# Monetary Tightening, Bank Fragility, and Emergency Liquidity Support*

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**Abstract**

When monetary policy tightens rapidly, banks holding long-duration government securities funded by uninsured deposits become vulnerable to runs. We study the Bank Term Funding Program (BTFP)—a Federal Reserve facility that lent at par against government-backed collateral during the March 2023 banking turmoil—providing an empirical test of the Goodfriend–King prescription that crisis liquidity should flow through government collateral. BTFP borrowing was concentrated among the most vulnerable banks, while operational readiness—prior discount-window collateral pledging—determined effective access. Non-BTFP borrowing banks facing deposit outflows raised deposit rates more aggressively than borrowers facing similar outflows, consistent with the facility weakening deposit-rate pass-through during the stress period. Consistent with narrow collateral limiting moral hazard, we find no evidence that borrowing banks expanded risky credit. Once the BTFP rate fell below reserve remuneration, arbitrage-motivated borrowing emerged. Because the shock was interest-rate-based rather than credit-based, a liquidity tool could address what appeared to be a solvency problem, illustrating how targeted macroprudential intervention can contain financial fragility without compromising ongoing monetary tightening.

**Keywords:** Lender of last resort, emergency liquidity facilities, monetary tightening, bank fragility, deposit outflows, interest rate risk, Bank Term Funding Program (BTFP)

**JEL Classifications:** E52, E58, G01, G21

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# 1 Introduction

When monetary policy tightens rapidly, it can impair the value of banks' fixed-income portfolios and make their uninsured deposit funding runnable. The mechanism is direct: rising rates reduce the market value of long-duration assets, eroding solvency buffers for banks that rely on uninsured deposits. If depositors recognize that a bank's assets are worth less than its liabilities at market prices, they run. This dynamic is not new. During the savings-and-loan crisis of the 1980s, hundreds of thrift institutions became insolvent because rising interest rates eroded the value of their fixed-rate mortgage portfolios while deposit costs climbed. The U.S. banking turmoil of March 2023 was the most recent instance: unrealized losses on Treasury and agency mortgage-backed securities purchased during the low-rate environment of the pandemic era, revealed by 425 basis points of Federal Reserve tightening, triggered runs on Silicon Valley Bank and Signature Bank and threatened contagion to other banks with similar balance-sheet exposures.

A central question for monetary economics is whether a central-bank liquidity backstop can contain teh risk of runs when the vulnerable asset is government-backed collateral. The Bank Term Funding Program (BTFP), established on March 12, 2023, provides a direct test. The BTFP lent to depository institutions for up to one year at a fixed rate of 10 basis points over the one-year overnight index swap rate, accepting Treasury securities, agency debt, and agency mortgage-backed securities valued at par rather than te reduced market value. The facility was narrow by design: it accepted only government-guaranteed collateral eligible for open market operations, imposed no haircuts, and leveraged the existing discount-window infrastructure for collateral management and loan origination. These design features—par valuation, narrow collateral, fixed-rate term lending—made the BTFP a natural laboratory for studying the Goodfriend and King (1988) prescription that central-bank lending during stress should operate through government collateral to avoid credit allocation and moral hazard. More broadly, the BTFP illustrates the Tinbergen separation principle in practice: a targeted macro-prudential tool was deployed to address financial fragility while monetary tightening continued for macroeconomic reasons (Tinbergen, 1952).[1]

In this paper, we carefully connect fundamentals that started the 2023 bank run to the intervention taken to stop the bank run, the BTFP, and evaluate any unintended consequences of the program. Three findings stand out from our analysis.

*First, vulnerability to rate-driven fragility was concentrated, and the BTFP was targeted to it.* Deposit outflows during the acute stress window sharply increased with the interaction between banks' reliance on uninsured deposit and their unrealized securities losses. Banks at the 75th percentile of securities losses lost roughly 5 cents per dollar of uninsured deposits, compared with

[1] For the assignment of instruments to objectives, see Mundell (1962).

2 cents at the 25th percentile (Table 1). The effect is driven primarily by held-to-maturity (HTM) losses, with a smaller contribution from available-for-sale (AFS) losses. In contrast, commercial real estate exposures—another sector under stress—did not predict deposit outflows conditional on bank characteristics, pointing that the turmoil episode was related to the materialization of interest rate risk, rather than credit risk. The BTFP responded to this specific vulnerability rather than to bank stress broadly. An average bank covered about 16 cents of every dollar of deposit outflows with BTFP borrowing, but a bank at the 75th percentile of securities losses covered 20 cents, while a regional bank at the same loss percentile used BTFP funding to cover more than 60 cents of every dollar of deposit outflows.

*Second, operational readiness determined banks' effective access to BTFP funding.* We find that banks with collateral already positioned at, or borrowing from, the discount window tapped the BTFP more quickly and substituted toward facility borrowing. Operationally-ready banks with high securities losses covered roughly 30 cents per dollar of outflows through BTFP borrowing, while high-losses banks without operational readiness relied more substantially on reserve drawdowns instead of BTFP. On the deposit pricing margin, comparing banks by actual BTFP borrower status, non-borrowing banks experiencing deposit outflows raised 6-month certificate-of-deposit rates more aggressively than borrowing banks facing similar outflows, with the differential persisting for approximately 16 weeks. These patterns suggest that the BTFP altered the margin through which monetary tightening was transmitted during the stress period: for borrowers with effective access, funding pressure was absorbed less through deposit-rate adjustment and more through central-bank liquidity.

*Third, the BTFP's narrow facility design limited moral hazard but created a bounded arbitrage cost.* We find no evidence that borrowing banks used BTFP funds to expand risky credit—banks used BTFP funding to accumulate reserves rather than to extend risky loans in the form of consumer, commercial real estate, or residential real estate loans, especially those with lower capital. This pattern is consistent with the facility's government-backed collateral requirement restricting the scope for risk-taking. However, once the BTFP rate fell below the interest rate on reserve balances in late 2023, borrowing became arbitrage-motivated: takeup was predicted by existing BTFP-borrower status rather than deposit outflows or securities losses, and credit unions—not vulnerable to deposit runs—engaged in arbitrage borrowing at 2.5 times the rate of banks. The Federal Reserve eliminated any scope for arbitrage within eight weeks by flooring the BTFP rate at the interest of Reserve Balances (IORB) rate.

Our contribution speaks to both the LOLR literature and the deposits channel of monetary transmission. First, we provide what is, to our knowledge, the first empirical evaluation of a facility that operationalizes the spirit of the Goodfriend and King (1988) prescription by restricting

collateral to government securities. Second, we show that formal eligibility is not enough: operational readiness determines whether a backstop can be accessed in real time. Third, because access to the facility altered how banks adjusted on the deposit-pricing margin, the BTFP appears to have weakened the deposit-rate channel of monetary transmission for BTFP borrowers during the stress period. Therefore, one lesson from our findings is that effective emergency liquidity support during rate-driven stress requires two complements—narrow collateral that limits moral hazard, and standing operational readiness that enables timely access. The external validity of this lesson is naturally bounded: narrow collateral works when the vulnerability is concentrated in government-backed assets, but not when the stress originates in private credit markets.

The remainder of the paper proceeds as follows. Section 2 provides background on the 2023 banking turmoil and the BTFP, presents a simple theoretical framework that generates four testable predictions, and describes the data. Section 3 presents the empirical results on vulnerability, BTFP targeting, operational readiness, and use of funds. Section 4 examines the arbitrage episode and its implications for pricing design. Section 5 concludes.

### 1.1 Related literature

Our findings contribute to three strands of the literature.

*Lender of last resort: theory and practice.* The classical LOLR doctrine, articulated by Bagehot (1873), prescribes lending freely against good collateral at a penalty rate to illiquid but solvent institutions (e.g., Freixas *et al.*, 2004; Rochet and Vives, 2004), though borrowing banks may already be under suspicion of insolvency (Goodhart, 1987) and a high penalty rate could worsen the problems of a bank close to insolvency (Goodhart and Schoenmaker, 1995; Dietrich *et al.*, 2014). A persistent concern is that LOLR facilities encourage moral hazard—risk-shifting or gambling for resurrection by borrowing banks (Drechsler *et al.*, 2016; Van Bekkum *et al.*, 2018; Jasova *et al.*, 2021, 2023; Minoiu *et al.*, 2024). Goodfriend and King (1988) propose a sharp remedy: central banks should provide crisis liquidity through open market purchases of government securities, avoiding the credit-risk transformation and supervisory burden inherent in discount-window lending against private collateral (Ennis and Weinberg, 2016).[2] Allen and Gale (2004) and Allen *et al.* (2009) formalize the conditions under which central bank open market operations that fix the price of safe long-term assets at fundamental value—effectively valuing them at par—efficiently address market liquidity strains. Our paper provides what is, to our knowledge, the first empirical evaluation of a facility that operationalizes the spirit of the Goodfriend–King prescription by restricting collateral

[2]Goodfriend and King's preferred policy is outright open market operations—purchasing Treasuries, not lending to individual banks. The BTFP retains the individual-lending structure they were skeptical of but restricts collateral to government securities, making it a practical compromise that moves closer to their ideal. We use "Goodfriend–King prescription" as shorthand for the principle that crisis liquidity should flow through government collateral, acknowledging that their broader argument favors eliminating discretionary lending to individual institutions altogether.

to government securities: the BTFP accepted only government collateral, valued it at par, and operated through existing discount-window infrastructure. We find no evidence that borrowing banks expanded risky credit, consistent with this narrow design limiting moral hazard, while the facility generated a bounded arbitrage cost. We also document a dimension absent from this theoretical literature: operational readiness as a determinant of effective access, distinct from formal eligibility. Minoiu *et al.* (2024), in their evaluation of the Main Street Lending Program's credit sillover effects, use prior discount-window collateral pledging as instrument for MSLP participation—exploiting the same operational-familiarity that we study as a direct determinant of BTFP access. Anbil *et al.* (2023) reach similar conclusions about the importance of operational familiarity in the contexts of the Paycheck Protection Program Liquidity Facility.

*Bank runs and interest rate risk.* In the canonical Diamond and Dybvig (1983) framework, runs arise because bank assets are illiquid: forced liquidation destroys value, making a run self-fulfilling. Recent work shows that runs can occur even when assets are fully liquid and high-quality if interest rate movements reduce their market value below par (Drechsler *et al.*, 2023; Jiang *et al.*, 2023; Haddad *et al.*, 2023), and that liquidity-driven runs are rarer than fundamentals-driven ones (Correia *et al.*, 2025). In these models, banks remain solvent only if they maintain their deposit franchises—an assumption that became testable in March 2023. Jiang *et al.* (2023) characterize the vulnerability that produced the run: the interaction of unrealized losses and uninsured deposit funding. Our paper is complementary. They study the run; we study the policy response and the adjustment margins banks used to manage it. By analyzing how banks substituted across funding sources—BTFP borrowing, reserve drawdowns, non-Fed wholesale funding, and deposit pricing—we trace how a narrow backstop altered the balance-sheet dynamics that these models predict. Our deposit-pricing evidence also connects to the deposits channel of monetary policy (Drechsler *et al.*, 2017): by allowing some banks to absorb funding pressure through central-bank liquidity rather than deposit repricing, emergency facilities may alter the speed at which tightening passes through to deposit rates.

