Suboptimal lending with deposit insurance

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[Work in progress. Results are preliminary.]

Abstract

The unprecedented use of the systemic risk exception to insure all deposits during the 2023 Regional Banking Crisis revived the debate on deposit insurance and its consequences. This paper investigates how expanding deposit insurance affects banks' lending decisions, combining insights from both theory and data. First, it develops a theoretical model highlighting how bank's funding structure and deposit elasticity influence the relationship between deposit insurance expansion and lending. Second, the paper derives and tests empirical predictions from the model to explore how shifts in the insured deposit ratio and funding sources affect lending. For deposit-funded banks, higher insurance coverage is related to increased lending, in line with risk-shifting predictions. In contrast, for banks relying on wholesale funding, the relationship is negative, consistent with underlending due to overhang.

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1 Introduction

In March 2023, the banking industry witnessed a series of significant deposit runs. Silicon Valley Bank faced a massive deposit run when customers withdrew $42 billion, roughly a quarter of total deposits, in a single day. Silvergate and First Republic experienced a similar fate, losing half of their deposits within a few weeks. To contain the risk of contagion, the authorities invoked the systemic risk exception to extend deposit insurance to all depositors, even those exceeding the standard $250,000 insurance limit.

The unprecedented use of the systemic risk exception to insure all deposits revived the debate on deposit insurance and its consequences. Deposit insurance, while crucial in mitigating bank runs, creates significant moral hazard distortions that have long been a subject of extensive research. The traditional view holds that deposit insurance leads to risk-shifting and overlending (Kareken and Wallace, 1978, Furlong and Keeley, 1989, Gennotte and Pyle, 1991). Empirical studies attempting to detect moral hazard build on this framework, assuming that more lending directly indicates greater moral hazard. However, the relationship between deposit insurance and moral hazard is more complex than previously believed. Recent literature suggests a more nuanced perspective, where the heterogeneous characteristics of a bank's loan portfolio may lead to overhang and underlending rather than simple overlending (Bahaj and Malherbe, 2020).

This paper makes two main contributions to the literature on the moral hazard consequences of deposit insurance on lending. First, it develops a theoretical model that examines the moral hazard effects of expanding deposit insurance on banks' lending decisions. One of the key insights from the model is that moral hazard resulting from deposit insurance can manifest differently depending on the bank's funding structure and deposit elasticity. When the bank funds marginal lending through deposits, either because it has stored deposits or because deposits are elastic, moral hazard looks like risk-shifting and overlending. Conversely, banks that fund marginal lending using wholesale funding, which in the model is justified by stickiness in deposit provision and uncertainty in the realization of the lending opportunity, face an overhang problem that leads them to underlend by passing on positive NPV loans. Furthermore, the overlending/underlending distortion is increasing in the proportion of insured deposits.

Second, this paper contributes an empirical analysis that tests the theoretical predictions derived from the model. Specifically, I use the model to generate both level and marginal predictions, allowing for a thorough examination of how changes in the insured deposit ratio and shifts in funding sources influence lending.

For the level prediction, the empirical results support the model's finding that the relationship between the insured deposit ratio and lending outcomes depends on the bank's funding structure. Specifically, for banks that primarily rely on deposits, there is a positive relationship between the insured deposit ratio and lending, suggesting overlending as insurance coverage expands. In contrast, for banks that depend more on wholesale funding, the relationship is negative, consistent with underlending due to overhang. Both effects are statistically significant and economically meaningful: a one-standard-deviation increase in the insured deposit ratio corresponds to a 238 basis point increase in the Loan-to-Deposit ratio for deposit-funded banks and a 374 basis point decrease for wholesale-funded banks.

For the marginal prediction, I use the 2023 Regional Banking Crisis as an exogenous funding shock that triggered significant deposit reallocation across banks. In such cases, some banks lose deposits and must seek alternative funding, such as wholesale sources, to support lending, while others gain deposits, benefiting from an increased supply of subsidized funds. The marginal prediction anticipates that banks losing deposits will reduce lending, while banks gaining deposits will increase lending, with the magnitude of these effects tied to each bank's insured deposit ratio. In March 2023, certain banks experienced substantial deposit outflows, while others received inflows, leading to a clear divergence in deposit levels. Importantly, prior to the crisis, banks that lost deposits and those that gained deposits had been on similar deposit trends, indicating the shock's exogeneity. Consistent with the marginal prediction, banks that lost deposits not only experienced declines in deposits but also contracted lending, forgoing positive NPV loans.

Overall, the empirical results align with the model predictions.

In the model, the bank selects lending to maximize expected profit, i.e. earnings after repaying all the funding providers. In period 1, the bank chooses how much of the deposits to allocate to initial loans versus store in a liquid asset. In period 2, a new lending opportunity materializes with some probability, and then the bank decides how much lending to extend. The paper explicitly acknowledges the existence of short-term deposit supply stickiness, which inhibits banks from promptly and inexpensively raising new deposits in the short-term. Since deposits are in limited supply, the bank funds new lending in period 2 by selling the liquid asset, raising equity, and resorting to wholesale funding if needed.

In period 2, if the bank can fully fund new lending with deposits that had been stored in the liquid asset, a risk-shifting effect drives the bank to overlend. Since insured deposits are cheaper than other funding sources, the bank continues to lend until the marginal return matches the lower marginal cost of deposits, leading to overlending. On the other hand, when the bank lacks sufficient deposits, an overhang effect causes the bank to underlend, as it must rely on wholesale funding. In this case, while increasing lending could improve total payoffs, the bank refrains from doing so because the marginal surplus would benefit taxpayers rather than shareholders, resulting in a suboptimal level of new lending.

In period 1, the bank decides on the allocation of deposits in initial loans versus liquid assets. When the new lending opportunity materializes for sure, the bank chooses initial loans to induce the selection of the optimal amount of new lending in $t = 2$. By setting aside sufficient deposits to fully finance the new lending opportunity, the bank avoids having to resort to wholesale funding providers. Then, the bank equalizes marginal return of lending in period 1 to marginal return of lending in period 2. When $p < 1$, however, the probability of the new lending opportunity materializing is not strong enough to incentivize setting aside deposits in the liquid asset in the amount corresponding to optimal new lending. The bank prefers to allocate more deposits to initial loans and overhang ensues.

The model diverges from existing literature on deposit insurance and lending in two key aspects. Firstly, while prior models tend to overlook uncertainty, this model extends the static setting to a three-period model, incorporating uncertainty in the realization of the lending opportunity materializing during the intermediate period. Secondly, the existing models often assume that deposits are elastically supplied, an assumption that automatically shuts down important funding structure channels. By acknowledging that deposits are sticky, I am able to model the modern bank funding structure consisting of an hierarchy of junior and senior funding providers. I then contrast the findings under the sticky deposits assumption with those that could have been derived using the traditional elastic deposits assumption.

Related literature. The role of insuring deposits in preventing bank runs is well established. There is ample literature on liquidity provision and bank runs pioneered by Diamond and Dybvig, 1983 and further extended by Bhattacharya and Gale, 1987, Allen and Gale, 2000, Matutes and Vives, 2000, Freixas, Martin, and Skeie, 2011, Dávila and Goldstein, 2023, amongst others. The paper takes as given the importance of deposit insurance in preventing bank runs. Instead, it takes focuses on the moral hazard consequences of deposit insurance.

The focus on moral hazard approximates the paper to the corporate finance literature on capital structure started by Modigliani and Miller, 1958, see Harris and Raviv, 1991 for an overview. In specific, this paper connects with capital structure theories focusing on the conflict of interest between shareholders and debtholders that show that debt contracts can incentivize equityholders to make suboptimal investments, either by choosing to invest in value-decreasing projects or by rejecting value-increasing projects (Jensen and Meckling, 1976, Myers, 1977,).

In the banking context, conflicts of interest between shareholders and taxpayers underpin the theoretical literature on deposit insurance and moral hazard. Risk-shifting effects, by which a bank chooses to invest in a riskier asset or in an asset with negative NPV, are at the core of traditional deposit insurance and moral hazard models (Merton, 1977, Kareken and Wallace, 1978, Furlong and Keeley, 1989, Gennotte and Pyle, 1991). Structurally, the model is closest to Bahaj and Malherbe, 2020 that show that overhang effects, by which a bank may reject a value-increasing project, may also arise from deposit insurance.

The empirical literature on the effects of extending deposit insurance on deposit reallocation, bank lending, and risk-taking provides mixed evidence. There is strong evidence of an increase in deposits when a bank experiences an increase in deposit insurance coverage or credibility but the evidence on lending and risk is less clear (Anginer, Demirguc-Kunt, and Zhu, 2014, Calomiris and Jaremski, 2019, Calomiris and Chen, 2022, Danisewicz, Lee, and Schaeck, 2022, Bonfim and Santos, 2023, Cucic et al., 2024).

The paper is structured as follows: Section II introduces the theoretical model, outlining its key assumptions and framework. Section III derives the model's predictions, which provide a basis for empirical testing. Section IV takes these predictions to the data, presenting and analyzing the empirical results to assess the validity of the model. Finally, Section V concludes.

2 Model

2.1 Setting

Timeline. Consider a three-period ($t = 1, 2, 3$) economy. There is a single bank that decides how much to lend and has access to several sources of funding: deposits (insured or uninsured), wholesale funding, and capital. The bank starts with deposits d. At $t = 1$, the bank decides how much deposits to lend (x_1), storing the remaining in a liquid asset (y). At $t = 2$, a new lending opportunity appears with probability p. If the new lending opportunity materializes, the bank chooses the amount of new lending (x_2). By assumption, the return of new lending $X(\cdot)$ satisfies the Inada conditions. At $t = 3$, the state of the economy realizes, the bank sells all its assets and repays funding providers (repayment is c). Insured deposits provide funds at unit cost, remaining funding is competitively priced. Figure 1 summarizes the timeline.

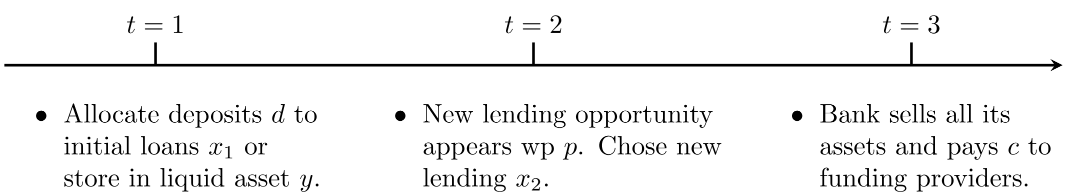


Figure 1: Timeline

The economy. The payoff of the loans depends on the state of the economy, denoted by $A \in [1 - \sigma, 1 + \sigma]$. The σ is a mean preserving spread that captures the level of risk in the economy. The state of the economy is a random variable continuously distributed according to pdf $f(A)$. Assume that $\mathbb{E}[A] = 1$ to make the bank indifferent between x_1 and y in the absence of any distortion.

