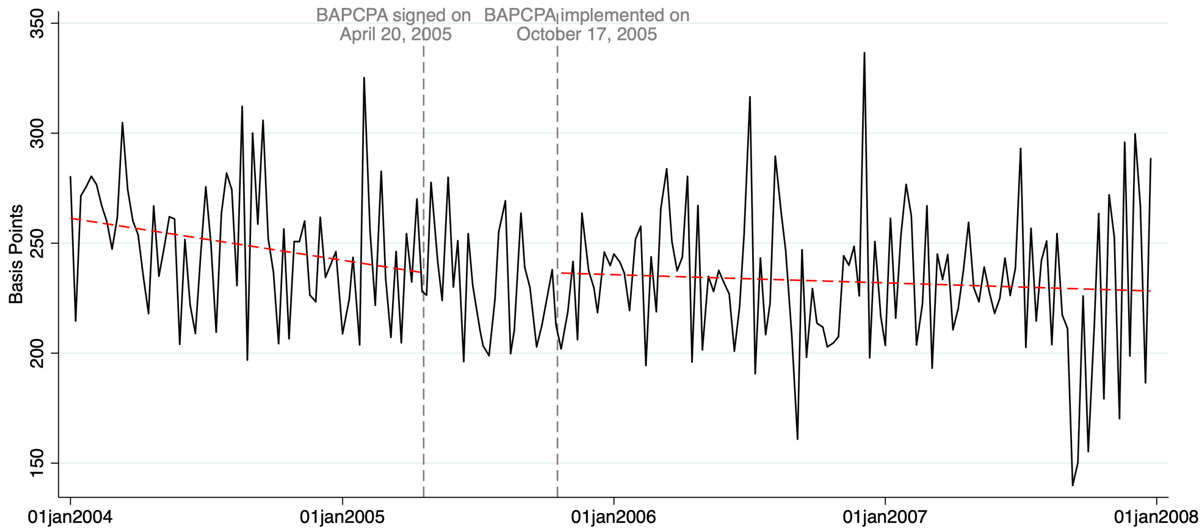
Figure C.1: 3-month London Interbank Offered Rate (LIBOR)



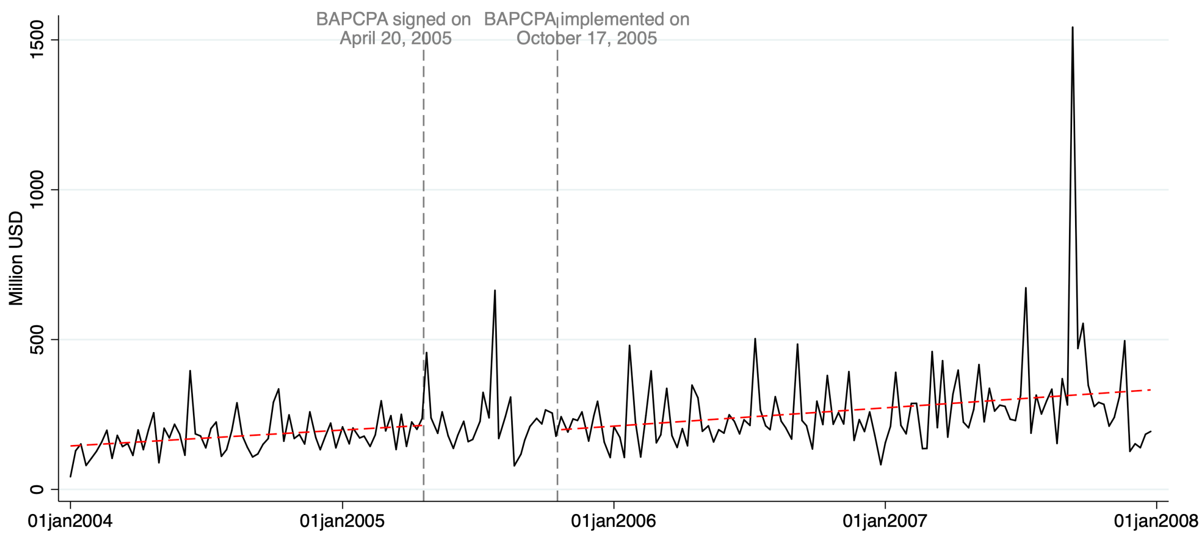
Note: This figure displays the monthly time series of the 3-month London Interbank Offered Rate (LIBOR) in the United Kingdom from 2004 to 2007, measured in percent. The two vertical dashed gray lines mark the passage of BAPCPA on April 20, 2005, and its implementation on October 17, 2005.

Figure C.2: Weekly Average Spreads and Sizes of Loans

Panel A. Average Spreads of Loans



Panel B. Average Sizes of Loans



Note: This figure shows the average spreads of loans (Panel A) and the average loan sizes (Panel B) in Dealscan from 2004 to 2007. We aggregate the daily averages into a weekly frequency based on the active dates of the loans. The two vertical dashed gray lines mark the passage of BAPCPA on April 20, 2005, and its implementation on October 17, 2005. In each panel, we plot two red fitted lines: one representing the period before BAPCPA was passed and the other for the period after its implementation. These fitted lines are linear predictions of the variable of interest over time.

D Data Appendix

Table D.1: Summary Statistics

	#obs	mean	sd	min	p25	p50	p75	max
Spread	18070	241.13	156.80	-95.00	150.00	225.00	300.00	1655.00
Loan size	21175	226.28	609.59	0.00	25.00	75.00	200.00	30000.00

Note: This table provides summary statistics for the Dealscan sample, where loan spreads are measured in basis points and loan sizes in millions of dollars. The sample is restricted to corporate loans with active dates from 2004 to 2007, originated within the United States, denominated in U.S. dollars, and issued as original loans rather than amendments.

Table D.1 presents summary statistics for the set of loans selected. In our sample, approximately 20,000 loans were issued between 2004 and 2007. The data indicate substantial variation in both loan spreads and sizes. Loan spreads are calculated exclusively for loans that use LIBOR as the base reference rate, which applies to approximately 98.58 of the loans in the sample. Figure C.1 displays the LIBOR series, showing it remained stable around 5% during the sample period, with no notable shifts around the dates when BAPCPA was signed or implemented. Relative to LIBOR, the median loan spread in our sample is 225 basis points, with an interquartile range of 150 basis points; that is, two-thirds of the median.

The second row of Table D.1 provides summary statistics for loan sizes. The median loan size is $75 million. The mean is significantly higher at $226 million, indicating that the sample is skewed toward larger loans. The interquartile range for loan size is $175 million, more than twice the median, reflecting considerable variability in loan sizes across the sample.