*The 2023 banking turmoil.* A growing empirical literature studies different facets of the March 2023 episode. Choi *et al.* (2023) document contagion effects following SVB's failure. Caglio *et al.* (2023) present evidence of flight-to-safety flows from regional to larger banks. Cookson *et al.* (2023) identify social media as a spillover mechanism that accelerated deposit withdrawals. Chang *et al.* (2023) argue that banks with more uninsured deposits were fundamentally riskier yet more profitable before the crisis. Cipriani *et al.* (2024) examine the role of fundamentals and public signals in prompting runs. While this literature focuses on explaining the run or its propagation, our contribution is to study the intervention: how facility design shaped banks' adjustment to tightening-induced fragility, and what the design tradeoffs imply for future episodes.

# 2 Background, framework, and data

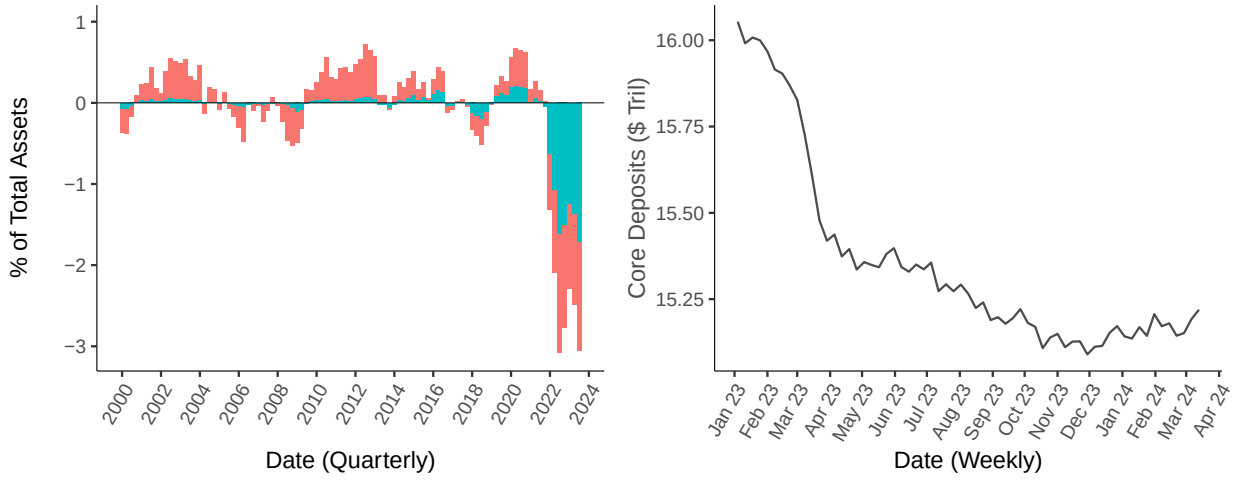
## 2.1 Background

### 2.1.1 The run

By early 2023, banks had become vulnerable along two dimensions: larger unrealized securities losses and greater reliance on uninsured deposit funding.

As the level of interest rates started to rise in the spring of 2022, banks accumulated significant unrealized losses on securities holdings (Figure 1, left panel). Meanwhile, uninsured deposits became more sensitive to solvency risk. The combination of unrealized losses and reliance on uninsured deposits culminated in runs in March 2023 and the failures of SVB and Signature Bank. The speed and magnitude of the deposit runs were unprecedented (Rose, 2023). For example, SVB—a $200 billion bank with a concentrated customer base in the technology industry—informed regulators on the morning of March 10 that $100 billion in deposit withdrawals were expected for that day. In contrast, depositors withdrew about $17 billion over the course of eight business days in September 2008 during the run on Washington Mutual, a much larger bank. Following these failures, concerns mounted over the health of other banks with similar characteristics—significant unrealized securities losses funded with uninsured deposits—prompting deposit outflows at other vulnerable banks (Figure 1, right panel).

Figure 1: Unrealized Securities Losses and Deposit Outflows




*Note: The left panel shows unrealized securities losses (held-to-maturity (HTM), in green, and available-for-sale (AFS), in red) for all U.S. commercial banks from 2000Q1 to 2023Q3 as a percent of total assets. The right panel shows the levels of core deposits for U.S. domestically-chartered commercial banks from January 2023 to March 2024. Source: author calculations, Call Reports, H.8.*

### 2.1.2 The intervention

To limit contagion from the runs, and to support the ability of the banking system to provide credit to households and businesses, the Federal Reserve and other agencies took decisive actions to protect depositors and maintain confidence in the banking sector. On March 12, the Federal Reserve Board announced the establishment of the BTFP. In the terms of operations, BTFP was set up with remarkable speed leveraging existing discount window infrastructure. With regards to the design of the program, the terms of the BTFP were specifically tailored to address interest rate risk—the key vulnerability that destabilized banks' deposit franchises.

First, the BTFP allowed depository institutions that were eligible for primary credit at the Federal Reserve's discount window to borrow at a favorable rate of 10 basis points over the one-year OIS rate, which reflects market's expectations about the path of monetary policy one year ahead. The favorable rate was crucial to afford liquidity in "unusual and exigent circumstances" which warrant the establishment of 13(3) programs. Yet, it was set at a premium to the market rate to meet Regulation A requirements on credit extensions by Federal Reserve Banks. Depository institutions could borrow for up to one year at a rate that was fixed for the life of the loan on the day the loan was made.[3] Additionally, BTFP provided further flexibility to depository institutions by applying no fees associated with usage of the facility and no penalty for early repayment of loans. These design choices effectively kept the overall cost of usage of the facility low.

Second, the BTFP only accepted government-guaranteed securities eligible for purchase in open market operations.[4] These included U.S. Treasury securities, agency debt, agency MBS and agency CMO. Since the runs were prompted by declines in the market value of securities holdings, eligible BTFP collateral was valued at the *par value* rather than market value, and no haircuts were applied. The BTFP's collateral valuation at par aimed to increase borrowing capacity especially for the institutions most likely in need of it, giving them the option to meet deposit outflows without having to realize losses from selling securities at depressed valuations (e.g., Brunnermeier and Pedersen, 2009).

BTFP's terms were tailored to address interest rate risk—the key vulnerability that destabilized deposit franchises. The idea behind the program's design was that a bank that substitutes deposit outflows with BTFP borrowing could replace demandable debt with term borrowing, thus lengthening the duration of its liabilities. Additionally, if banks held the BTFP funds as remunerated reserves, they could fund a floating-rate asset (reserves) with debt that reprices annually, thus reducing the net duration of their balance sheets and therefore addressing interest rate risk.

As such, the BTFP's terms were unique relative to alternatives. For example, although FHLBs

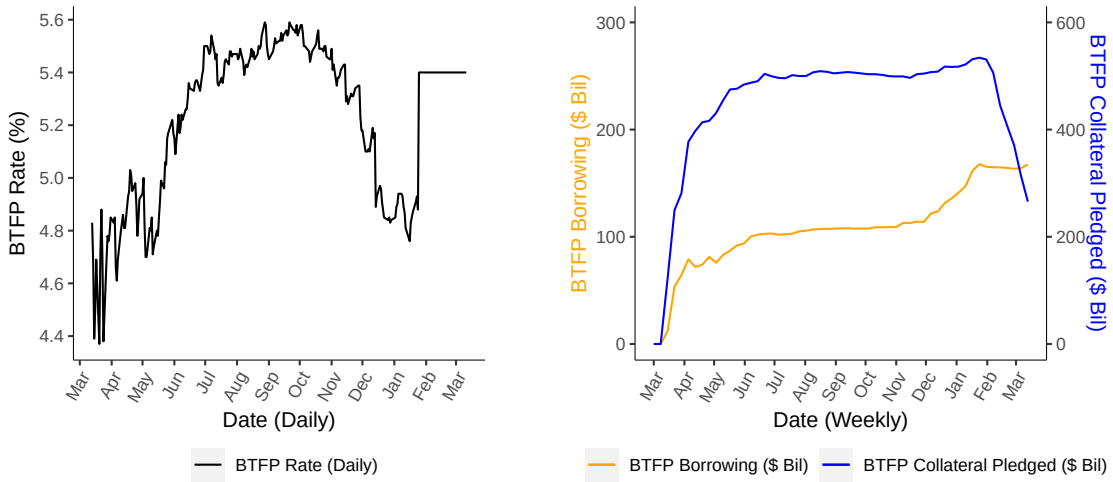
[3]The BTFP ceased extending new loans on March 11, 2024.

[4]Depository institutions needed to own these securities as of March 12, 2023.

offer longer-term funding options, collateral is generally valued at market prices and subject to haircuts, reducing the borrowing capacity of banks contending with valuation declines. In addition, while the Federal Reserve's discount window accepts a wider range of collateral, loans have floating rates and shorter terms ($\leq$90 days) and thus do not address interest rate risks.

Figure 2 summarizes the BTFP rate and uptake. The BTFP rate tracked one-year OIS expectations, rising through October 2023 before declining; on January 24, 2024, it was floored at the IORB rate. Outstanding borrowing and collateral pledged grew rapidly through mid-2023, with institutions pledging substantially more collateral than they borrowed.

Figure 2: BTFP rate and uptake




*Note: The left panel of the figure shows BTFP rate (in percent). The right panel of the figure shows BTFP borrowing and collateral pledging ($B). The time period is between March 12, 2023 and March 11, 2024.*

## 2.2 Framework

We develop a simple hybrid model that extends the Jiang *et al.* (2023) solvency framework into a setting where a central bank can intervene. Following Jiang *et al.* (2023), we treat bank balance sheets and deposit contracts as exogenous primitives; following Allen and Carletti (2008) for the interbank market structure with an interim asset price and Allen *et al.* (2009) for central bank liquidity operations, we embed them in a setting with a central bank facility. The model's contribution relative to these building blocks is the synthesis: Jiang *et al.* (2023) characterize the vulnerability but do not model the intervention; Allen *et al.* (2009) model central bank intervention for pure liquidity crises and Allen and Carletti (2008) characterize the fire-sale externality from mark-to-market accounting that such intervention addresses, but neither incorporates interest-rate-driven fundamentals deterioration or uninsured deposit run dynamics.[5] Our framework combines both,

[5] Allen and Carletti (2008) note in their conclusion that fundamental uncertainty in $R$ would exacerbate the fire-sale problem they identify. Our framework combines their liquidity-pricing insight with precisely this channel: the

generating predictions about which banks borrow, why access frictions matter, and when carry borrowing emerges—predictions that neither building block produces alone. Although framed in terms of liquidity, the no-run condition depends on the same key determinants—portfolio duration and uninsured deposit share—as the solvency condition in Jiang *et al.* (2023).[6] As emphasized by Goodfriend and King (1988) and subsequent work (Freixas *et al.*, 2000; Gorton and Huang, 2004; Diamond and Rajan, 2005), liquidity and solvency runs can appear indistinguishable in real time. The model serves as an organizing framework for our empirical analysis rather than a standalone theoretical contribution.

### 2.2.1 Setup

**Timeline.** Three periods $t \in \{0, 1, 2\}$. At $t = 0$, the bank chooses its portfolio and accepts deposits. At $t = 1$, an interest-rate shock is realized, the market price is determined, depositors withdraw, and the bank sells assets or borrows from the facility. At $t = 2$, long assets mature, late depositors are paid, and facility loans are repaid.