If the realized state of the economy is so low that the bank is unable to repay its funding providers, it defaults. In default, the hierarchy for payment prioritizes insured depositors at the forefront, followed by uninsured depositors and wholesale funding providers. Shareholders are residual claimants. Define A^{Δ} as the lowest possible realization of the state of the economy that still supports repaying insured depositors. Note that $A^{\Delta} < A^d < A^w$, where A^d and A^w are similarly defined for uninsured depositors and wholesale funding providers, respectively.

Regulation. In the model, increasing deposit insurance coverage corresponds to increasing Δ, the proportion of insured deposits. Insured depositors always get repaid, which makes them willing to provide funds at unit cost. Uninsured depositors and wholesale funding providers lack this insurance, so they demand additional premiums, r_d and r_w, to compensate for default risk. Capital from shareholders is also priced competitively. There is no hierarchical distinction between capital raised in the first period versus the second. When raising more capital, it is assumed that the market for new capital is competitive, i.e. new shareholders break even in expectation.

In addition to deposit insurance, the bank is subject to capital and liquidity requirements. Capital requirements are $k_t \geq \gamma x_t$, where k_t is capital raised in $t \in \{1, 2\}$, and γ is the capital requirement applicable to the risky assets x_t. Liquidity requirements are $y \geq \rho d$, meaning the bank must hold a proportion of its deposits in the liquid asset. If the bank breaches capital or liquidity requirements, the government revokes the bank's operating license and takes over, leaving shareholders with nothing.

The bank's problem. Given $\{\Delta, \gamma, \rho, d\}$, the equilibrium is defined as a set of quantities $\{x_1, x_2\}$ that maximize shareholders' expected profit (Π) provided that all funding is competitively priced, where:

$$\Pi \equiv p \cdot \left[A\big(x_1 + X(x_2)\big) + y^+ - c\right]^+ + (1 - p) \cdot \left[Ax_1 + y^+ - c\right]^+ \tag{1}$$

Other remarks. For simplicity, the risk-free rate is set to zero. Funding providers are risk-neutral and do not discount the future. Notation wise, equilibrium objects have a star in superscript, subscripts are used for partial derivatives, and function dependencies are omitted for readability unless the exposition is made more clear by their explicit statement. Also, $x^+ \equiv max\{x, 0\}$.

2.2 The sticky deposits equilibrium

Post-crisis estimates indicate that retail deposits are rate-inelastic in the short term (Chiu and Hill, 2015). Theory provides several possible explanations for deposit inelasticity, such as switching costs, search and information acquisition, behavioral traits, or exit deterrence strategies adopted by banks (see Degryse and Ongena, 2008 for a review of empirical evidence on the sources of bank rents). When deposits are inelastic, or *sticky*, banks struggle to quickly attract deposit inflows, and resort to alternative funding sources like wholesale funding to finance lending.

This section models short-term deposit stickiness by assuming that deposits are in limited supply and then solves for the equilibrium by backward induction.

Assumption I. *Deposits are in limited supply.*

In the model, **assumption I** captures short-term deposit stickiness, which limits banks' ability to quickly and affordably raise deposits. Since deposits are in limited supply, the bank funds new lending in $t = 2$ by selling the liquid asset (y), raising equity (k_2), and resorting to wholesale funding (w) if needed. Table 1 depicts the balance sheet at $t = \{1, 2\}$ when capital requirements are binding and the lending opportunity materializes.

t=1

Initial loans: x_1 Liquid asset: y	Deposits: $d = (1-\gamma)x_1 + y$ Equity: $k_1 = \gamma x_1$

t=2

Initial loans: x_1 Liquid asset: y $= [d - (1-\gamma)(x_1+x_2)]^+$ New loans: x_2	Deposits: $d = (1-\gamma)x_1 + y$ Wholesale funding: $w = (1-\gamma)x_2 - y$ Equity: $k_1 + k_2 = \gamma(x_1+x_2)$

Table 1: **The balance sheet of the bank when deposits are sticky.** The parameter γ is the capital requirement applicable to the risky assets, $k_t \geq \gamma x_t$, where k_t is capital raised in $t \in \{1,2\}$. The equalities arise because capital requirements are binding in equilibrium.

2.2.1 New lending decision in t=2

Substituting in binding capital requirements and the balance sheet identities (see appendix for details), the expected profit of the bank if the new lending opportunity materializes simplifies to:

$$\Pi^{YES} = X(x_2) - x_2 + \underbrace{\int_{1-\sigma}^{A^{\Delta}} \Delta d - A\big(x_1 + X(x_2)\big) - [d - (1-\gamma)(x_1+x_2)]^+ \, dF(A)}_{\text{implicit subsidy } (s^{YES})}$$
$$\text{where } A^{\Delta} = \frac{\Delta d - [d-(1-\gamma)(x_1+x_2)]^+}{x_1 + X(x_2)} \tag{2}$$

Expected profit can be decomposed into two terms. The first term is the economic surplus generated by new lending. The second term is the implicit subsidy. Insured depositors provide deposits at a discount, in the sense that they do not require a risk-premium to compensate them for the possibility that the bank may go bust and not repay them in full. The total savings for the bank from not paying a risk premium to the insured depositors are equivalent to an implicit subsidy. The magnitude of the implicit subsidy corresponds to the expected shortfall that the government has to cover when the value of the assets is insufficient to repay insured depositors. This interpretation of deposit insurance as an implicit subsidy for the bank is consistent with Merton, 1977 and Bahaj and Malherbe, 2020.

For benchmark, consider the case of zero deposit insurance coverage. When $\Delta = 0$, there is no implicit subsidy. In the absence of the implicit subsidy, the bank chooses the level of new lending that maximizes economic surplus, henceforth referred to as x_2^{MM}, the *optimal* new lending. In this case, the bank lends until the marginal loan has a zero NPV. The Modigliani-Miller proposition applies and equilibrium new lending is independent of the capital structure used to finance it.

In general, deposit insurance coverage is not null. When a non-null proportion of deposits are insured ($\Delta > 0$), the bank chooses the level of new lending that maximizes total profit, i.e. economic surplus plus the implicit subsidy. As discussed before, the economic surplus is maximum when the marginal loan has a zero NPV. The implicit subsidy, however, is not maximum at this point.

Proposition 1. *The marginal loan has positive or negative NPV depending on the source of financing. Then, equilibrium new lending can be above or below optimal depending on the source of financing.*

$$d \lesseqgtr (1-\gamma)(x_1 + x_2^*) \Rightarrow x_2^* \lesseqgtr x_2^{MM}$$

Two points are in order.

First, equilibrium x_2^* is not a point but a function of x_1. For rigor, focus on a case of interest where $\Pi_{x_2}^{YES}(x_1, x_2^*) = 0$ exists, $\Pi_{x_2}^{YES} : \mathbb{R}^2 \to \mathbb{R}$ is a continuously differentiable function where (x_1^*, x_2^*) is a point in the curve such that $\Pi_{x_2}^{YES}(x_1^*, x_2^*) = 0$ that is twice differentiable, $\Pi_{x_2 x_1}^{YES}(x_1^*, x_2^*) \neq 0$. Then, for the curve around (x_1^*, x_2^*)

define:

$$x_2^* = h(x_1) \text{ , where } h \text{ is a real function.}$$

Second, we can expect some non-linearity in $h(x_1)$. Recall that the deposits the bank doesn't use for initial loans are stored in a liquid asset that can be sold to fund new lending in period 2. Two scenarios may occur: either the bank sets aside sufficient deposits in $t = 1$ that entirely finance new lending, or it fails to do so and must resort to wholesale funding in $t = 2$.

When the bank sets aside sufficient deposits, there is an *risk shifting effect* driving the bank to extend new lending past the point that would be optimal. The derivative of the implicit subsidy with respect to new lending is positive:

$$d > (1-\gamma)(x_1 + x_2) \Rightarrow s_{x_2}^{YES} > 0 \Leftrightarrow x_2^* > x_2^{MM}$$

As long as lending is being funded by deposits, the marginal implicit subsidy is positive. Why? Because deposits are insured, they are cheaper and the marginal cost of utilizing this funding source is lower. The bank continues to lend until the marginal return equals this lower marginal cost. This behavior leads the bank to extend more loans than optimal, including some with negative NPV. Risk-shifting incentives due to deposit insurance is the classic insight from the early literature (Kareken and Wallace, 1978; Furlong and Keeley, 1989; Gennotte and Pyle, 1991).

In opposition, when the bank does not set aside sufficient deposits, there is an *overhang effect* that leads the bank to choose a sub-optimal amount of new lending. For values of x_1 such that the bank is forced to resort to wholesale funding, the derivative of the implicit subsidy with respect to new lending is negative:

$$d \leq (1-\gamma)(x_1 + x_2) \Rightarrow s_{x_2}^{YES} \leq 0 \Leftrightarrow x_2^* \leq x_2^{MM}$$

The overall effect of scaling up new lending is a reduction in the implicit subsidy.

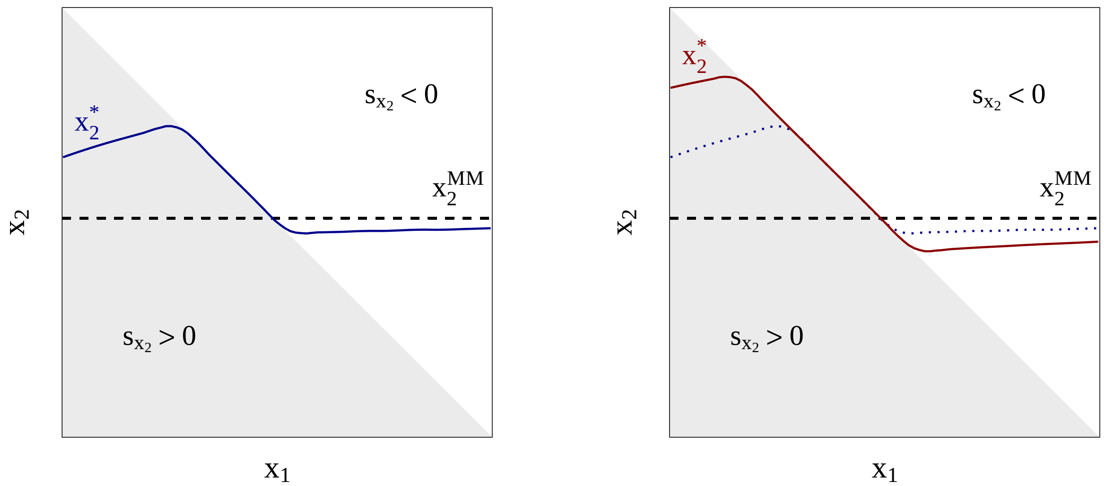
Under the assumptions on $X(\cdot)$, scaling up new lending increases the total payoff from loans. At the same time, the amount of insured deposits to repay remains unchanged (new lending is being funded by wholesale funding providers and equity). Additional lending unambiguously reduces the expected shortfall that the deposit insurance fund would need to cover, should the economy perform badly. In this case, the bank opts for a suboptimal level of new lending since extending more loans would divert surplus from shareholders to taxpayers. The seniority of insured depositors creates an overhang effect like in Myers, 1977 that causes equilibrium lending to be below the optimal level.