**Assets.** A representative bank invests $x \in (0, 1)$ in liquid reserves and $1 - x$ in a safe long-term asset paying $R > 1$ at $t = 2$. At $t = 2$, each unit of the long asset not sold at $t = 1$ matures at $R$, regardless of whether it has been pledged as collateral. We take the portfolio allocation $x$ as given and do not solve for the optimal $t = 0$ portfolio choice. Deposits are normalized to unity. Reserves held through $t = 2$ earn gross return $\rho \geq 1$; reserves deployed at $t = 1$ to meet withdrawals are paid out at face value and do not earn $\rho$. At $t = 1$, an aggregate interest-rate shock $\Delta r \geq 0$ reduces the mark-to-market value of the long asset:

$$P(\Delta r) = R \cdot e^{-D\Delta r}, \tag{1}$$

where $D > 0$ is the weighted-average duration of the bank's securities portfolio. This is the standard modified-duration approximation under continuous compounding; it is exact for a zero-coupon bond with maturity $D$.

**Deposits.** Following the sequential-service structure of Diamond and Dybvig (1983), a demand deposit contract promises gross payment $d > 1$ at withdrawal. There is a continuum of depositors. Early withdrawers receive $d$ in full; late withdrawers hold claims on the residual portfolio, which

interest-rate shock reduces $P$ below $R$ through both fundamentals deterioration and liquidity scarcity.

[6] We use a competitive deposit market rather than the monopolist-bank structure with deposit franchise values in Jiang *et al.* (2023). This trades off the franchise-value channel—in which deposit markups hedge interest-rate risk until a run destroys them—for tractability of the intervention analysis. The sufficient statistics for fragility in Jiang *et al.* (2023) also include book capital and franchise value, which our simpler framework subsumes into the ex-ante solvency condition.

in stress states ($P < R$) may be worth less than $d$. A baseline fraction $\bar{\lambda} \in (0,1)$ withdraw early for liquidity reasons. A share $u \in [0,1]$ of deposits is uninsured, with $\bar{\lambda} + u \leq 1$, and uninsured withdrawals respond to perceived losses:

$$\lambda(\Delta r) = \bar{\lambda} + u \cdot \kappa\left(1 - \frac{P(\Delta r)}{R}\right), \qquad \kappa(0) = 0, \quad \kappa' > 0, \tag{2}$$

where $\kappa\colon [0,1] \to [0,1]$ is $C^1$ and maps mark-to-market losses into uninsured withdrawal rates, so that total withdrawals satisfy $\lambda \leq \bar{\lambda} + u \leq 1$.[7] When a facility with collateral floor $\underline{P}$ is available, depositors evaluate losses at $P^{\text{eff}} = \max(P, \underline{P})$ instead of $P$, and (2) is evaluated at $P^{\text{eff}}$.

**Liquidity constraint.** At $t = 1$:

$$x + Py \geq \lambda(\Delta r)d, \qquad 0 \leq y \leq 1 - x, \tag{3}$$

where $y$ denotes long-asset sales. When a central bank facility is available, borrowing $b$ against long assets modifies the constraint to $x + b + Py \geq \lambda d$ with $b \leq \underline{P}(1 - x - y)$. In laissez-faire ($b = 0$), if $\lambda d > x$ the bank must sell long assets into a market with limited outside demand (Shleifer and Vishny, 1997), at the depressed fire-sale price $P < R$. When $P < R$, selling at a discount reproduces the fire-sale cost structure in Allen and Carletti (2008), though we take $P$ as exogenous (driven by the rate shock via (1)) rather than endogenizing it through limited outside demand.

**Assumptions.** Depositors are risk-neutral and the deposit market is competitive: the deposit rate $d$ is pinned by a zero-profit condition rather than by depositor optimization.[8] Depositors' outside option is the gross money market rate $r_{mm} \geq 1$, with $r_{mm} \leq R$ (the bank's long-asset return exceeds the money market rate). The bank is ex-ante solvent: $R(1-x) + \rho x \geq d$, where $d$ is determined in equilibrium by (4) below; this restricts the parameter space to configurations where the bank can meet all obligations when assets mature at face value.

### 2.2.2 No-run condition

We focus on the *no-run region* in which only baseline withdrawals $\bar{\lambda}$ occur, plus partial stress-related withdrawals governed by $\kappa$. Rather than fully specifying the underlying coordination game,

[7] The reduced-form $\kappa$ can be microfounded via a global-games coordination structure à la Morris and Shin (2003). The function governs partial withdrawals when the bank remains solvent; when the no-run condition (6) fails, all uninsured depositors strictly prefer early withdrawal ($\kappa = 1$), giving $\lambda = \bar{\lambda} + u$. The super-modularity result in Proposition 2.3 relies on the separable structure of (2), where $u$ scales a withdrawal function that depends on losses but not directly on $u$ itself.

[8] Risk neutrality is standard in models following Diamond and Dybvig (1983). The competitive-market assumption means $d$ adjusts so that depositors' expected payoff equals their outside option, regardless of the bank's portfolio choice $x$.

we use a piecewise reduced-form withdrawal rule: partial withdrawals while the sufficient no-run condition holds, and full uninsured withdrawal ($\lambda = \bar{\lambda} + u$) when it fails.[9]

Competitive entry pins the deposit rate $d$ so that depositors break even. Under sequential service, each depositor faces probability $\lambda$ of being an early withdrawer (by the law of large numbers applied to the continuum). Early withdrawers receive $d$ in full. Late withdrawers hold claims on the residual portfolio.

**Assumption 2.1** (Late-depositor recovery rate)**.** *Late depositors receive $d \cdot P/R$ per dollar of promised payment. This reduced-form recovery rate equates the late-depositor payoff to the mark-to-market value of the underlying assets: late claimants recover $P$ per unit of face value $R$, regardless of the volume of interim liquidation. When $P = R$, late depositors are paid in full.*[10]

Given Assumption 2.1, the zero-profit condition equates the expected deposit payoff to the outside option:

$$\lambda \cdot d + (1 - \lambda) \cdot d \cdot \frac{P}{R} = r_{mm}. \tag{4}$$

When a facility is available, $P$ is replaced by $P^{\text{eff}} = \max(P, \underline{P})$ in (4), as formalized in the equilibrium definition (Definition A.1). Solving for $d$:

$$d = \frac{r_{mm}}{\lambda + (1 - \lambda)P/R}. \tag{5}$$

When $P < R$, competitive pricing requires $d > r_{mm}$ to compensate depositors for the possibility of recovering less than par if they wait. Under par-value lending ($\underline{P} = R$), $P^{\text{eff}} = R$ and $d = r_{mm}$.

Under Assumption 2.1, late depositors prefer to wait when their continuation payoff weakly exceeds $d$; this requires $x + P(1 - x) \geq \lambda d$ (see Appendix A.1 for the full derivation). Using (5):

$$\lambda d = \frac{\lambda \cdot r_{mm}}{\lambda + (1 - \lambda)P/R} \leq r_{mm},$$

where the inequality holds because $(1-\lambda)P/R \geq 0$. A sufficient condition for the liquidity constraint to be satisfied is therefore:

$$r_{mm} \leq x + P(\Delta r)(1 - x). \tag{6}$$

This is the no-run bound. Since $P$ is decreasing in $\Delta r$ while $r_{mm}$ is fixed, there exists a threshold

[9] The reduced-form withdrawal schedule can be motivated by a global-games microfoundation (Morris and Shin, 2003). We impose the piecewise rule directly: partial withdrawals in the no-run region and full uninsured withdrawal when the no-run bound fails.

[10] The assumption can be motivated by pro-rata sharing of the marked-to-market estate among late claimants, as in Allen and Carletti (2008). Alternative liquidation protocols (e.g., absolute priority) would yield different recovery rates and a different no-run bound.

$\Delta r^*$ above which the no-run condition fails:

$$r_{mm} = x + Re^{-D\Delta r^*}(1 - x). \tag{7}$$

The threshold is decreasing in $D$: banks with longer-duration portfolios are vulnerable to smaller rate shocks. The uninsured share $u$ does not appear in the no-run bound because (6) is a sufficient condition that bounds $\lambda d$ above by $r_{mm}$, replacing withdrawal-specific quantities with the bank's interim liquidation value. This bound is conservative: for banks with low $u$, the actual run threshold may be at a larger $\Delta r^*$ than (7) implies. Nevertheless, $u$ drives withdrawal volume conditional on stress through (2).

*Remark* 2.2 (Liquidity–solvency parallel). The no-run condition depends on portfolio duration through $P$, paralleling the asset-side solvency constraint in Jiang *et al.* (2023). Duration and the uninsured share interact super-modularly—their joint effect exceeds the sum of their individual effects—in driving withdrawals (Proposition 2.3), consistent with both being among the key determinants of bank fragility.

### 2.2.3 Fragility amplification

**Proposition 2.3.** *For any $\Delta r > 0$, $D > 0$, such that the no-run condition (6) holds, and $u > 0$:*

$$\frac{\partial \lambda}{\partial u} > 0, \qquad \frac{\partial \lambda}{\partial D} > 0, \qquad \frac{\partial^2 \lambda}{\partial u \, \partial D} > 0. \tag{8}$$

*Banks with both high uninsured funding and long duration are disproportionately fragile.*

*Proof.* See Appendix A.1.

### 2.2.4 Central bank intervention

Having characterized the vulnerability, we now introduce the policy instrument. A facility lends against long assets at a collateral floor $\underline{P} \in [P, R]$, charging gross rate $\phi > 0$ with a fixed access cost $\varepsilon > 0$ representing operational and stigma frictions. When $\phi \geq \rho$, the facility rate is at or above the return on reserves (penalty pricing); when $\phi < \rho$, a carry spread emerges.

In the no-run equilibrium with a par-value facility ($\underline{P} = R$), withdrawals revert to $\bar{\lambda}$ (shown in Theorem 2.5 below). A bank with $x < \bar{\lambda} d$—reserves insufficient to cover baseline withdrawals—must borrow. It minimizes borrowing cost by borrowing exactly the shortfall:

$$b^* = \bar{\lambda} d - x. \tag{9}$$

This is optimal because borrowing is costly at rate $\phi \geq 1$, so the bank borrows no more than

necessary.[11] The borrowing must satisfy the collateral constraint: $b^* \leq \underline{P}(1 - x - y^*)$. Since pledging dominates selling when $\underline{P} > P$ (so $y^* = 0$), this reduces to $b^* \leq \underline{P}(1 - x)$.

At $t = 2$, long assets mature at $R(1 - x)$. The bank repays the facility $\phi b^*$, pays late depositors $(1 - \bar{\lambda})d$, and bears the access cost $\varepsilon$. For liquidity-motivated borrowers ($x < \bar{\lambda}d$), reserves $x$ are fully deployed at $t = 1$ to meet part of the early withdrawals and do not earn $\rho$. The $t = 2$ solvency condition for such banks is:

$$R(1 - x) \geq \phi(\bar{\lambda}d - x) + (1 - \bar{\lambda})d + \varepsilon. \tag{10}$$

Carry borrowers with $x \geq \bar{\lambda}d$ retain their reserves through $t = 2$ and earn $\rho x$; their solvency condition differs and is stated in Corollary A.3.

**Assumption 2.4** (Observability)**.** *The collateral floor $\underline{P}$ and each bank's access decision $a$ are publicly observable to depositors at $t = 1$ before withdrawal decisions are made.*

**Theorem 2.5** (Par-value lending and the no-run outcome)**.** *Suppose $\underline{P} = R$, the bank accesses the facility ($a = 1$), and Assumption 2.4 holds. Under par valuation, competitive pricing gives $d = r_{mm}$. For a bank with $x < \bar{\lambda}r_{mm}$ (liquidity shortfall) and $\bar{\lambda}r_{mm} - x \leq R(1 - x)$ (collateral sufficiency), satisfying (10), and with counterfactual fire-sale losses exceeding $\varepsilon$ (so access is individually rational):*

*(a) Lending at par sustains the no-run outcome: withdrawals revert to $\bar{\lambda}$ and fire-sale liquidation is avoided.*

*(b) Under (10), the facility is repaid in full at $t = 2$.*

*Remark* 2.6 (Pricing and carry incentives). At $\phi = \rho$, a bank that borrows from the facility and retains reserves faces zero net carry, so the arbitrage motive disappears. When $\phi < \rho$, the carry spread $\rho - \phi$ creates an incentive to borrow beyond liquidity needs, bounded by collateral capacity $R(1 - x)$.

The intuition behind Theorem 2.5 is as follows. With $\underline{P} = R$, depositors evaluate the bank's eligible collateral at par, so $\kappa(0) = 0$ and withdrawals revert to $\bar{\lambda}$. Conditional on facility access, pledging dominates selling because the bank can meet liquidity needs without liquidating long assets at the fire-sale price $P < R$. Under the stated period-2 solvency condition, the bank repays the facility in full at maturity. The formal proof is in Appendix A.1.

[11] For $\phi = 1$ the bank is indifferent over borrowing amounts; for $\phi > 1$, minimizing $b$ strictly minimizes cost. We focus on the minimum-borrowing equilibrium.

### 2.2.5 Selective and arbitrage borrowing

The fixed cost $\varepsilon$ partitions banks into those more and less likely to access the facility. A bank is more likely to access when the fire-sale losses avoided by borrowing exceed the fixed access cost. In laissez-faire, a bank with liquidity shortfall $\bar{\lambda}d - x > 0$ must sell $y^* = (\bar{\lambda}d - x)/P$ units of long assets at price $P < R$, incurring a loss of $y^*(R - P)$ relative to holding to maturity. A sufficient condition for access is $y^*(R - P) > \varepsilon$ (Corollary A.2).

Among accessing banks, those with $x \geq \bar{\lambda}d$ can meet baseline withdrawals from reserves alone and need not borrow; those with $x < \bar{\lambda}d$ borrow $b^* = \bar{\lambda}d - x$. When $\rho > \phi$, a bank that can meet withdrawals from reserves nonetheless finds it profitable to borrow from the facility at rate $\phi$ and retain reserves earning $\rho$, capturing the spread $\rho - \phi$ per dollar. Such carry borrowing is bounded by the collateral constraint: $b \leq R(1 - x)$.

### 2.2.6 Testable implications

The framework yields four predictions:

(i) **Cross-sectional vulnerability.** Deposit outflows increase in $u$ (uninsured deposits), $D$ (duration), and their interaction (Proposition 2.3).

(ii) **Selective takeup.** The likelihood of borrowing from the facility rises with avoided fire-sale losses.

(iii) **Adjustment-margin substitution.** Among exposed banks, access shifts adjustment from reserve depletion toward facility borrowing.

(iv) **Arbitrage.** Carry borrowing emerges when $\rho > \phi$ (the remuneration on reserves exceeds the facility borrowing cost).

The framework is not estimated structurally. Instead, it organizes the empirical analysis around observable proxies for the model's key objects: we measure runnable funding ($u$) with uninsured deposits as a share of assets, duration-sensitive exposure ($D$) with unrealized securities losses, access frictions ($\varepsilon$) with pre-existing discount-window operational readiness, and the carry condition ($\rho > \phi$) with the observed spread between reserve remuneration and the BTFP borrowing rate. The empirical results should be interpreted as theory-guided reduced-form evidence on the margins through which banks adjusted to the 2023 stress and the role of facility design in shaping that adjustment.

Several simplifications bound the model's scope. We do not solve for optimal portfolio choice at $t = 0$, do not model bank capital or equity buffers, and treat the interim asset price $P$ as exogenous rather than determined by aggregate liquidation volume. Banks do not compete strategically in deposit pricing. These restrictions are standard for organizing frameworks in the empirical banking literature and keep the comparative statics tractable; they would need to be relaxed in a model

intended as a standalone theoretical contribution. A formal equilibrium definition and all proofs are collected in Appendix A.1.

### 2.3 Data

We combine four data sets covering the SVB shock's impact, the BTFP's mitigating role, and subsequent changes in bank behavior.

Our first and highest-frequency data set contains transaction-level borrowing information from the Bank Term Funding Program.[12] These data are made available to the public pursuant to section 11(s) of the Federal Reserve Act. These data are at the loan-bank frequency, and contain the name of the borrower, the original term of the loan, the origination date, the repayment date, the amount borrowed, and the rate on the loan. They allow us to pinpoint not only the date of initiation of borrowing from the BTFP, but also any refinancing activity that occurred. Both of these features help us to trace out the interaction with the BTFP with run dynamics at the start of our sample, as well as to identify any moral hazard behavior because of the borrowing once the acute stress of March 2023 abated.

Our second data set uses weekly information from form FR 2644, a stratified random sample of U.S. banks covering regional and larger institutions (Appendix Figure A1 compares sample representativeness).[13] The FR 2644 provides detailed asset-side classifications (loan types, securities, cash) and liability-side balances (core deposits, large time deposits, wholesale borrowings).[14] We isolate Federal Reserve borrowing (discount window and BTFP) from other wholesale borrowings, which are predominantly FHLB advances.[15]

Our third data source is the quarterly Call Reports. The Call Report provides detailed measures of bank condition leading into the spring of 2023, which we use to estimate the relationship between uninsured deposits and securities losses and the deposit runs that occurred around the time of the SVB failure. We also use the Call Report data to test whether borrowing was followed by changes in lending or portfolio composition, including whether less well capitalized banks were more likely to extend risky loans after borrowing from the BTFP.

Our fourth data source is RateWatch, which provides bank-level posted deposit rates by product and maturity. We use RateWatch data to test whether banks without effective BTFP access bore

[12] These data are available at https://www.federalreserve.gov/financial-stability/bank-term-funding-program.htm.

[13] We restrict to domestically chartered banks, omitting those in holding companies principally involved in investment banking or custodian activities and excluding failed banks.

[14] "Core" deposits are defined as liquid (non-CD) deposits plus small (under $100,000) time deposits. This definition includes brokered deposits participated out in shares below $100,000, so we may underestimate deposit outflows to the extent that banks offset outflows by raising such brokered deposits.

[15] Discount window and BTFP data are daily; we aggregate to weekly using the FR 2644 timing convention (Wednesday close of business).

higher funding costs, as measured by CD rate changes. We merge these data with the FR 2644 and Call Report data to link deposit pricing to balance sheet characteristics and BTFP usage.

Our outcomes of interest include changes in core deposits during the stress, changes in BTFP balances and other balance sheet items, and shifts in deposit rates by borrower status and operational readiness. In total, our cross-sectional sample contains 668 banks. (See the Appendix Table A1 for summary statistics.) For exercises involving credit unions, we draw on a separate sample of credit union balance sheets and BTFP transaction data.

# 3 Empirical results

Our identification relies on cross-sectional variation in predetermined bank characteristics. Uninsured deposit shares and securities losses are measured as of 2022Q4, before the stress event. These variables are predetermined with respect to the March 2023 event: banks' deposit composition and securities portfolio duration reflect pre-crisis business model choices, not responses to the run. The interaction of uninsured deposits with securities losses captures the run motive: depositors at banks with both high exposure and large losses had stronger incentives to withdraw. We do not claim a clean quasi-experimental design; our approach identifies cross-sectional patterns consistent with the model's predictions using predetermined balance-sheet characteristics.

We first identify which banks were vulnerable to deposit outflows, then show how the BTFP served as a targeted substitution margin, document the role of operational readiness, trace balance-sheet dynamics around borrowing episodes using local projections, and examine whether BTFP borrowers expanded risky credit.

## 3.1 The run: which banks experienced deposit outflows?

We begin by identifying the banks that were vulnerable to deposit outflows and hence the population the BTFP was designed to reach. We run cross-sectional regressions predicting changes in core deposits between March 8 and May 3, because this period covers the height of the banking turmoil episode, though we will present results for intervals before and after the SVB collapse as well. We regress the change in core deposits on bank-specific risk factors measured as of 2022Q4:

$$\frac{\Delta\text{Deposits}_{i,t,t'}}{\text{Assets}_{i,t}} = \beta_1 \frac{\text{Uninsured deposits}_{i,22q4}}{\text{Assets}_{i,22q4}} + \beta_2 \frac{\text{Securities Losses}_{i,22q4}}{\text{Assets}_{i,22q4}} + \gamma' X_{i,t} + \varepsilon_{i,t} \tag{11}$$

where $i$ indexes banks, $t$ and $t'$ denote the start and end of the eight-week window, and uninsured deposits and securities losses (both normalized by total assets as of 2022Q4) are the primary risk factors. We additionally consider specifications interacting the two risk factors to capture the fact

that securities losses may affect uninsured depositors' incentives to withdraw (Jiang *et al.*, 2023). The baseline specification uses total unrealized securities losses; we then decompose into HTM and AFS losses separately, since banks face greater impediments to hedging interest rate risk and selling HTM assets (Granja *et al.*, 2024). We also add the share of CRE loans in total assets to distinguish between banks' vulnerability to interest rate risk and credit risk. $X_{i,t}$ includes loan growth $\Delta\text{Loans}_{i,t,t'}/\text{Assets}_{i,t}$, and the following 2022Q4 Call Report items: liquid asset holdings as a share of total assets (the sum of cash, federal funds, reverse repo, and securities holdings); deposit growth leading into the period of bank turmoil, from 2022Q1 to 2022Q4; average funding costs (annualized interest expense as a percent of total liabilities); FHLB advances as a share of total assets; banks' tier 1 capital as a fraction of total assets; and bank size indicators.[16]

Table 1 presents the results. Columns 1–2 use total securities losses, showing that reliance on uninsured deposits played a significant role in prompting deposit outflows during the period of most acute stress. Core deposits fell by about 3 cents for every dollar of uninsured deposits. Moreover, a one standard deviation increase in uninsured deposits to assets (12.8 percentage points) reduces core deposits by about 44 basis points as a fraction of assets, relative to an average decline of 1.7 percent. Securities losses in levels have little effect on outflows and are not statistically significant.

Column 2 interacts the two risk factors, showing that securities losses amplified the role of uninsured deposits in prompting deposit outflows. Deposit outflows for banks at the 25th percentile of securities losses exhibit smaller sensitivity to uninsured deposits, at 2 cents per dollar of uninsured deposits. A bank at the 75th percentile of securities losses faces more than twice the sensitivity: core deposits fall by about 5 cents per dollar of uninsured deposits. This super-modularity—losses amplify the run motive of uninsured depositors—is a key cross-sectional finding and is consistent with the BTFP's at-par collateral design.[17]

Columns 3–4 decompose securities losses into HTM and AFS components. The interaction with uninsured deposits is driven primarily by HTM losses, consistent with depositors reacting more strongly to losses on securities that banks were less likely to sell or hedge (Granja *et al.*, 2024). AFS losses also interact with uninsured deposits, but the effect is smaller and not statistically significant. Columns 5–6 additionally include CRE loan exposures; as expected, given that the episode reflected interest rate risk rather than credit risk, the interaction of uninsured deposits with CRE loan exposures is not statistically significant, while the securities-loss interaction is robust to this control.