In sum, new lending in $t = 2$ can be above or below optimal depending on the source of financing. Lending too much or lending too little and, equivalently, funding negative NPV loans or passing on positive NPV loans, are two sides of the same coin. These are both moral hazard behaviors adopted by the bank to maximize the size of the subsidy. Panel A in Figure 2 exemplifies.

The source of moral hazard is the deposit insurance. Accordingly, when the authorities expand deposit insurance coverage, increasing Δ, they also increase the size of the implicit subsidy. How that distortion manifests in the lending outcomes depends, in turn, on how the marginal loan is being funded. Corollary 1 summarizes this idea and Panel B in Figure 2 exemplifies.

Corollary 1. *Extending deposit insurance exacerbates the overlending or underlending problem in $t = 2$, depending on the marginal funding source.*

$$d \lesseqgtr (1-\gamma)(x_1 + x_2^*) \Rightarrow s^{YES}_{x_2\Delta} \lesseqgtr 0$$



Panel A: $x_2^* = h(x_1)$ Panel B: $x_2^* = h(x_1)$ when Δ increases

Figure 2: **Numerical example of Proposition 1 and Corollary 1.** The figures provide a numerical example of $x_2^* = h(x_1)$, represented by the solid line. The horizontal dashed line indicates the optimal level of new lending without deposit insurance x_2^{MM}. The figures are divided into two triangular regions. The boundary between these regions represents the combinations of initial loans and new lending that use all deposits, defined by $d = (1-\gamma)(x_1+x_2)$. The lower grey triangle corresponds to $D > (1-\gamma)(x_1+x_2)$, meaning that the bank can fully fund new lending with the deposits stored in the liquid asset. Conversely, the upper white triangle corresponds to $D < (1-\gamma)(x_1+x_2)$, meaning that the deposits are not enough to finance new lending and the bank needs to resorts to wholesale funding. In Panel B, we observe the effect of increasing Δ on the $x_2^* = h(x_1)$ schedule. In this example, A is uniformly distributed between $[0,2]$ and $X(x_2) = 1.5\sqrt{x_2}$.

2.2.2 Initial loans decision in t=1

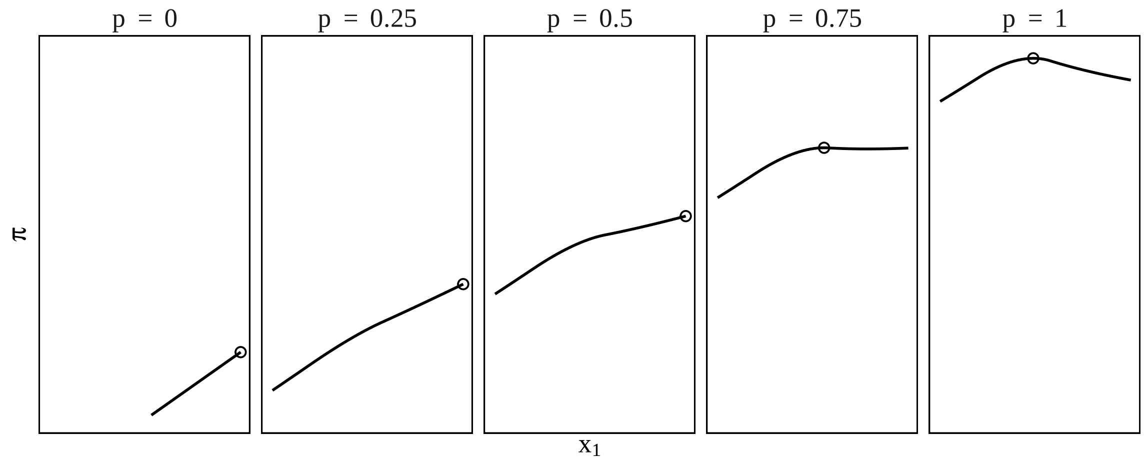
Taking as given the choice rule of new lending $x_2^* = h(x_1)$ and the probability of the new lending opportunity materializing p, the bank decides on the allocation of deposits in initial loans versus liquid assets.

Proposition 2. *(i) When* $p = 0$*,* $y^* = 0$ *and* $x_1^* = \frac{d}{(1-\gamma)}$*; (ii) When* $p = 1$*,* $y^* = x_2^{MM}$*,* $x_1^* = x_1^{MM}$ *and* $x_2^* = x_2^{MM}$*, where* x_1^{MM} *is defined as the amount that* *induces the bank to select* x_2^{MM}*; (iii) When* $p \in (0, 1)$*,* $y^* \leq x_2^{MM}$*,* $x_1^* \geq x_1^{MM}$ *and* $x_2^* \leq x_2^{MM}$*.*

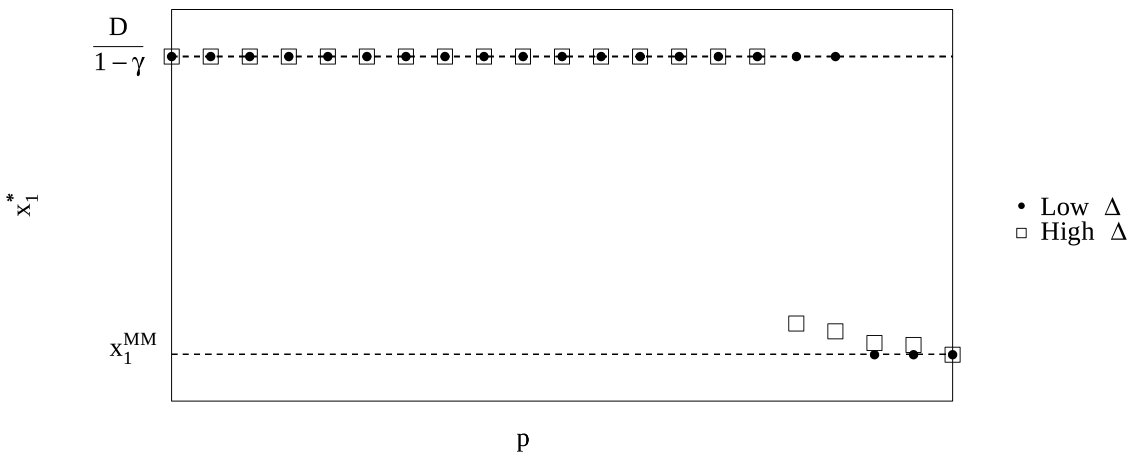
When there is no further lending opportunity ($p = 0$), the expected profit consists solely of the implicit subsidy. Then, the bank simply allocates all deposits to initial loans because investing in the risky asset instead of the safe asset maximizes the implicit subsidy.

When the new lending opportunity materializes for sure ($p = 1$), the bank chooses initial loans to induce the selection of the optimal amount of new lending in $t = 2$. By setting aside sufficient deposits to fully finance the new lending opportunity, the bank avoids having to resort to wholesale funding providers. Then, $x_1^* = x_1^{MM}$ and $y^* = x_2^* = x_2^{MM}$ is the point that equalizes marginal return of lending in period 1 to marginal return of lending in period 2.

When $p < 1$, the probability of the new lending opportunity materializing is not strong enough to incentivize setting aside deposits in the liquid asset in the amount corresponding to optimal new lending. The bank prefers to allocate more deposits to initial loans. Panel A in Figure 3 illustrates.



Panel A: Π as a function of x_1 for varying p



Panel B: x_1^* as a function of p

Figure 3: **Numerical example of Proposition 2.** Panel A shows Π as a function of initial loans for a range of p. The circle marks the point where expected profit is maximum. Panel B shows the choice of initial loans x_1^* as a function of p for low and high deposit insurance coverage values Δ. In this example, A is uniformly distributed between $[0, 2]$ and $X(x_2) = 1.5\sqrt{x_2}$.

2.2.3 Other regulation

Capital requirements. To offset the distortion created by deposit insurance, the regulator can increase capital requirements. When capital requirements are higher, the bank is forced to use more capital and less deposits to fund new lending. Since only depositors are insured, forcing the bank to use more capital reduces the size of the implicit subsidy. Consequently, increasing capital requirements ameliorates the overlending or underlending distortion in $t = 2$.

Liquidity requirements. Introducing liquidity requirements consists of requiring the bank to set aside ρ of the deposits in the liquid asset, $y \geq \rho d$. If the requirement always binds, it is not effective in offsetting the moral hazard distortion created by deposit insurance. If the requirement is more flexible, meaning that the regulator allows the bank to use the liquid asset in case of need, and the calibration is precisely $\rho^* d = x_2^{MM}$, then it is effective.

Deposit insurance pricing. Authorities charge a contribution to banks that benefit from deposit insurance. If the contribution requested exactly matches the size of the implicit subsidy, the distortion is eliminated. This model lends strength to pricing rules that explicitly consider the proportion of insured depositors.

2.3 The elastic deposits equilibrium

The key friction driving the results in the model is the bank's inability to attract more deposits to fund the new lending opportunity. This section illustrates the importance of sticky deposits in driving the results presented by contrasting it against the case where deposits are perfectly elastic, the standard assumption in the literature.

Assumption II. *Deposits are in unlimited supply.*

In the model, **assumption II** captures perfectly elastic deposits. This requires making some adjustments to the model setting. First, define d_1 as initial deposits and d_2 as deposits raised in $t = 2$. Seniority order stands and there are no differences between initial and new funding providers, they split pro rata. Additionally note that since deposits are senior to wholesale funding, $r_d < r_w$ which results in the bank prefering to raise new deposits over relying on wholesale funding.

Then, after substituting in binding capital requirements and the balance sheet identities, the expected profit if the new lending opportunity materializes is:

$$\Pi^{YES} = X(x_2) - x_2 + \underbrace{\int_{1-\sigma}^{A^{\Delta}} \Delta(d_1 + d_2) - A\big(x_1 + X(x_2)\big) - y \; dF(A)}_{\text{implicit subsidy } (s^{YES})} \qquad (3)$$

$$\text{where } A^{\Delta} = \frac{\Delta(d_1 + d_2)}{x_1 + X(x_2)}$$

In the case of elastic deposits, the marginal implicit subsidy with respect to new lending in period 2 is always positive. Since deposits are insured, they are cheaper and the marginal cost of utilizing this funding source is lower. The bank continues to lend until the marginal return equals this lower marginal cost. This behavior leads the bank to overlend. And the larger the deposit insurance coverage, the larger the overlending. Additionally, in period 1 the bank has no incentive to store deposits in the liquid asset, since it can get new deposits in the following period.

3 Model predictions

The model revealed a complex relation between deposit insurance and lending, shaped by a bank's funding structure and deposit elasticity. This complexity may explain why empirical studies on deposit insurance often prefer focusing on deposit reallocation and why those examining lending struggle to find unequivocal evidence of moral hazard effects (Bonfim and Santos, 2023; Danisewicz, Lee, and Schaeck, 2022; Calomiris and Chen, 2022; Calomiris and Jaremski, 2019). In this section, I derive testable predictions from the model, which will serve as the foundation for empirical analysis in the subsequent section.