[16] We control for loan growth because deposit flows tied to credit line draws do not relieve funding needs (Glancy *et al.*, 2020; Cooperman *et al.*, 2023). Size indicators equal one for community banks (under $10 billion in assets) or regional banks ($10–$250 billion); the omitted category is banks above $250 billion.

[17] The robustness results in the Appendix Table A3 do not support the idea of a non-linear effect of securities losses in driving the impact of uninsured deposits on outflows.

Table 1: Determinants of Core Deposit Outflows—Baseline Results

| | $\frac{\Delta\text{Deposits}}{\text{Assets}}$ | | | | | |
|---|---|---|---|---|---|---|
| | Securities losses | | HTM, AFS | | HTM, AFS, CRE | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | -0.034** | -0.008 | -0.034** | -0.006 | -0.030** | -0.004 |
| | (0.013) | (0.022) | (0.014) | (0.022) | (0.014) | (0.035) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.012* | | | | |
| | | (0.006) | | | | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | | -0.031*** | | -0.032*** |
| | | | | (0.011) | | (0.011) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | | -0.009 | | -0.009 |
| | | | | (0.006) | | (0.006) |
| $\times \frac{\text{CRE loans}}{\text{Assets}}$ | | | | | | 0.000 |
| | | | | | | (0.001) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.022 | 0.362** | | | | |
| | (0.081) | (0.156) | | | | |
| $\frac{\text{HTM losses}}{\text{Assets}}$ | | | 0.014 | 1.014*** | 0.020 | 1.049*** |
| | | | (0.141) | (0.298) | (0.141) | (0.295) |
| $\frac{\text{AFS losses}}{\text{Assets}}$ | | | 0.024 | 0.283* | 0.018 | 0.280* |
| | | | (0.080) | (0.158) | (0.081) | (0.158) |
| $\frac{\text{CRE loans}}{\text{Assets}}$ | | | | | -0.011 | -0.016 |
| | | | | | (0.010) | (0.023) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.137 | 0.146 | 0.137 | 0.151 | 0.138 | 0.154 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 |

*Notes: The table shows results from cross-sectional regressions of changes in banks' core deposits relative to beginning of period total assets ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$) over the interval March 8—May 3, 2023 on uninsured deposits, total securities losses, HTM and AFS losses, CRE loans, contemporaneous loan growth ($\Delta Loans_{i,t,t'}/Assets_{i,t}$), tier 1 capital-to-assets ratio, liquid asset holdings (the sum of cash, federal funds, reverse repo and securities holdings), average funding cost (annualized interest expense as a percent of total liabilities), deposit growth in 2022, FHLB advances, and bank size indicators (i.e., community banks are ones with assets under $10 billion in assets and regional banks ones with assets between $10 and $ 250 billion in assets) measured as of 2022:Q4. Results for the full set of controls are reported in the Appendix Table A2. Core deposit and loan growth are winsorized at the 1 and 99 percent levels. All continuous variables are measured in percentage points (specifically–with the exception of 2022 deposit growth and average funding cost–measure variables as a percent of initial total assets). *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

These effects are confined to the two months following the bank failures. Table 2 provides a formal pre-trends test, with Panel A estimating the same specification over three eight-week intervals ending before March 8, 2023. In columns 5 and 6, a pre-period placebo (January 11 to March 8) shows that the coefficient on uninsured deposits is negative and significant, consistent with moderate deposit outflows during monetary tightening for banks more reliant on unstable uninsured deposits. However, in none of the pre-SVB intervals in columns 1-6 does the interaction of uninsured deposits and securities losses predict deposit outflows—the coefficients are small and statistically insignificant. This pattern is important for our cross-sectional identification: it indicates that the specific vulnerability combination driving the March 2023 outflows did not produce differential deposit flows in the preceding months, consistent with the interaction capturing a run motive activated by the SVB event rather than a pre-existing trend. In Panel B, the eight-week intervals post-SVB show no predictive power of uninsured deposits or securities losses for deposit outflows.

Table 2: Determinants of Core Deposit Outflows, Before and After SVB

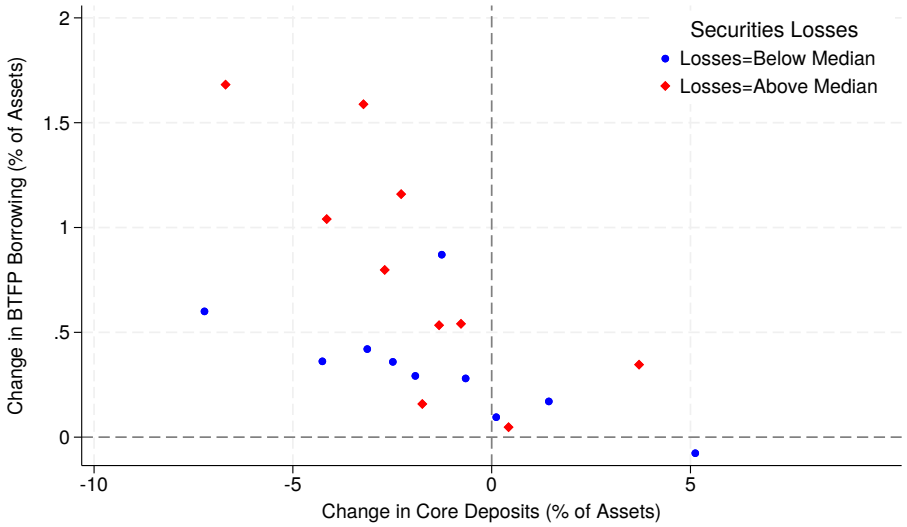
| | $\frac{\Delta\text{Deposits}}{\text{Assets}}$ | | | | | |
|---|---|---|---|---|---|---|
| | Panel A: Before SVB | | | | | |
| | Sep 28 to Nov 23, 2022 | | Nov 23, 2022 to Jan 18, 2023 | | Jan 18 to Mar 8, 2023 | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.01 | 0.01 | 0.01 | 0.01 | -0.02** | -0.03** |
| | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) | (0.01) |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | 0.00 | | -0.01 | | 0.00 |
| | | (0.01) | | (0.01) | | (0.01) |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | 0.17 | 0.01 | -0.04 | 0.27 | 0.24* | 0.14 |
| | (0.11) | (0.35) | (0.11) | (0.35) | (0.13) | (0.34) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.089 | 0.089 | 0.097 | 0.098 | 0.069 | 0.069 |
| Observations | 673 | 673 | 676 | 676 | 675 | 675 |
| | Panel B: After SVB | | | | | |
| | May 3 to Jun 28, 2023 | | Jun 28 to Aug 23, 2023 | | Aug 23 to Oct 18, 2023 | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02* |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | -0.00 | | 0.01 | | -0.01 |
| | | (0.01) | | (0.01) | | (0.01) |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | 0.15 | 0.25 | 0.23* | -0.07 | -0.02 | 0.27 |
| | (0.14) | (0.33) | (0.13) | (0.30) | (0.10) | (0.31) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.132 | 0.132 | 0.078 | 0.080 | 0.066 | 0.067 |
| Observations | 674 | 674 | 678 | 678 | 674 | 674 |

*Notes: Panel A reports pre-SVB placebo regressions over three eight-week intervals ending March 8, 2023. Panel B reports post-stress regressions over three eight-week intervals starting May 3, 2023. Same specification and controls as Table 1. *, **, *** denote significance at 10%, 5%, and 1%.*

### 3.2 The intervention: BTFP as targeted substitution margin

Having established which banks were vulnerable to deposit outflows, we investigate how they managed those outflows. When banks lose deposits, they can increase funding from other sources—from the BTFP, from Federal Home Loan Bank (FHLB) advances, from large time deposits—or reduce liquid asset holdings. For illustrative purposes, Figure 3 provides a non-parametric view of the relationship between BTFP funding and deposit changes from March 8 to May 3, 2023 in the form of a binscatterplot. It shows a negative relationship between negative deposit changes (i.e., outflows) and BTFP borrowing, which vanishes for positive deposit changes (i.e., inflows). Futhermore, the relationship between deposit outflows and BTFP borrowing is steeper for banks with larger securities losses (in red diamonds), suggesting those banks tapped into BTFP funding to a greater extent to replace deposit losses.

Figure 3: Binscatter of BTFP Funding vs. Deposit Changes by Securities Loss Group




*Note: The chart shows a binscatter plot of banks' changes in BTFP funding (horizontal axis) against banks' changes in deposits. It distinguishes by banks with securities losses above and below the sample median (in red diamonds and blue dots, respectively). Each dot shows the means of BTFP and deposit changes for banks of each type (securities losses above and below the median) grouped into 10 equal-sized bins.*

Next, we examine how banks adjusted their non-deposit borrowings from March 8 to May 3 in response to core deposit outflows during that interval, including by borrowing from the BTFP or borrowing from other wholesale funding sources, which predominantly consist of FHLB advances.[18] For this purpose, we replace the left-hand side of (11) with changes in balance sheet items and add

[18]Since wholesale borrowings include funding from sources other than FHLBs, we use the term "non-Fed borrowings" to refer to it. Non-Fed borrowings exclude borrowing from the discount window, of which the variation was minimal during this period. While discount window borrowing spiked at the onset of the stress, by May 3rd the most seriously strained banks were closed, and borrowing returned to near pre-SVB levels. In addition, the closed banks, which accounted for most of the discount window borrowing during stress, are not in our sample.

core deposit changes as an explanatory variable. Because the response to deposit flows is likely asymmetric, we allow ΔDeposits to enter as a linear spline that differentiates between deposit outflows and inflows with a knot at zero:

$$\frac{\Delta Y_{i,t,t'}}{\text{Assets}_{i,t}} = \beta_1 \frac{\Delta\text{Deposits}^{-}_{i,t,t'}}{\text{Assets}_{i,t}} + \beta_2 \frac{\Delta\text{Deposits}^{+}_{i,t,t'}}{\text{Assets}_{i,t}} + \beta_3 \frac{\text{Securities Losses}_{i,22q4}}{\text{Assets}_{i,22q4}} + \beta_4 \frac{\text{Uninsured deposits}_{i,22q4}}{\text{Assets}_{i,22q4}} + \gamma' X_{i,t} + \varepsilon_{i,t}, \tag{12}$$

where $\Delta\text{Deposits}^{-}_{i,t,t'} = \min\{0, \Delta\text{Deposits}_{i,t,t'}\}$ and $\Delta\text{Deposits}^{+}_{i,t,t'} = \max\{0, \Delta\text{Deposits}_{i,t,t'}\}$. $\beta_1$ measures how banks meet a one-dollar deposit outflow; $\beta_2$ measures how banks respond to inflows.