One of the key insights from the model is that moral hazard resulting from deposit insurance can manifest differently depending on the bank's funding structure. When the bank funds marginal lending through deposits, either because it has stored deposits (Proposition 1) or because deposits are elastic (Proposition 3), moral hazard looks like risk-shifting and overlending. Conversely, banks that fund marginal lending using wholesale funding, which in the model is justified by stickiness in deposit provision and uncertainty in the realization of the lending opportunity, face an overhang problem that leads them to underlend by passing on positive NPV loans (Proposition 1 and 2). Furthermore, as shown in Corollary 1, the overlending/underlending distortion, is increasing in Δ, the proportion of insured deposits.

3.1 Level predictions

To derive the model's level predictions more precisely, we must formalize several aspects. Define a sequence $(d_1, d_2, \ldots, d_T)$, where d_t represents deposits at time t with $d_1 = 1$. For simplicity, assume that $d_{t+1} - d_t \in \{0, 1\}$, indicating whether deposits remain unchanged or increase at time $t+1$. Next, define a sequence $(x_1, x_2, \ldots, x_T)$, where x_t represents lending at time t. The model in the previous section shows that when $d_{t+1} - d_t = 0$, the bank underlends, which is formalized as $x_{t+1} - x^{MM} < 0$, where x^{MM} denotes the optimal level of lending. Conversely, when $d_{t+1} - d_t = 1$, the bank overlends, defined as $x_{t+1} - x^{MM} > 0$. The magnitude of the distortion, denoted as $|gap| \equiv |x_{t+1} - x^{MM}|$, increases in Δ, the proportion of insured deposits.

Now, consider two banks: a deposit-funded bank and a non-deposit-funded bank. A deposit-funded bank has experienced more realizations of $d_{t+1} - d_t = 1$ and, as a result, has accumulated more instances where $x_{t+1} - x^{MM} > 0$, compared to a non-deposit-funded bank. Since $|gap|$ increases with Δ, at any given point in time:

$$\frac{\partial x_t^D}{\partial \Delta} > 0$$

For a non-deposit-funded bank, the opposite holds. A non-deposit funded bank has experienced more instances where $d_{t+1} - d_t = 0$ resulting in underlending, or $x_{t+1} - x^{MM} < 0$, more frequently. Thus, at any given point in time:

$$\frac{\partial x_t^{ND}}{\partial \Delta} < 0$$

The model predicts that the distortion increases with Δ, resulting in a *positive* relationship between Δ and lending outcomes for banks that rely heavily on deposit funding, and a *negative* relationship between Δ and lending outcomes for banks that rely more on wholesale funding.

3.2 Marginal predictions

A more direct implication of the model is that for $|d'_{t+1} - d_t| > |d_{t+1} - d_t|$ we expect $|x'_{t+1} - x_t| > |x_{t+1} - x_t|$. And since $|gap|$ is increasing in Δ:

$$\frac{\partial^2 x}{\partial d \partial \Delta} > 0 \tag{4}$$

A big challenge in ascertaining the effect of deposit insurance on lending is that changes in deposit insurance coverage often lead to a reshuffling of deposits in the system. Some banks lose deposits and other banks gain deposits. Banks that lose deposits have to raise funding for lending from other sources, including wholesale funding. Banks that gain deposits now have an increased supply of subsidized funding. Based on this empirical prediction, I look for evidence of underlending from banks that lose deposits and overlending from banks that gain the deposits and connect the magnitude of the effect to the bank's insured deposits ratio.

4 Empirics

4.1 Measurement and data

Data and sample. The Federal Deposit Insurance Corporation makes available a list of FDIC-insured banks and branches from 1934 to the present day. Given the focus on lending, I select commercial banks that were active as of 2022-12-31, the last quarter before the start of the 2023 Regional Banking Crisis. Further, institutions are analyzed at the highest level of consolidation. For banks that are part of a holding company, only the parent bank is considered, with balance sheet and income statement information drawn from the Consolidated Financial Statements for Holding Companies (FRY9C). Data for standalone banks is from the Consolidated Reports of Condition and Income (Forms 31 and 41).

To complement the bank-level data, I use loan-level mortgage data from the Home Mortgage Disclosure Act (HMDA). HMDA requires covered institutions to report detailed information on each mortgage application and purchased loan from the previous year. Based on transaction type, loan type, conforming loan status, and Federal Housing Finance Agency (FHFA) loan limits, single-family loans are grouped into five categories: 1) Conventional Conforming; 2) Conventional Non-conforming (Jumbo); 3) Insured or Guaranteed by Agencies; 4) HELOC; and 5) Reverse Mortgage. Conventional conforming mortgages are classified as safe since they are automatically eligible for purchase by government-sponsored entities like Fannie Mae and Freddie Mac. Similarly, loans insured or guaranteed by agencies such as the Federal Housing Administration, Veterans Affairs, or USDA are considered safe. In contrast, Jumbo loans and HELOCs, which are not automatically eligible for purchase, are classified as risky. The data is then collapsed to the bank level to obtain originations by loan category.

I identified 3882 active commercial banks at the highest level of consolidation in the FDIC file. I was able to match 3757 of those institutions to the call reports data and 2063 to the lar data. However, only 509 of those institutions had a valid percentage of uninsured deposits in the call reports data, of which only 299 institutions were matched in LAR. Table 2 provides summary statistics of the financial data for the 509 banks in the bank-quarter sample, from 2014 to 2024Q1. Table 3 provides summary statistics of the mortgage data by loan category for the 299 banks in the bank-year sample, from 2017 to 2023.

Variable	N	Avg	Std Dev	P5	Median	P95
Total Assets	13908	55410.61	281739.70	1152.83	4418.37	164761.50
Total Loans	13908	23159.26	102668.30	684.58	3000	86850.74
Total Deposits	13908	30641.70	149172.00	952.17	3505.59	103937.50
Uninsured deposits	13908	14633.78	76796.80	109.54	1042.04	43842.17
Insured deposit ratio	13908	0.67	0.17	0.38	0.68	0.93
Deposit-to-liability ratio	13908	0.89	0.11	0.72	0.92	0.98
Loan-to-deposit ratio	13871	0.83	0.21	0.48	0.85	1.11
Leverage ratio	11271	10.25	4.09	7.37	9.63	13.97
NPLs ratio	13588	0.01	0.01	0	0.01	0.03
Return-On-Assets ratio	13908	0.01	0.02	0	0.01	0.02
Net interest margin ratio	13908	0.04	0.02	0.02	0.03	0.05
Liquidity ratio	13908	0.08	0.08	0.02	0.05	0.24
Total loans qoq growth	13800	0.03	0.05	-0.03	0.02	0.10

Table 2: **Descriptive statistics for financial variables.** This table presents summary statistics for the key financial variables in the analysis. Amounts in million dollars, ratios and growth rates in decimal form. The appendix contains a detailed description of the variables. The unit of observation is at the bank-quarter level. The final sample includes 509 banks matched in call reports for which the insured deposit ratio is available from 2014 to 2024Q1. To avoid the impact of mergers and acquisitions, I removed the bank-quarter observations corresponding to the two quarters after a bank went through the transformation. Variables winsorized at the 99th percentile.

Loan category	Variable	N	Avg	SD	P5	Median	P95
Conventional Conforming	Number of applications	1349	4801.47	16113	87.4	1354	14833.2
	Number of originations	1349	3656.68	12419.2	59.4	1139	11703.2
	Amount of applications	1349	1063.81	3824.06	16.21	288.18	3688.64
	Amount of originations	1349	893.21	3301.36	13.38	247.01	2940.93
	Origination-to-deposit ratio	1349	0.06	0.06	0	0.04	0.21
Conventional Non-conforming or Jumbo	Number of applications	1339	560.68	2549.4	4	71	1813.5
	Number of originations	1339	481.25	2167.76	3	61	1532.5
	Amount of applications	1339	666.86	3203.02	3.95	75.24	2076.04
	Amount of originations	1339	570.87	2772.96	3.06	64.46	1690.56
	Origination-to-deposit ratio	1339	0.02	0.03	0	0.01	0.06
HELOC	Number of applications	877	4400.14	13280.1	51.2	1121	15461.2
	Number of originations	877	2556.6	6610.77	35.4	834	9449.2
	Amount of applications	877	597.04	1712.19	13.09	146.09	2496.4
	Amount of originations	877	374.6	942.74	9.29	113.83	1499.21
	Origination-to-deposit ratio	877	0.02	0.02	0	0.02	0.04
Nonconventional	Number of applications	1067	590.89	1379.64	2	132	3386.9
	Number of originations	1067	470.19	1084.58	0	103	2718.6
	Amount of applications	1067	136.32	317.54	0.28	28.91	780.58
	Amount of originations	1067	111.67	256.31	0	23.47	632.66
	Origination-to-deposit ratio	1067	0.01	0.02	0	0	0.05

Table 3: **Descriptive statistics for mortgage variables.** This table presents summary statistics for the mortgage variables in the analysis. The appendix contains a detailed description of the variables. The unit of observation is at the bank-year level. Numbers in units, amounts in million dollars, ratio is in decimal form. The final sample includes 299 banks at the highest consolidated level from 2017 to 2023. To avoid the impact of mergers and acquisitions, I removed the bank-quarter observations corresponding to the two quarters after a bank went through a transformation. Variables winsorized at the 99th percentile.

Variables and measurement. The main variable of interest is Δ, the proportion of insured deposits in total deposits. The FRY9C does not provide a consolidated insured deposit ratio. However, Forms 31 and 41 require banks to estimate the amount of uninsured deposits on an unconsolidated basis. To approximate the insured deposit ratio at the consolidated bank level, data from these forms is used. Specifically, insured deposits across all institutions that consolidate under a parent are summed and divided by total deposits after exclusions. While this method offers a useful proxy for the consolidated insured deposit ratio, it has limitations.

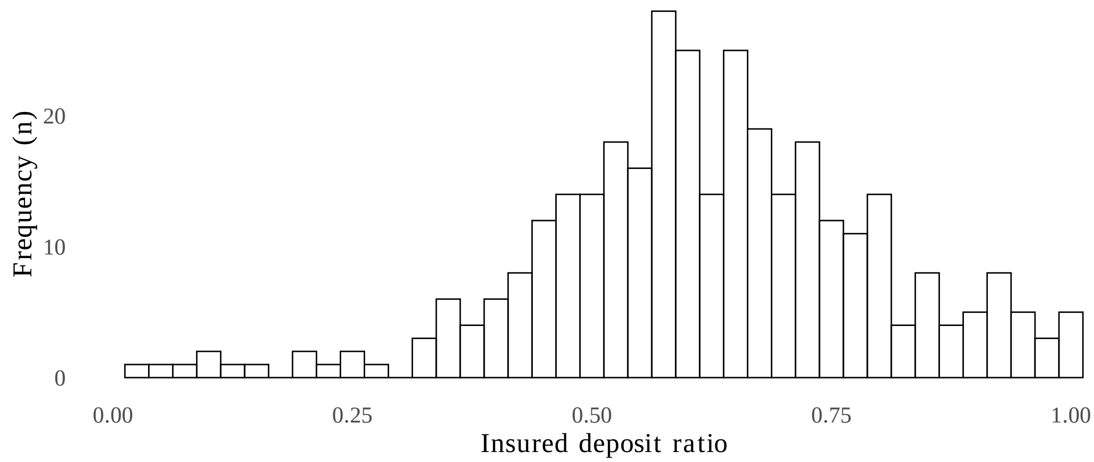
The preferred lending outcomes are the loan-to-deposit ratio and the logarithm of total loans. By fixing the level of deposits, I isolate lending decisions from fluctuations in deposit levels, ensuring that I am measuring how banks allocate their existing resources.

Controls include bank size, proxied by logged total assets, and the CAMEL indicators, which are commonly used to assess the overall health and performance of banks. Specifically, these indicators include capital adequacy, proxied by the leverage ratio; asset quality, proxied by the non-performing loans (NPL) ratio; management, proxied by the return-on-assets ratio; earnings, proxied by the net interest margin ratio; and liquidity adequacy, proxied by the liquidity ratio.

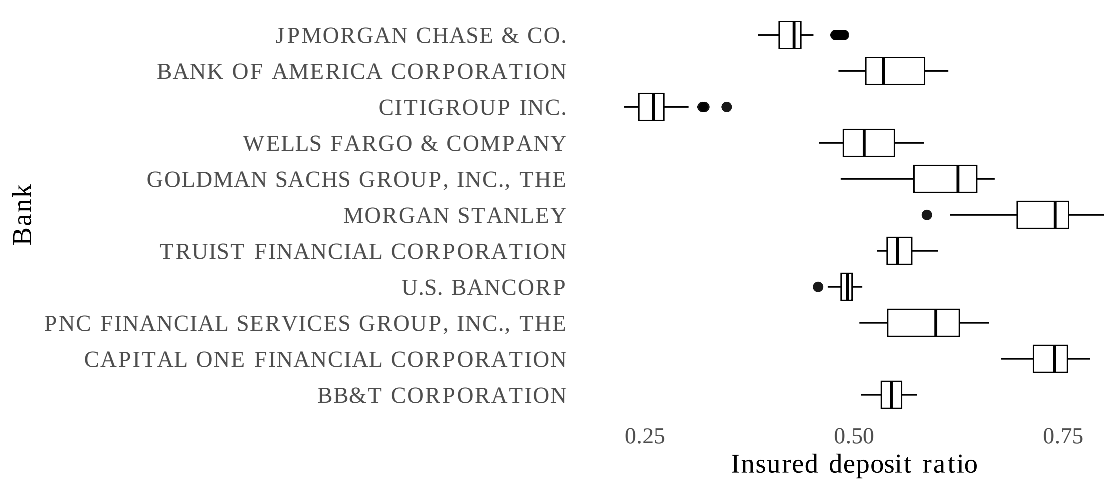
Sources of variation in the insured deposit ratio. The distribution of the insured deposit ratio, shown in Panel A of Figure 4, reveals considerable variation, with most observations clustered around the median but notable dispersion across the full 0 to 1 range. The first row in table 4, which reports mean squared errors from regressions with the insured deposit ratio as the dependent variable, shows that most of the variation is across banks. The inclusion of bank fixed effects in column (2) explains 85% (1-0.0045/0.0301) of the variation in the insured deposit ratio. Observed time-varying bank characteristics only explain 29% (1-0.0214/0.0301) of the variation.

Observable bank characteristics explain very little of the variation in the insured deposit ratio. Banks that are otherwise similar may have remarkably different insured deposit ratio, as seen in Panel B of figure 4, for the largest banks. The opposite is also true, one aspect where deposit-funded and non-deposit funded are remarkably similar is in their average insured deposit ratio (as seen in table 5). What underlying factors, then, might drive the heterogeneity?

Ultimately, being below or above the insurance threshold is a decision made by households and firms. Households and firms make this decision, yet many hold deposits exceeding the insured limit - an action that seems at odds with rationality. Households, for instance, could spread their deposits across multiple banks to ensure all deposits fall under the insurance threshold. Possible explanations include a lack of awareness about the coverage threshold or limited financial literacy. For firms, however, these explanations are less convincing. Firms are likely to be informed about insurance limits, so their choice to hold uninsured deposits might reflect different motivations. For example, they may need substantial liquidity to manage operations, such as payroll, making the insured threshold impractical. Alternatively, firms may view the likelihood of bank failure as low, deeming the risk of holding uninsured deposits acceptable.



Panel A: Distribution of the insured deposit ratio



Panel B: Distribution of the insured deposit ratio in largest banks

Figure 4: **Distribution of the insured deposit ratio.** Panel A presents the distribution of the insured deposit ratio across banks as of December 31st, 2022. Panel B displays box-and-whisker plots illustrating the distribution across time of the insured deposit ratio for the ten largest banks in the sample, ranked by total assets.

	Mean Squared Error in OLS Regressions					
	(0)	(1)	(2)	(3)	(4)	(5)
Insured deposit ratio	0.0301	0.0292	0.0045	0.0214		
Uninsured deposits (log)	3.0197				0.7555	0.5268
Time FE	No	Yes	No	No	No	No
Bank FE	No	No	Yes	No	No	No
Observed bank characteristics:						
Total assets (log)	No	No	No	Yes	Yes	Yes
Deposit rate	No	No	No	Yes	No	No
Leverage ratio	No	No	No	Yes	No	No
NPLs ratio	No	No	No	Yes	No	No
Return-on-Assets	No	No	No	Yes	No	No
Net-interest-margin	No	No	No	Yes	No	No
Liquidity ratio	No	No	No	Yes	No	No

Table 4: **Components of the variance of the insured deposit ratio.** The table shows the components of the variance in the insured deposit ratio. The unit of observation is at the bank-quarter level. The sample includes 509 banks matched in call reports for which the insured deposit ratio is available from 2014 to 2024Q1. Columns (0)-(3) provide the mean squared error from OLS regressions that include no controls (0), time fixed effects (1), bank fixed effects (2), and observed bank characteristics (3). Columns (4)-(5) provide the mean squared error from OLS regression on the extensive (number of uninsured deposit accounts) and intensive margin (average amount of an uninsured deposit account), respectively, and controlling for bank size.

4.2 Results

4.2.1 Level predictions

To test the level predictions I use variations of the following reduced-form model:

$$y_{i,t} = \alpha + \Delta_{i,t-1}\beta + X'_{i,t-1}\gamma + f_i + f_t + \epsilon_{i,t} \tag{5}$$

where $y_{i,t}$ represents the lending outcome of bank i at time t. The main coefficient of interest is β, capturing the relationship between $y_{i,t}$ and $\Delta_{i,t-1}$, the lagged insured deposit ratio. f_i and f_t are bank and time fixed effects, respectively. $X_{i,t-1}$ is a vector of time-varying bank characteristics. I estimate this specification using ordinary least squares (OLS) and obtain standard errors clustered at the bank level.

As discussed in the previous section, the level prediction states that β ought to be *positive* in deposit-funded-banks and *negative* in non-deposit-funded banks.

The first step is to distinguish between deposit-funded-banks and non-deposit-funded banks. A bank is classified as deposit-funded if their deposit/liability ratio exceeds the 66th percentile at least half of the time. A bank is classified as non-deposit-funded if their deposit/liability ratio is below the 33rd percentile at least half of the time. Table 5 shows mean comparison balance tables. Non-deposit funded banks are larger banks. They also differ from deposit funded banks on the CAMEL indicators.

Sample mean	Deposit-funded	Non-deposit-funded	t-ratio
Insured deposit ratio	0.6797	0.6602	-4.9
Loan-to-Deposit ratio	0.7623	0.8983	28.82
Total Loans (log)	7.728	9.0417	41.05
Total Assets (log)	8.1907	9.568	40.33
Deposit rate	0.0051	0.0074	15.55
Leverage ratio	9.966	9.8489	-1.91
NPLs ratio	0.0071	0.0096	11.87
Return-On-Assets ratio	0.0119	0.0125	2.98
Net interest margin ratio	0.0369	0.0356	-2.51
Liquidity ratio	0.0903	0.0808	-5.21

Table 5: **Comparison table for banks according to funding type.** This table presents a mean comparison of financial variables between deposit-funded and non-deposit-funded banks. The unit of observation is at the bank-year level. There are 178 deposit-funded banks and 144 non-deposit-funded banks from 2014 to 2024Q1.

Before starting, I estimate the model for the full bank-quarter sample. Table 6, column (1) and (5) use the Loan-to-Deposit ratio and the logarithm of total loans as the independent variable, respectively. The coefficients associated with the insured deposit ratio are not statistically significant for neither lending outcome. The model had already showed that the relationship between deposit insurance and lending is complex and shaped by a bank's funding structure and deposit elasticity. The fact that the coefficient is not significant in this strict specification, using both time and bank fixed effects, testifies to this complexity. A naive reading of these estimates would conclude that moral hazard is not present.

One of the key insights from the model, however, is that moral hazard resulting from deposit insurance manifests differently depending on the bank's funding structure. The results in the remaining columns of table 6 lend strength to this hypothesis. Column (2) and (3) estimate the specification separately for deposit-funded and non-deposit-funded banks, looking at the Loan-to-Deposit ratio as the outcome. The coefficient for the insured deposit ratio is *positive* when the bank is deposit-funded; and *negative* when the bank is non-deposit-funded. Both results are statistically different from zero. The magnitude is also economically meaningful: a one-standard deviation increase in the insured deposit ratio is associated with a 238 basis points (0.17×0.14) increase in the Loan-to-Deposit ratio for deposit-funded banks and a 374 basis points ($0.17\times$-0.22) decrease in non-deposit-funded banks. Column (6) and (7) repeat the exercise using the logarithm of total loans as the outcome and confirm the findings. Column (4) and (8) are robustness exercises, interacting the full sample with a dummy for funding type instead of splitting the sample. The coefficients in this case are to be interpreted as the differential against the mixed funding structure banks.