Table 3 presents the results. For BTFP borrowing, we explore how both the extensive and intensive margin this outcomewere related to deposit outflows and bank vulnerabilities. In columns 1-3, the extensive margin results show which banks were more likely to borrow from the BTFP. In column 1, on average, a one-percent decline in core deposits relative to total assets raised the probability of BTFP borrowing by about 2.8 percentage points, relative to 12 percent of the sample banks having borrowed from the BTFP. In column 2 (or column 3), banks with higher securities losses (or higher HTM losses) were more likely to tap BTFP borrowing; i.e., for a one-percent decline in core deposits relative to assets, banks with securities losses at the 25th and 75th percentiles were 1.9 and 3.4 percentage points more likely, respectively, to borrow from the BTFP.

In columns 4-6, the intensive margin results relate the amount of BTFP borrowing to deposit outflows and vulnerabilities. Column 4 shows that, for a one-dollar decline in core deposits, the average bank increased BTFP borrowing by 16 cents. Furthermore, risk factors associated with deposit outflows also independently raise BTFP borrowing beyond their effect on actual outflows, consistent with precautionary demand. A one standard deviation increase in securities losses and in uninsured deposit share were associated with increases of BTFP borrowing of 42 basis points and 18 basis points, respectively, as a share of assets. These results suggest that BTFP was used both to meet realized deposit outflows and to raise precautionary funding for banks vulnerable to potential future outflows resulting from their securities losses. Moreover, to assess how banks differ in their propensity to fund deposit outflows with BTFP borrowing, column 5 interacts deposit outflows with securities losses. The estimates imply that banks with relatively low securities losses (25th percentile) only fund about 12 cents of every dollar of deposit outflows with BTFP funding. However, a bank with high securities losses (75th percentile of losses) would replace about 20 cents of every dollar of deposit outflows with BTFP borrowing.

Is the higher demand for BTFP borrowing by banks with high securities losses reflective of the program's design (including the at-par valuation of collateral), or does it reflect broader demand

for wholesale borrowing? To assess this, columns 7 to 9 repeat the same analysis but for non-Fed borrowing. This borrowing was a more prominent source of funding overall, on average, with banks increasing borrowing by about 40 cents for every dollar of outflows. However, there is no statistically significant interaction between deposit outflows and securities losses. This result indicates that the higher use of BTFP for banks with greater securities losses did not reflect a general increase in the demand for wholesale funding, but rather targeted borrowing to address the specific vulnerabilities of these institutions.

Table 3: Wholesale Borrowing—Baseline Results

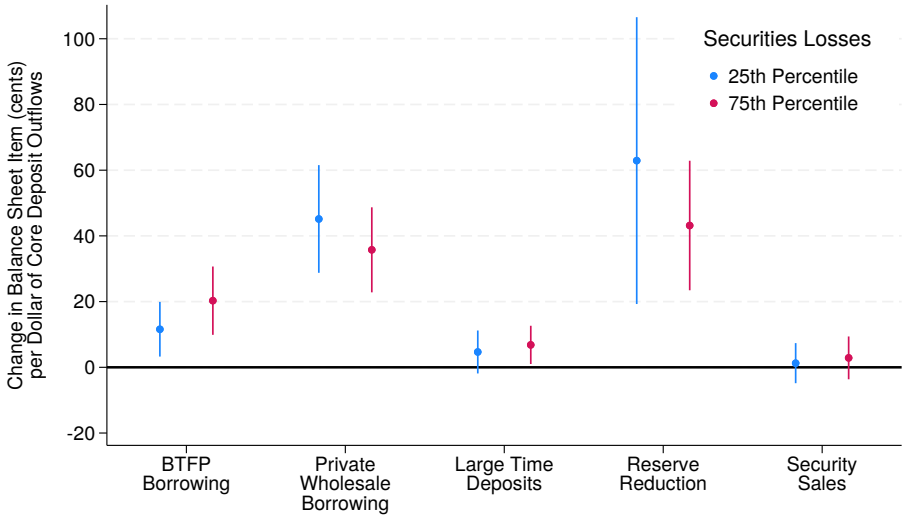
| | 0/1 BTFP Borrowings | | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.028*** | -0.012 | -0.012 | -0.162*** | -0.073 | -0.070 | -0.401*** | -0.498*** | -0.501*** |
| | (0.007) | (0.008) | (0.009) | (0.053) | (0.057) | (0.059) | (0.067) | (0.104) | (0.105) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.006** | | | -0.036* | | | 0.039 | |
| | | (0.003) | | | (0.018) | | | (0.024) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.015* | | | -0.095 | | | 0.086 |
| | | | (0.008) | | | (0.085) | | | (0.066) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.005 | | | -0.025 | | | 0.030 |
| | | | (0.003) | | | (0.017) | | | (0.025) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.034*** | 0.016 | | 0.210*** | 0.104 | | 0.093 | 0.207** | |
| | (0.007) | (0.011) | | (0.050) | (0.070) | | (0.063) | (0.099) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.012 | | | 0.022 | | | 0.372* |
| | | | (0.026) | | | (0.202) | | | (0.202) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.018 | | | 0.124* | | | 0.179* |
| | | | (0.011) | | | (0.072) | | | (0.103) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.002* | 0.002* | 0.001 | 0.014** | 0.014** | 0.012** | -0.001 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.006) | (0.006) | (0.006) | (0.009) | (0.009) | (0.010) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.084 | 0.092 | 0.098 | 0.102 | 0.108 | 0.116 | 0.170 | 0.173 | 0.174 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 |

*Notes: The table shows results from cross-sectional regressions of changes in banks' BTFP borrowings and non-Fed borrowings (wholesale borrowings that exclude BTFP and discount window) over the interval March 8—May 3, 2023 on contemporaneous core deposit growth ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), uninsured deposits, total securities losses, HTM and AFS securities losses, contemporaneous loan growth ($\Delta Loans_{i,t,t'}/Assets_{i,t}$), tier 1 capital-to-assets ratio, liquid asset holdings (the sum of cash, federal funds, reverse repo and securities holdings), average funding cost (annualized interest expense as a percent of total liabilities), deposit growth in 2022, FHLB advances, and bank size indicators (i.e., community banks are ones with assets under $10 billion in assets and regional banks ones with assets between $10 and $ 250 billion in assets) measured as of 2022:Q4. The spline regression approach differentiates between banks with positive and negative core deposits growth; the table reports the coefficients for negative deposits growth banks and interactions with securities losses; results for the full set of controls are in the Appendix. Core deposit and contemporaneous loan growth are winsorized at the 1 and 99 percent levels. All continuous variables are measured in percentage points (specifically, with the exception of 2022 deposit growth and average funding cost, measure variables as a percent of initial total assets). Results for the full set of controls are reported in the Appendix Table A4. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

Figure 4 displays the full set of adjustment margins evaluated at the 25th and 75th percentiles of securities losses based on regression results like in specification (12) presented in the Appendix

Table A5.[19] For banks at the 25th percentile, BTFP covers about 12 cents per dollar of outflows, non-Fed borrowing covers 45 cents, and cash drawdowns cover 45 cents. For banks at the 75th percentile, BTFP borrowing rises to 20 cents per dollar of outflows, while non-Fed borrowing falls to 35 cents, and cash drawdowns fall to 43 cents. In short, banks with high securities losses shift toward BTFP funding on the margin, and away from other funding sources, while the interactions between outflows and securities looses are statistically significant for BTFP borrowing.

Figure 4: How Banks Fund Core Deposit Outflows



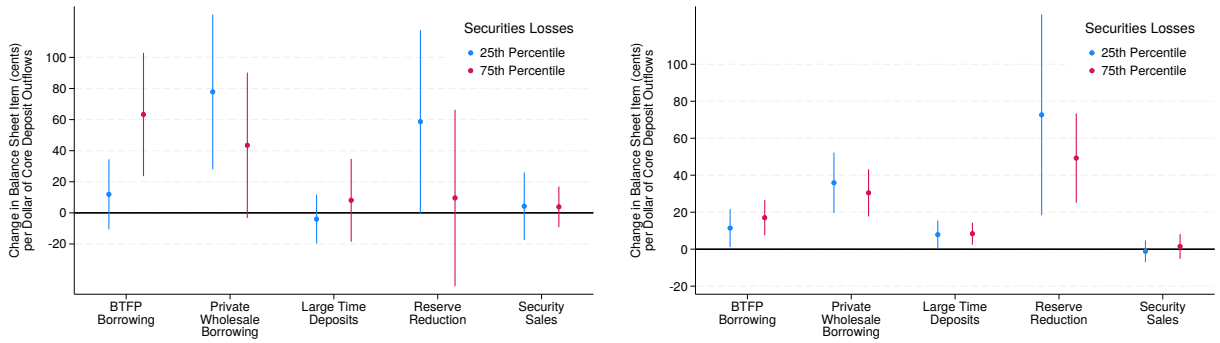

*Notes: Estimates of how much various funding sources are used (in cents) to meet a $1 increase in funding needs. Blue dots (lines) show point estimates (90% confidence intervals) for banks with low securities losses (25th percentile). Red dots and lines show estimates for banks with high securities losses (75th percentile). Underlying regressions follow specification* (12).

Figure 5 disaggregates the results by bank size. The shift toward BTFP for high-loss banks is driven primarily by regional banks: a regional bank at the 75th percentile of securities losses funds about two-thirds of its core deposit outflows with BTFP funding. Community banks exhibit qualitatively similar patterns, but with less reliance on BTFP.[20]

[19] The Appendix Table A6 shows similar results for specifications in which deposit when core deposit outflows and inflows are replaced, in a spline regression approach, with positive and negative in excess loan growth, respectively. Excess loan growth is the difference between core loan and core deposit growth, with a positive value showing a change in core loans that is not fully covered by the change in deposits. THe Appendix Figure A7 summarizes the results.

[20] The robustness results in the Appendix Table A7 and Table A8 confirm that for regional banks and banks lower tier 1 capital ratios, larger securities losses amplified the substitution between deposit outflows and BTFP borrowing. However, the results in Table A9 do not support the idea of a non-linear effect of securities losses in driving the substitution between deposit outflows outflows and BTFP borrowing.

Figure 5: How Banks Fund Deposit Outflows, by Bank Size




*Notes: Left panel shows regional banks ($10–$250 billion in assets); right panel shows community banks (under $10 billion). Same methodology as in Figure 4.*

To summarize, while most banks did not use BTFP funding, those that did appear to do so for precautionary reasons or to replace deposit outflows. Though banks typically met such funding needs by raising private borrowing or reducing cash holdings, banks with high securities losses relied more heavily on BTFP funding, especially regional banks. While this higher reliance on BTFP for high-loss banks may reflect numerous factors—for example, precautionary demand for liquidity, less liquid initial asset holdings, or a greater benefit from at-par collateral valuation—the main takeaway is the same: BTFP provided a backstop source of funding that enabled vulnerable banks to manage funding pressures during the period of most acute stress.

### 3.3 Operational readiness, collateral pledging, and the cost of non-access

The BTFP relied on existing discount-window infrastructure, so formal eligibility was not the same as effective access. Banks that had previously pledged collateral at, or borrowed from, the discount window could access BTFP funds in as little as 15 minutes. We define a bank as *operationally ready* if it had collateral pledged at the discount window as of March 8 or had borrowed from the discount window in the previous five years. Operational readiness is not randomly assigned, and we do not interpret the resulting estimates as causal in a narrow sense. Our claim is instead that readiness is a useful proxy for the ability to use the facility quickly during acute stress. Together with the pre-stress placebo results and the targeted substitution toward BTFP borrowing rather than other wholesale funding sources, heterogeneity across operational readiness further narrows the set of plausible alternative explanations. The evidence below illustrates the importance of operational readiness along three margins: banks with greater readiness tapped the facility sooner, substituted more strongly toward BTFP borrowing when exposed to core deposit outflows, and appear to have faced lower short-maturity funding pressure.