Moral hazard should be present only when banks are dealing with risky loans. If banks choose safe loans, their funding structure and insured deposit ratio should not matter. This idea can be tested using HMDA data, which provides detailed information on mortgage originations. Safe loans are defined as those automatically eligible for purchase by government-sponsored entities or otherwise insured. When banks offer these loans, they assume minimal risk because they can quickly sell

	Loan-to-Deposit				Total loans (log)			
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sub-sample:	All	Deposit	Non-dep.	All	All	Deposit	Non-Dep.	All
Variables								
Δ_{t-1}	-0.01	0.14**	-0.22**		-0.01	0.16*	-0.28**	
	(0.05)	(0.06)	(0.09)		(0.08)	(0.08)	(0.14)	
$\Delta_{t-1} \times I_{ND}$				-0.14*				-0.28**
				(0.08)				(0.12)
$\Delta_{t-1} \times I_D$				0.04				0.17**
				(0.06)				(0.08)
$Assets_{t-1}$					0.95***	0.97***	0.90***	0.95***
					(0.03)	(0.04)	(0.07)	(0.03)
Fixed-effects								
Year-Quarter (41)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
# Bank	509	178	144	509	509	178	144	509
Observations	13,871	4,332	4,227	13,871	13,908	4,332	4,264	13,908
R^2	0.88	0.90	0.88	0.89	1.00	0.99	1.00	1.00
Within R^2	0.00	0.02	0.02	0.01	0.78	0.82	0.70	0.78

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 6: **Moral hazard effects vary by funding structure.** This table presents evidence on how moral hazard effects vary by bank funding structure. $\Delta_{i,t-1}$ is the insured deposit ratio in the previous quarter. I_D is an indicator variable that equals 1 if the bank is deposit-funded, a bank is classified as deposit-funded if their deposit/liability ratio exceeds the 66th percentile at least half of the time. I_{ND} is an indicator variable that equals 1 if the bank is non-deposit-funded, a bank is classified as non-deposit-funded if their deposit/liability ratio is below the 33rd percentile at least half of the time. Column (1) to (4) use the Loan-to-Deposit ratio as the dependent variable. Column (1) estimates the model using the entire bank-quarter sample, column (2) reestimates the model for a sample consisting of only deposit-funded banks and column (3) for a sample consisting only of non-deposit funded banks. Column (4) estimates the model for the entire sample, but interacting the insured deposit ratio with dummies for funding type. Column (5) to (8) repeat the same exercise but using the logarithm of total loans as the dependent variable and include total assets in the previous quarter as a control.

them, removing the loan from their balance sheets. Therefore, I do not expect to see moral hazard effects with safe loans. In contrast, risky loans are those that are not automatically eligible for government purchase, and for these loans, the model's predictions apply.

As a placebo test, table 7 compares the coefficient estimates from specification 5, using the origination-to-deposit ratio for risky loans as the lending outcome, alongside that for safe loans. The relationship between insured deposits and the origination-to-deposit ratio is only statistically different from zero when loans are risky, as expected. The strongest effect is in column (3), showing the *negative* relationship between the insured deposit ratio and risky lending when the bank is non-deposit-funded. Note that the mortgage variables are only available at an yearly frequency and for a limited subset of the banks in the sample.

The central parameter of interest is β, and its sign when banks are deposit-funded versus non-deposit-funded. Estimation by OLS of this parameter in a fixed effects model, however, is confounded by the existence of time-varying bank-specific variables that influence both the insured deposit ratio and the lending outcome. The omitted variable formula implies that the OLS coefficient from the regression is:

$$\beta_{OLS} = \beta + \frac{cov(\Delta_{i,t-1}, X'_{i,t-1}\gamma)}{Var(\Delta_{i,t-1})} + \frac{cov(\Delta_{i,t-1}, f_i)}{Var(\Delta_{i,t-1})} + \frac{cov(\Delta_{i,t-1}, f_t)}{Var(\Delta_{i,t-1})} \tag{6}$$

To assuage this concern, table 8 includes the CAMEL indicators as controls. CAMEL indicators are widely recognized as a comprehensive summary of a bank's financial condition and risk profile. These indicators capture critical aspects of bank performance that could affect both the insured deposit ratio and lending outcomes, thereby helping to isolate the true effect of deposit insurance. Including CAMEL indicators is particularly relevant given that deposit-funded and non-deposit-funded banks differ significantly in these characteristics, as observed in table 5. The main results remain robust when CAMEL indicators are included, suggesting that the

	Origination-to-Deposit					
Loan riskiness:		Risky			Safe	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Sub-sample:	All	Deposit	Non-dep.	All	Deposit	Non-dep.
Variables						
Δ_{t-1}	-0.03***	-0.02	-0.04***	-0.01	-0.03	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Fixed-effects						
Year-Loan category (12)	Yes	Yes	Yes	Yes	Yes	Yes
Bank	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
# Bank	254	84	88	255	84	88
Observations	2,216	751	759	2,416	849	783
R^2	0.60	0.67	0.54	0.74	0.72	0.75
Within R^2	0.01	0.01	0.01	0.00	0.00	0.00

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 7: **Placebo test - moral hazard effects visible only with risky loans.** This table presents evidence on how moral hazard effects are present only when loans are risky. $\Delta_{i,t-1}$ is the insured deposit ratio in the previous quarter. Column (1) to (3) use the Origination-to-Deposit ratio of risky loans (Conventional non-conforming or 'jumbo' loans, home equity line of credit or 'HELOC' loans) as the dependent variable. Column (1) estimates the model using the entire bank-quarter sample, column (2) reestimates the model for a sample consisting of only deposit-funded banks and column (3) for a sample consisting only of non-deposit funded banks. Column (4) to (6) repeat the same exercise but using the Origination-to-Deposit ratio of safe loans (conventional conforming mortgages, loans guaranteed by agencies such as the Federal Housing Administration, Veterans Affairs, or USDA) as the dependent variable.

observed effects are not merely driven by other time-varying bank-specific characteristics but are instead reflective of the underlying relationship between deposit insurance and lending.

	Loan-to-Deposit				Total loans (log)			
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sub-sample:	All	Deposit	Non-dep.	All	All	Deposit	Non-dep.	All
Variables								
Δ_{t-1}	0.01	0.13***	-0.11**		0.01	0.15**	-0.10*	
	(0.04)	(0.05)	(0.05)		(0.05)	(0.07)	(0.05)	
$Assets_{t-1}$	0.05***	0.04	0.04	0.05***	0.99***	1.01***	0.98***	0.99***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
$Leverage_{t-1}$	0.01***	0.00	0.02***	0.01***	0.01	-0.01	0.02	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
$NPLs_{t-1}$	-1.09*	-1.58**	-1.14	-1.05*	-0.85	-2.08**	-0.24	-0.74
	(0.57)	(0.79)	(1.26)	(0.57)	(0.56)	(0.99)	(1.18)	(0.57)
ROA_{t-1}	-0.31	-0.13	-0.71	-0.31	-0.72	-0.09	-1.89	-0.71
	(0.81)	(0.48)	(0.95)	(0.80)	(1.50)	(0.57)	(1.45)	(1.47)
NIM_{t-1}	2.96**	4.48***	0.51	2.88**	8.34***	6.16***	8.95***	8.10***
	(1.40)	(0.91)	(2.03)	(1.38)	(2.30)	(1.73)	(2.89)	(2.25)
$Liquidity_{t-1}$	-0.76***	-0.45***	-1.23***	-0.76***	-0.73***	-0.54***	-1.14***	-0.73***
	(0.07)	(0.10)	(0.14)	(0.07)	(0.12)	(0.14)	(0.24)	(0.12)
$\Delta_{t-1} \times I_{ND}$				-0.06				-0.15**
				(0.05)				(0.07)
$\Delta_{t-1} \times I_{D}$				0.03				0.14*
				(0.06)				(0.07)
Fixed-effects								
Year-Quarter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
# Year-Quarter	40	37	40	40	40	37	40	40
# Bank	444	141	130	444	445	141	131	445
Observations	11,232	3,261	3,499	11,232	11,269	3,261	3,536	11,269
R^2	0.92	0.92	0.93	0.92	1.00	1.00	1.00	1.00
Within R^2	0.27	0.24	0.37	0.27	0.83	0.85	0.79	0.83

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 8: **Moral hazard effects vary by funding structure (robustness).** This table presents evidence on how moral hazard effects vary by bank funding structure even after controlling for time varying bank-specific characteristics. Detailed variable definitions in the appendix. This table repeats the exercise in table 6 but with additional controls.

4.2.2 Marginal predictions

To test the marginal prediction, I use the 2023 Regional Banking Crisis as an exogenous funding shock that triggered significant deposit reallocation across banks. In the aftermath of the crisis, some banks lost deposits and had to seek alternative funding, such as wholesale sources, to support lending, while others gained deposits, benefiting from an increased supply of subsidized funds. The marginal prediction anticipates that banks losing deposits will reduce lending, while banks gaining deposits will increase lending, with the magnitude of these effects tied to each bank's insured deposit ratio.

The 2023 Regional Banking Crisis On March 8th, 2023, Silvergate Bank's closure announcement sent shockwaves through the financial sector. On the same day, Silicon Valley Bank (SVB) disclosed significant losses and unveiled plans for a stock offering. The disclosure, coupled with reports of financial distress circulating on social media platforms, ignited widespread panic among depositors, triggering a sudden and severe run on the bank. By March 10th, SVB had succumbed to the pressures of the unfolding crisis, officially declaring bankruptcy. On the same day, depositors of Signature Bank initiated a run on the institution.

On Sunday, March 12th, the Treasury, Federal Reserve, and FDIC issued a joint statement invoking the systemic risk exception to extend deposit insurance coverage to all depositors at the failing banks. The justification for this unprecedented measure was based on concerns about potential wider financial instability and to protect the overall health of the banking system. In general, FDIC cannot use its fund to protect uninsured depositors and creditors if it would increase the fund's losses. Under the systemic risk exception to least-cost resolution, however, the FDIC may resolve a failed bank without following the least-cost rule if doing so would cause serious harm to economic conditions or financial stability, and if the alternative would help avoid or mitigate these adverse effects. [1] Additionally, the Federal Reserve Board announced the Bank Term Funding Program, which providing additional funding to eligible institutions. Figure 9 summarizes the timeline of the 2023 Regional Banking Crisis.

The failures of Silicon Valley Bank (SVB) and Signature Bank in early 2023 were highly idiosyncratic and unexpected, making the 2023 Regional Banking Crisis an exogenous shock to the broader banking sector. These banks encountered unique, severe challenges that have since been widely analyzed in media reports and recent studies. In addition to the main insights from classic bank run models (Diamond and Dybvig, 1983, Dávila and Goldstein, 2023), factors mentioned in connection with this particular crisis include the rapid rise in interest rates and the role of uninsured depositors (Drechsler et al., 2023, Jiang et al., 2023), as well as the speed of information dissemination enabled by widespread social media usage (Cookson et al., 2023, FDIC, 2023).

Despite the idiosyncratic origins of the crisis, from March 8th to March 14th, depositors—especially those with uninsured deposits—moved substantial funds out of affected banks. Cipriani, Eisenbach, and Kovner, 2024 identify 22 ”run banks” where net liquidity outflows exceeded five standard deviations of their historical

[1] The systemic risk exception was only used five times, all during the 2007-2009 Great Financial Crisis. At the peak of the crisis, the FDIC used the systemic risk exception to propose partial asset guarantees to Wachovia, Citigroup, and Bank of America. In the case of Wachovia and Bank of America, the proposed action never occurred, and in the case of Citibank the guarantee was never paid out. Additionally, the systemic risk exception was also invoked in the context of the Debt Guarantee Program (DGP) and the Transaction Account Guarantee Program (TAG). Under DGP, the FDIC guaranteed certain bank-issued debt. Under TAG, the FDIC guaranteed non-interest-bearing deposit accounts above the deposit limit, mainly for businesses and local governments. Both programs charged fees to participating banks to cover potential costs. Finally, although the Treasury’s Public Private Investment Program (PPIP) was never implemented, the systemic risk exception would have played a crucial role in its proposal. Under PPIP, the FDIC would have partially guaranteed ”legacy loans” acquired by the program.

averages. They also note that the runs were mostly driven by large (institutional) depositors, but that there is almost no evidence of runs by small (retail) depositors. In the analysis that follows, I use the deposit reallocation during 2023 Regional Banking Crisis to examine marginal predictions from the model, particularly that banks losing access to deposits are more likely to exhibit overhang.

Mar 8 (wed)	**Silvergate Bank** announces wind down of operations and self-liquidation. **SVB** announces stock offering and reports losses in the sale of its available-for-sale securities portfolio. The announcement, along with warnings shared in social media platforms, triggers the bank run.
Mar 9 (thu)	**SVB** bank run. Fed notifies FDIC of possible failure of SVB.
Mar 10 (fri)	**SVB** failure. FDIC, as the appointed receiver, transfers SVB deposits to newly created Deposit Insurance National Bank of Santa Clara. **Signature Bank** bank run. Fed notifies FDIC of possible failure of Signature Bank.
Mar 11 (sat)	Fed and FDIC coordinate use of the systemic risk exception to least cost resolution.
Mar 12 (sun)	**Signature Bank** failure, FDIC appointed receiver. Bids received for **SVB** considered not to meet least-cost test. Announcement of the systemic risk exception for **SVB** and **Signature Bank**.
Mar 13 (mon)	Bridge banks for **SVB** and **Signature Bank** open for normal business.

Table 9: Timeline of the 2023 Regional Banking Crisis

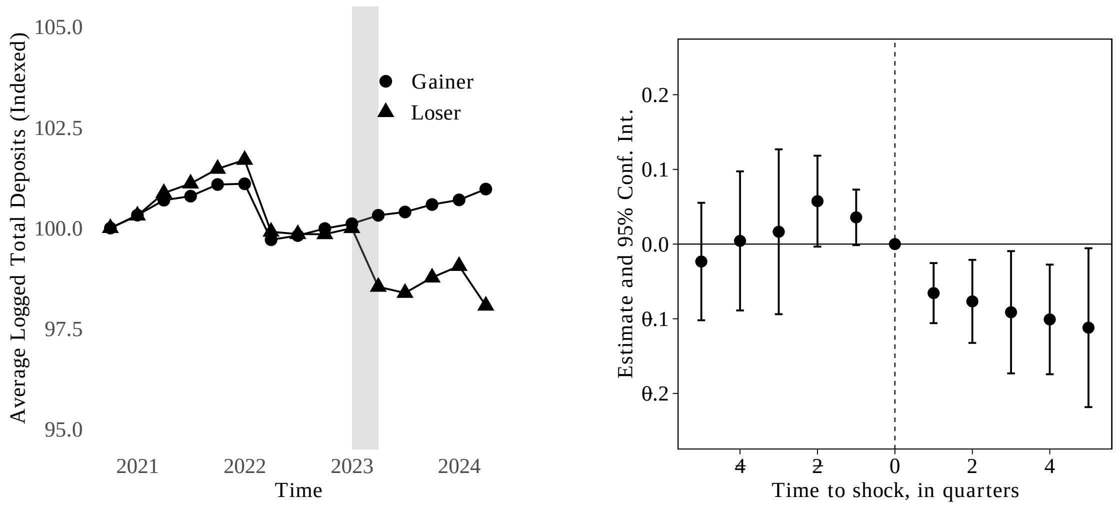
Deposit reallocation The Regional Banking Crisis created a sharp and largely exogenous shock that drove significant shifts in deposit levels across banks. Between December 31, 2022, and March 31, 2023, some banks experienced substantial deposit outflows, while others saw deposit inflows, resulting in a clear divergence in deposit levels during this period.

Prior to this shock, however, banks that ultimately lost deposits ("losers") and those that gained deposits ("gainers") were on a similar trends in terms of deposits. Figure 5 examines pre-trends in deposit evolution between the two groups. Panel A plots the raw data, showing the evolution of average deposits for each group over time, highlighting the similar deposit level trajectories before the crisis-induced divergence. Panel B displays the coefficient estimates from an event study model:

$$d_{i,t} = \alpha + \sum_{t=-5}^{5} \mu_t \cdot \tau_t \cdot Loser_i + f_t + f_i + \epsilon_{i,t} \tag{7}$$

where $d_{i,t}$ is the logarithm of total deposits for bank i at time t, τ_t is an indicator variable for each time period t relative to the last quarter before the shock, i.e. December 31, 2022; $Loser_i$ is a dummy variable equal to 1 for banks that lost deposits and 0 otherwise; f_t and f_i represent time and bank fixed effects, respectively; and $\epsilon_{i,t}$ is the error term. The coefficients μ_t capture the relative difference in deposits between the banks that lost and gained deposits around the shock.

The coefficient estimates in Panel A of figure 5 show that they were evolving in broadly similar ways until the March 2023 Regional Banking Crisis, when some banks lost a lot of deposits. The magnitude is also economically relevant. On average, deposits for the banks that lost deposits decreased 6.35% $((e^{-0.065653} + 1) * 100)$ more from December 31st, 2022, to March 31st, 2023, than in banks that did not lose deposits.



Panel A: Evolution of average deposits.

Panel B: Difference in average deposits.

Figure 5: **Comparison of the evolution in deposits in banks that lost versus gained deposits in the aftermath of the 2023 Regional Banking Crisis.** *Losers* are banks with a negative quarter-on-quarter change in total deposits from December 31, 2022 to March 31, 2023. Conversely, *gainers* are banks that had a positive quarter-on-quarter change in total deposits from December 31st, 2022 to March 31st, 2023. Silvergate Capital Corporation, Signature Bank, and Silicon Valley Bank were excluded from the sample. There are 198 *losers* and 169 *gainers* in the sample. The unit of observation is at the bank-year level. Panel A shows the evolution of the average logarithm of total deposits in the two groups, where the reference date for the index is June 30th, 2020. Panel B shows the coefficient estimates of the event study specification in 7. Confidence intervals at 95% confidence level.

Lending outcomes In the aftermath of the 2023 Regional Banking Crisis, *losers* banks suddenly lost access to a marginal source of funding that was subsidized. In the language of the model, these banks transitioned into the "sticky deposit" scenario, where the bank struggles to raise new deposits. The model predicts that in such conditions, "overhang" becomes the dominant effect.

Empirically, the data reveals that *losers* banks not only experienced deposit losses but also scaled back their lending activities. This contraction suggests that banks passed up positive net present value (NPV) lending opportunities because their only option to fund these loans would be to resort to wholesale funding. In order to quantify the degree of underlending, I estimate the following difference-in-differences (DiD) specification:

$$y_{i,t} = \alpha + \beta_1 Post_t \cdot Loser_i + \beta_2 Loser_i + \beta_3 Post_t + f_t + f_i + \epsilon_{i,t} \tag{8}$$

where $y_{i,t}$ represents the logarithm of total loans for bank i at time t, $Loser_i$ identifies banks that lost deposit funding, $Post_t$ denotes the post-treatment period (from March 31st, 2023 onwards), f_t and f_i are time and bank fixed effects, respectively, and $\epsilon_{i,t}$ is the error term.

To explore the degree of underlending, table 10 compares the baseline with various post-treatment periods. The first column captures the immediate effect from December 31st, 2022, to March 31st, 2023, while the second column captures the effect from December 31st to June 30th, with each subsequent column increasing the time horizon of the comparison. This sequential approach allows me to analyze whether the observed impacts are transient or enduring. The coefficient in (2) reveals a negative and significant effect, indicating that banks losing deposits during the March 2023 Regional Banking Crisis contracted lending. I interpret the initial effect as a reactionary response, potentially driven by an "information-revealing panic." Moreover, the difference in lending behavior between 'losers' and 'gainers' persisted over time, as evidenced by the coefficients in (3) to (10). These findings suggest that the relationship between deposit access and lending contraction was not only immediate but also sustained.

	Total loans (log)									
Outcome date:	2023Q1		2023Q2		2023Q3		2023Q4		2024Q1	
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables										
Constant	8.62***		8.62***		8.62***		8.62***		8.62***	
	(0.09)		(0.09)		(0.09)		(0.09)		(0.09)	
Loser	0.14		0.14		0.14		0.14		0.14	
	(0.15)		(0.15)		(0.15)		(0.15)		(0.15)	
Post	0.00		0.03		0.05**		0.06***		0.08***	
	(0.02)		(0.02)		(0.02)		(0.02)		(0.02)	
Loser × Post	-0.08**	-0.03***	-0.11***	-0.04***	-0.09**	-0.05***	-0.08*	-0.04***	-0.17***	-0.04***
	(0.03)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)
Fixed-effects										
Bank		Yes		Yes		Yes		Yes		Yes
Year-Quarter		Yes		Yes		Yes		Yes		Yes
Fit statistics										
# Bank	–	350	–	350	–	351	–	350	–	367
Observations	683	683	682	682	682	682	678	678	694	694
R^2	0.002	0.999	0.001	0.999	0.001	0.999	0.002	0.998	0.001	0.998
Within R^2		0.04		0.06		0.05		0.02		0.02

Clustered (Bank) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 10: **Banks that lose access to deposits contract lending.** This table presents evidence on how banks that lose access to deposits contract lending. *Losers* is a binary variable equal to 1 for banks with a negative quarter-on-quarter change in total deposits from December 31, 2022 to March 31, 2023. Post is a binary variable equal to 1 for observations from March 31, 2023 onward (inclusive). Detailed variable definitions are provided in the Appendix. Silvergate Capital Corporation, Signature Bank, and Silicon Valley Bank were excluded from the sample. There are 198 "losers" and 169 "gainers" in the sample. Odd column numbers estimate specification (9) without fixed effects, for different Post dates. Even columns repeat the exercise, but with time and bank fixed effects.

5 Conclusion

The paper sheds light on the delicate balance between deposit insurance, funding structure and unintended moral hazard consequences. Indeed, the model shows that lending too much or lending too little and, equivalently, funding negative NPV loans or passing on positive NPV loans, are two sides of the same coin. The empirical evidence further reinforces this, revealing that "overhang," or the tendency to refrain from lending in the face of costly funding alternatives, may be more prevalent than previously understood.

This paper contributes to the debate regarding the policy changes that may be warranted in the aftermath of the 2023 Regional Banking Crisis. While deposit insurance remains critical for safeguarding depositors and reducing run incentives, extending the scope of deposit insurance may have unintended consequences in terms of the amount of credit made available by banks.