**Collateral pledging.** As Figure 2 shows, depository institutions pledged substantially more collateral than they actually borrowed from the BTFP. Table 4 regresses collateral pledged (as a share of assets) on deposit outflows and risk factors. One dollar in deposit outflows, HTM securities losses, or uninsured deposits raises total pledging by 18, 49, and 5 cents, respectively—substantially more than the amount actually borrowed. Banks with larger securities losses benefited more from at-par collateral valuation, increasing borrowing capacity. Pledging was predominantly agency MBS/CMO, which disproportionately experienced fair value declines due to the negative convexity of mortgage prepayments. Roughly two-thirds of the additional pledging driven by deposit outflows, securities losses, or uninsured deposits was in MBS/CMO collateral.

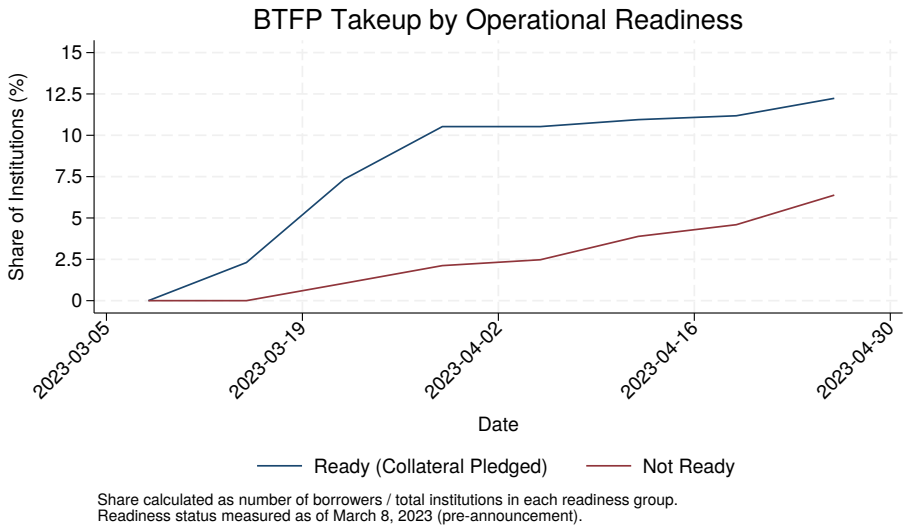
Table 4: BTFP Collateral Pledging

| | Total | | MBS/CMO | | Agency Securities | | Treasury Securities | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.179** | -0.072 | -0.098* | -0.079 | -0.040** | 0.005 | -0.040* | 0.002 |
| | (0.075) | (0.083) | (0.058) | (0.074) | (0.020) | (0.030) | (0.022) | (0.021) |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | -0.186+ | | -0.062 | | -0.055** | | -0.068 |
| | | (0.129) | | (0.084) | | (0.026) | | (0.059) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | -0.012 | | 0.004 | | -0.010 | | -0.006 |
| | | (0.032) | | (0.028) | | (0.015) | | (0.011) |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | 0.493** | 0.037 | 0.333** | 0.212 | 0.129* | -0.021 | 0.032 | -0.154 |
| | (0.215) | (0.351) | (0.163) | (0.259) | (0.066) | (0.089) | (0.054) | (0.127) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | 0.433*** | 0.394*** | 0.288*** | 0.297*** | 0.111** | 0.085+ | 0.034* | 0.013 |
| | (0.089) | (0.121) | (0.081) | (0.091) | (0.049) | (0.056) | (0.018) | (0.026) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.054*** | 0.051*** | 0.043*** | 0.042*** | 0.005+ | 0.004 | 0.006*** | 0.005** |
| | (0.011) | (0.011) | (0.010) | (0.010) | (0.003) | (0.003) | (0.002) | (0.002) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.143 | 0.156 | 0.132 | 0.138 | 0.078 | 0.089 | 0.038 | 0.065 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 |

*Notes: Cross-sectional regressions of BTFP collateral pledged as a share of assets over March 8 to May 3, 2023 on deposit outflows, HTM and AFS securities losses, and controls. Columns 1–2 report total collateral; columns 3–8 disaggregate by MBS/CMO, agency debt, and Treasury securities. Same controls as in Table 1. *, **, *** denote significance at 10%, 5%, and 1%.*

**Takeup speed by operational readiness.** Figure 6 shows that operationally-ready banks tapped the BTFP facility faster. Banks with prior discount window collateral or borrowing experience began drawing on the BTFP within the first days of the program, while non-ready banks took substantially longer to initiate borrowing.

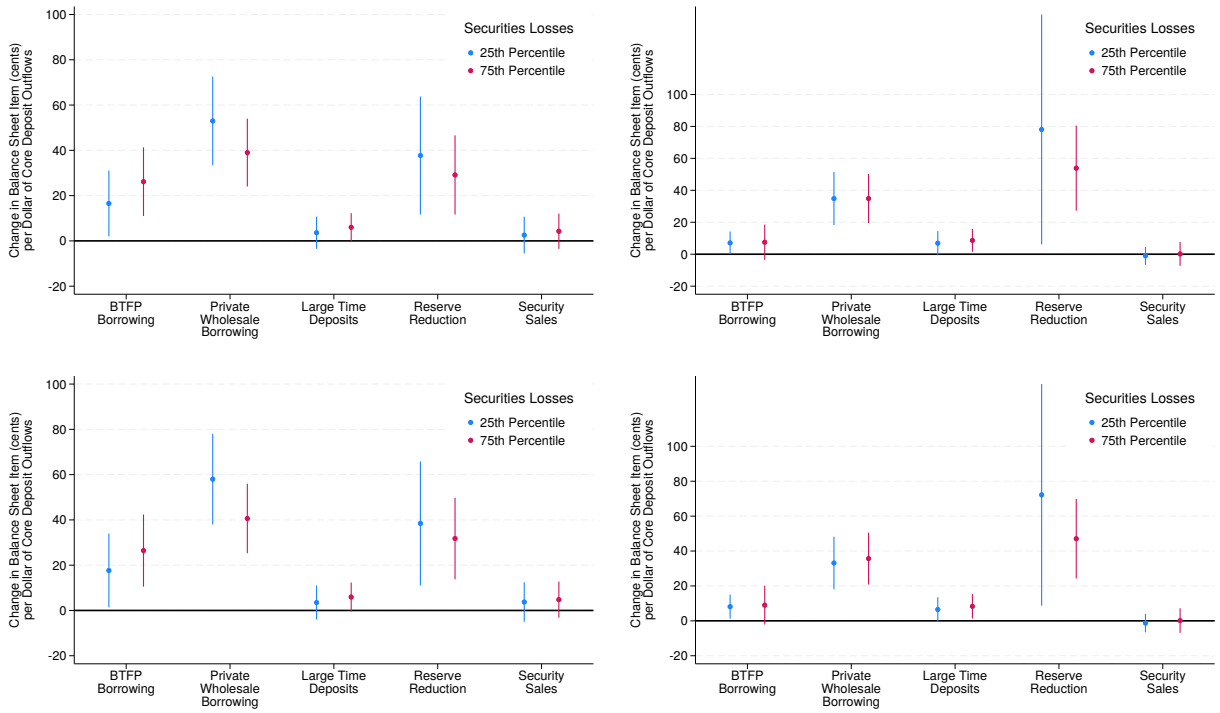
Figure 6: BTFP Takeup Speed by Operational Readiness




*Notes: Cumulative share of eventual BTFP borrowers that initiated first borrowing, by week since program launch (March 12, 2023). Banks are split by operational readiness (prior collateral pledged at discount window as of March 8, 2023).*

**Funding by operational readiness.** Figure 7 presents the full adjustment margin estimates split by operational readiness. We find that banks that were operationally ready (panels a and c)—in terms of both pledging collateral at, and previous borrowing from, the discount window—borrowed more from the BTFP, especially if they had high securities losses, and relied less on their reserves to meet deposit outflows. Among banks that were operationally ready, those with low securities losses appear to increase BTFP funding by about 20 cents per dollar of deposit outflows, while banks at the 75th percentile of securities losses to assets appear to increase BTFP funding by almost 30 cents per dollar of deposit outflows. In contrast, banks that were not operationally ready to access the BTFP (panels b and d) relied almost exclusively on their reserves to meet deposit outflows. Among banks that were not operationally ready, those with low securities losses appear to reduce reserves by about 70-to-80 cents per dollar of deposit outflows, while banks with high securities losses to assets appear to reduce reserves by about 50 cents per dollar of deposit outflows. This result highlights the importance of being operationally ready to tap an emergency lending facility, especially among vulnerable banks that perhaps need the facility the most.

Figure 7: How Banks Fund Deposit Outflows, by Operational Readiness




*Notes: Panels (a) and (c) show operationally ready banks (prior collateral pledged or prior borrowing from the discount window); panels (b) and (d) show operationally non-ready banks. Same methodology as in Figure 4.*

Table 5 further explores the readiness interaction by estimating the liquidity response to lagged deposit flows separately for operationally ready and non-ready banks. Ready banks that experienced outflows accumulated BTFP balances and maintained reserves; non-ready banks drew down reserves and increased non-Fed wholesale borrowing.

Table 5: Liquidity Response to Lagged Deposit Flows by Operational Readiness

| | $\frac{\Delta \text{BTFP}}{\text{Assets}}$ | | $\frac{\Delta \text{Reserves}}{\text{Assets}}$ | | $\frac{\Delta \text{Non-Fed Bor.}}{\text{Assets}}$ | |
|---|---|---|---|---|---|---|
| | Ready | Not Ready | Ready | Not Ready | Ready | Not Ready |
| Dep. Outflow (lagged, neg) | 0.187* | -0.004 | -0.097 | -0.303 | -0.132 | -0.035 |
| | (0.111) | (0.022) | (0.076) | (0.194) | (0.149) | (0.048) |
| $\frac{\text{Loss MTM}}{\text{Assets}}$ | 0.058 | 0.046 | 0.278** | 0.109 | 0.279** | 0.039 |
| | (0.122) | (0.048) | (0.126) | (0.172) | (0.132) | (0.086) |
| c.outflow_dep_lag#c.lossMTM_TA | -0.148** | 0.004 | 0.021 | 0.070 | 0.143* | -0.017 |
| | (0.073) | (0.011) | (0.032) | (0.055) | (0.077) | (0.017) |
| Dep. Inflow (lagged, pos) | 0.004 | -0.022 | -0.032 | -0.970** | 0.101 | -0.006 |
| | (0.074) | (0.022) | (0.144) | (0.439) | (0.080) | (0.034) |
| c.inflow_dep_lag#c.lossMTM_TA | 0.026 | 0.019 | -0.030 | 0.217** | -0.003 | 0.044 |
| | (0.034) | (0.019) | (0.054) | (0.107) | (0.026) | (0.027) |
| Constant | -1.522*** | 0.317 | 2.097 | 0.277 | 4.901*** | 1.491* |
| | (0.543) | (0.295) | (1.401) | (2.647) | (1.222) | (0.821) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Readiness | Ready | Not Ready | Ready | Not Ready | Ready | Not Ready |
| Outcome | BTFP | BTFP | Reserves | Reserves | Non-Fed Bor | Non-Fed Bor |
| Adj. $R^2$ | 0.123 | -0.00561 | 0.0497 | 0.480 | 0.0957 | -0.0160 |
| N | 407 | 260 | 400 | 217 | 407 | 260 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