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Appendix

Proofs

The sticky deposits equilibrium

Start by stating the bank's profit condition in full:

$$\Pi \equiv (1-p)\cdot\int_{A^d}^{1+\sigma} \underbrace{Ax_1 + [d-(1-\gamma)x_1]^+}_{\text{Payoff from selling the assets}} \underbrace{-\Delta d - (1-\Delta)d(1+r_d) - \nu_1}_{\text{Payment to funding providers, } c} \, dF(A) \quad +$$

$$p\cdot\int_{A^w}^{1+\sigma} \underbrace{A\big(x_1 + X(x_2)\big) + [d-(1-\gamma)(x_1+x_2)]^+}_{\text{Payoff from selling the assets}} \underbrace{-\Delta d - (1-\Delta)d(1+r_d) - w(1+r_w) - \upsilon_1 - \upsilon_2}_{\text{Payment to funding providers, } c} \, dF(A)$$

s.t.

$$(1-\Delta)d = \int_{A^\Delta}^{A^d} A\big(x_1+X(x_2)\big)+[d-(1-\gamma)(x_1+x_2)]^+-\Delta d \, dF(A)+\int_{A^d}^{1+\sigma}(1-\Delta)d(1+r_d)\, dF(A)$$

$$w = \int_{A^d}^{A^w} A\big(x_1+X(x_2)\big)+[d-(1-\gamma)(x_1+x_2)]^+-\Delta d-(1-\Delta)d(1+r_d)\, dF(A)+\int_{A^w}^{1+\sigma} w(1+r_w)\, dF(A)$$

$$K_t = \begin{cases} \int_{A^w}^{1+\sigma} \upsilon_t \, dF(A) & \text{if } d \le (1-\gamma)(x_1+x_2) \\ \int_{A^d}^{1+\sigma} \nu_t \, dF(A) & \text{if } d > (1-\gamma)(x_1+x_2) \end{cases}$$

$$k_i \ge \gamma x_i$$

$$y \ge \rho d$$

$$x_1 + x_2 + y = d + w + k_1 + k_2$$

Note that $y = [d-(1-\gamma)x_1]^+$ if the new lending opportunity does not materialize and $y = [d-(1-\gamma)(x_1+x_2)]^+$ if it does.

Proof of Proposition 1. Define Π^{YES} as profit conditional on the new lending opportunity realizing. Substituting in binding capital requirements and the balance sheet identities simplifies to:

$$\Pi^{YES} = X(x_2) - x_2 + \int_{1-\sigma}^{A^{\Delta}} \Delta d - A\big(x_1 + X(x_2)\big) - [d - (1-\gamma)(x_1 + x_2)]^+ \; dF(A)$$
$$\text{where } A^{\Delta} = \frac{\Delta d - [d - (1-\gamma)(x_1 + x_2)]^+}{x_1 + X(x_2)}$$

Taking x_1 as given, implicitly define x_2^* as the solution to the FOC:

$$\Pi^{YES}_{x_2}(x_1, x_2^*) = 0 \Leftrightarrow X_{x_2}(x_2^*, x_1) - 1 \; + \; s^{YES}_{x_2}(x_2^*, x_1) \; = \; 0$$
$$\text{where } s^{YES}_{x_2} = \int_{1-\sigma}^{A^{\Delta}} (1-\gamma) \cdot \mathbf{1}\big(d > (1-\gamma)(x_1 + x_2^*)\big) - A X_{x_2}(x_2^*) \; dF(A)$$

Note that when $d > (1-\gamma)(x_1 + x_2)$:

$$(1-\gamma) = A^{\Delta} \underbrace{\frac{x_1 + X(x_2)}{x_1 + x_2}}_{\text{avg return}} + A^{\Delta} \underbrace{\frac{(1-\Delta)d}{x_1 + x_2}}_{>0} \; \geq \; A \underbrace{X_{x_2}(x_2)}_{\text{mg return}}$$

Why? Because we are in the state region where $A^{\Delta} \geq A$ and the fact that average lending return exceeds marginal lending return given the assumptions on X.
Then $d \lesseqgtr (1-\gamma)(x_1 + x_2^*) \Rightarrow s^{YES}_{x_2} \lesseqgtr 0 \Rightarrow x_2^* \lesseqgtr x_2^{MM}$, which concludes the proof.

Proof of Corollary 1. Taking the derivative of $s^{YES}_{x_2}$ wrt Δ:

$$s^{YES}_{x_2\Delta} = \big((1-\gamma) \cdot \mathbf{1}\big(d > (1-\gamma)(x_1 + x_2) - A^{\Delta} X_{x_2}(x_2)\big) \; \cdot \; f(A^{\Delta}) \; \cdot \; A^{\Delta}_{\Delta}$$

Then $d \lesseqgtr (1-\gamma)(x_1 + x_2^*) \Rightarrow s^{YES}_{x_2\Delta} \lesseqgtr 0$, which concludes the proof.

Proof of Proposition 2. I will prove (i), (ii), and (iii) in sequence.

For (i), start by defining Π^{NO} as profit conditional on the new lending opportunity not materializing. Substituting in binding capital requirements and the balance sheet identities simplifies to:

$$\Pi^{NO} = \int_{1-\sigma}^{A^{\Delta}} \Delta d - \big(Ax_1 + [d-(1-\gamma)x_1]^+\big)\ dF(A)\ ,\ \text{where } A^{\Delta} = \frac{\Delta d - [d-(1-\gamma)x_1]^+}{x_1}$$

Derive FOC wrt x_1:

$$\Pi^{NO}_{x_1}(x_1) = \int_{1-\sigma}^{A^{\Delta}} (1-\gamma) - A\ dF(A)\ >\ 0$$

Why $\Pi^{NO}_{x_1}(x_1) > 0$? Because we are in the state region $A^{\Delta} \geq A$. Then $\frac{\Delta d-[d-(1-\gamma)x_1]^+}{x_1} \geq A \Rightarrow \frac{(\Delta-1)d}{x_1} + (1-\gamma) \geq A$ and $\frac{(\Delta-1)d}{x_1} > 0$.

Then, profit is maximum when bank allocates all the deposits to initial loans ($x_1^* = \frac{d}{1-\gamma}$) and none to the liquid asset ($y = 0$). Since the new lending opportunity does not materialize $x_2^* = 0$.

For (ii), recall that equilibrium new lending x_2^* is not a point but a function of x_1 defined as $x_2^* = h(x_1)$.

Observe that for any given x_1, $d \leq (1-\gamma)(x_1 + h(x_1))$ dominates $d > (1-\gamma)(x_1+h(x_1))$ since $x_1 \geq 0$ and $h(x_1) \geq 0$:

$$\begin{aligned}
\Pi^{YES\leq} &= X(h(x_1)) - h(x_1) + \int_{1-\sigma}^{A^{\Delta}} \Delta d - A\big(x_1 + X(h(x_1))\big)\ dF(A) \\
&> \\
\Pi^{YES>} &= X(h(x_1)) - h(x_1) + \int_{1-\sigma}^{A^{\Delta}} \Delta d - A\big(x_1 + X(h(x_1))\big) - \big(d - (1-\gamma)(x_1 + h(x_1))\big)\ dF(A)
\end{aligned}$$

Consequently, focus on $\Pi^{YES\leq}$. Derive FOC wrt x_1, omitting function dependencies for readability:

$$\Pi^{YES\leq}_{x_1} = X_h(h) \cdot h' - h' + \int_{1-\sigma}^{A^\Delta} -A(1 + X_h(h) \cdot h')\ dF(A)$$

Guess and verify the solution when $X_h(h) = 1$ and $h' = -1$:

$$1 \cdot (-1) - (-1) + \int_{1-\sigma}^{A^\Delta} -A(1 + 1 \cdot (-1))\ dF(A) = 0$$

Then, profit is maximum when $y^* = x_2^{MM}$, $x_1^* = x_1^{MM}$ and $x_2^* = x_2^{MM}$, where x_1^{MM} is defined as the amount that induces the bank to select x_2^{MM} in $t = 2$.

For (iii), take the FOC of Π wrt to x_1:

$$\Pi_{x_1} = (1-p) \cdot \Pi^{NO}_{x_1} + p \cdot \Pi^{YES}_{x_1}$$

Focus on the region close to x_1^{MM}, so that $h' = -1$ (not looking at extreme cases). Then:

$$\frac{\partial \Pi}{\partial x_1} = (1-p)\Big[\int_{1-\sigma}^{A^\Delta} (1-\gamma) - A\ dF(A)\Big] + p\Big[(1 - X_h) - \int_{1-\sigma}^{A^\Delta} A\ (1 - X_h) dF(A)\Big]$$

x_1	X_h	$\Pi^{YES}_{x_1}$	$\Pi^{NO}_{x_1}$	Π_{x_1}	**p**	**Conclusion**
$x_1 < x_1^{MM}$	< 1	> 0	> 0	> 0	$(0,1)$	increase x_1, not an equilibrium
$x_1 = x_1^{MM}$	$= 1$	$= 0$	> 0	> 0	$(0,1)$	increase x_1, not an equilibrium
$x_1 > x_1^{MM}$	> 1	< 0	> 0	$= 0$	for $p \geq p^*$	equilibrium $\frac{d}{1-\gamma} > x_1^* \geq x_1^{MM}$
				> 0	for $p < p^*$	extreme case $x_1^* = \frac{d}{1-\gamma}$

Note that for certain γ and Δ it can be that in the region close to x_1, no such p^* can be sustained; and in the region further away from x_1^{MM} the result is indeterminate.

Empirics

Variable construction

Metric	**FRY9C**	**Form 31/Form 41**
Total Assets	BHCK2170	RCFD2170 or RCON2170
Total Loans	BHCK5369 + BHCKB529	RCFD5369 + RCFDB529 or RCON5369 + RCONB529
Total Deposits	BHDM6631 + BHDM6636 + BHFN6631 + BHFN6636	RCON2200 or RCFN2200
Total Liabilities	BHCK2948	RCFD2948 or RCON2948
Insured Deposits Ratio	-	1 - (RCON5597 divided by RCON2200)
Leverage Ratio	BHCA7204	RCFA7204 or RCOA7204
NPLs Ratio	(BHCK1407 or BHCK5525 - BHCK3506) + (BHCK1403 or BHCK5526 - BHCK3507) divided by BHCK2122	(RCFD1407 + RCFD1403) divided by RCFD2122 or (RCON1407 + RCON1403) divided by RCON2122
ROA (Return-On-Assets)	(BHCK4340 * 4 / report date quarter) / BHCK3368	(RIAD4340 * 4 / report date quarter) / RCFD3368 or RCON3368
NIM (Net Interest Margin)	(BHCK4074 * 4 / report date quarter) / (BHCK0395 + BHCK0397 + BHCK5369 + BHCKB529 + BHCK3545 + BHCK1754 + BHCK1772 + BHDMB987 + BHCKB989)	(RIAD4074 * 4 / report date quarter) / (RCFD0071 + RCFD5369 + RCFDB529 + RCFD3545 + RCFD1754 + RCFD1772 + RCONB987 + RCFDB989 or RCON0071 + RCON5369 + RCONB529 + RCON3545 + RCON1754 + RCON1772 + RCONB987 + RCONB989)
Liquidity Ratio	(BHCK0081 + BHCK0395 + BHCK0397 + BHDMB993 + BHCK0213 + BHCK1287) / BHCK2170	(RCFD0081 + RCFD0071 + RCONB993 + RCFD0213 + RCFD1287) / RCFD2170 or (RCON0081 + RCON0071 + RCONB993 + RCON0213 + RCON1287) / RCON2170
Deposit Rate	((BHCKHK03 or BHCKA517 + BHCKHK04 or BHCKA518 + BHCK6761) * 4 / report date quarter) / (BHDM6631 + BHDM6636)	((RIAD4508 + RIAD0093 + RIADHK03 or RIADA517 + RIADHK04 or RIADA518) * 4 / report date quarter) / RCON2200