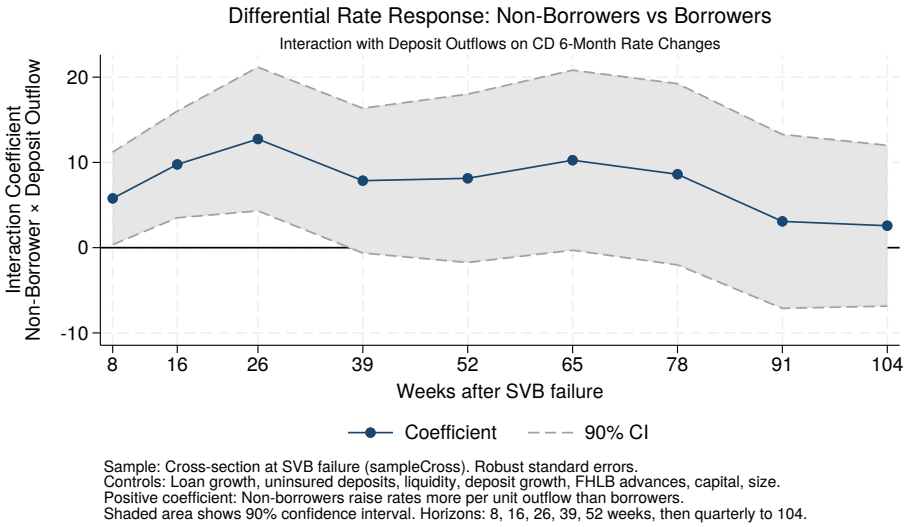
*Notes: Cross-sectional regressions of balance sheet adjustments on lagged deposit flows, split by operational readiness. Readiness is defined by prior collateral pledged at the discount window as of March 8, 2023. Same controls as in Table 1. *, **, *** denote significance at 10%, 5%, and 1%.*

The combined evidence reveals a complementarity between collateral design and operational preparedness. The BTFP's at-par collateral valuation channeled funding to banks with the greatest interest rate risk—the collateral dimension. But operational readiness determined whether a bank could actually access those funds quickly enough to matter during acute stress—the infrastructure dimension. Facility design and operational preparedness are complements, not substitutes.

**Deposit rate evidence and monetary transmission.** We treat the CD-rate evidence as supportive rather than dispositive. Because borrowing is endogenous, comparisons between BTFP borrowers and non-borrowers do not isolate readiness cleanly. Even so, Figure 8 shows that non-borrowers experiencing deposit outflows raised 6-month CD rates more aggressively than borrowers facing similar outflows, and the difference persisted for approximately 16 weeks. The non-borrower level effect clarifies the mechanism: without the interaction, non-borrowers raised rates *less* on average—reflecting that borrowers were the more stressed institutions—but once we condition on outflows, non-borrowers repriced more per unit of funding pressure. This pattern is consistent with the quantity-margin evidence: banks without comparable effective access appear to have relied more heavily on deposit pricing to retain funding. In that sense, the facility appears to have weak-

ened deposit-rate pass-through for BTFP borrowers during the stress period by allowing them to absorb part of the funding pressure through central bank liquidity rather than deposit repricing. That non-BTFP borrowing banks raised deposit rates is itself consistent with monetary tightening operating as intended on the non-stressed segment of the banking system; the facility dampened pass-through only for the vulnerable banks it was designed to stabilize, preserving the Tinbergen separation principle between the macro-prudential and monetary policy objectives (Tinbergen, 1952).

Figure 8: Non-Borrower × Deposit Outflow Interaction: 6-Month CD Rate




*Notes: Dynamic difference-in-differences estimates of the interaction between non-BTFP-borrower status and deposit outflows on 6-month CD rates. Dashed lines show 90% confidence intervals. The differential fades after approximately 16 weeks.*

The absence of a differential at the 12-month maturity is consistent with the BTFP's one-year tenor influencing pricing at that horizon, though other explanations are possible. The 24-month rate differential reopens, suggesting the BTFP's pricing influence was bounded by its term structure (see the Appendix Figures A2 to A6).

### 3.4 Dynamic evidence: local projections

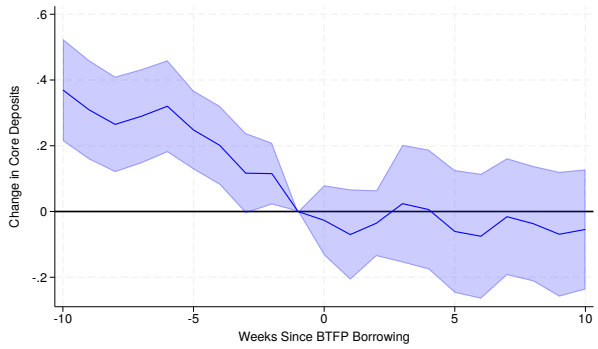
The cross-sectional evidence establishes which banks used the BTFP, how much they borrowed, and at what cost to those who lacked effective access. Cross-sectional regressions, however, cannot capture the timing of adjustment. We now use local projections to trace balance-sheet dynamics around borrowing episodes:

$$\frac{y_{i,t+h} - y_{i,t-1}}{Assets_{i,t-1}} = \beta^h \frac{\Delta BTFP_{i,t}}{Assets_{i,t-1}} + \tau_t^h + \epsilon_{i,t}^h \tag{13}$$

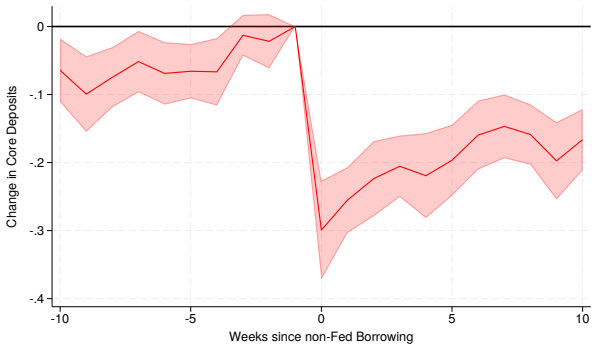
where $\tau_t^h$ is a week fixed effect and $\{\beta^h\}$ traces the path of balance sheet variables surrounding an increase in BTFP balances relative to banks that did not change borrowing in a particular week. We estimate an analogous specification for non-Fed borrowings. The sample covers $t$ from March 15 to July 26, with leads and lags of 10 weeks ($h \in \{-10, \ldots, 10\}$), so the estimation data span January 4 to October 4.

Figure 9 shows three broad patterns. First, BTFP borrowing follows a period of sustained deposit weakness—banks with one dollar higher BTFP borrowing had about 40 cents more in cumulative core deposit outflows over the previous 10 weeks—whereas non-Fed borrowing responds more contemporaneously to outflows (panels a–b). Second, BTFP borrowing is associated with persistent reserve accumulation: cash holdings rise by about one-third of the borrowing amount on impact and remain elevated for 10+ weeks (panels c–d). Third, loan balances remain broadly flat around borrowing events, with a small and statistically insignificant increase following BTFP borrowing (panels e–f).

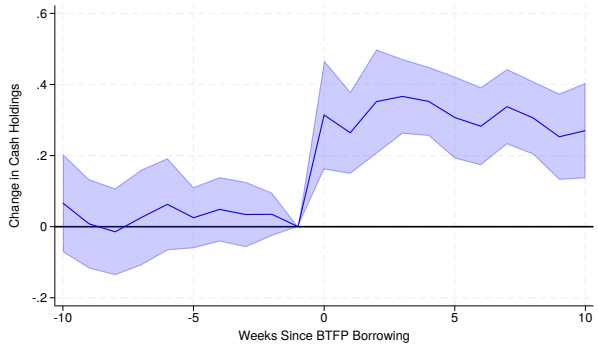
Figure 9: Balance-Sheet Dynamics around Borrowing



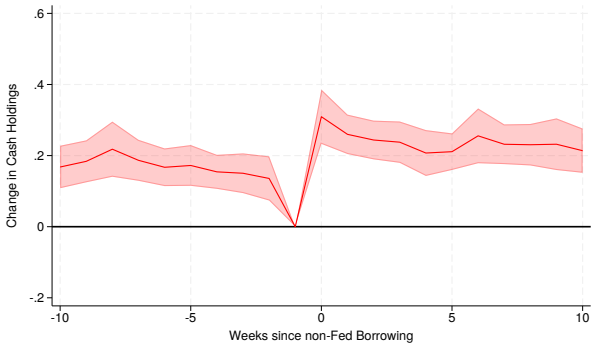

(a) Core deposits: BTFP



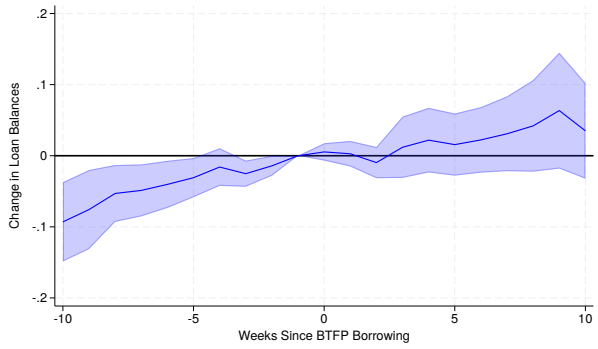

(b) Core deposits: non-Fed



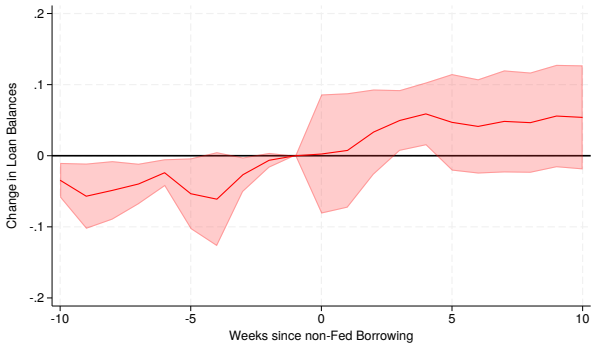

(c) Cash holdings: BTFP




(d) Cash holdings: non-Fed




(e) Loan balances: BTFP




(f) Loan balances: non-Fed

*Notes: Local projection estimates of changes in core deposits (panels a–b), cash holdings (panels c–d), and loan balances (panels e–f) surrounding a $1 increase in BTFP borrowing (left column) or non-Fed borrowing (right column), controlling for week fixed effects. Week 0 is the week of borrowing.*

Because BTFP borrowing and balance-sheet changes are jointly determined within a week, we interpret these local projections as documenting balance-sheet dynamics around borrowing episodes rather than as causal estimates. The aggregate local projection evidence indicates that BTFP borrowing is associated with reserve accumulation following deposit outflows. Banks did not expand lending around borrowing episodes. These patterns are consistent with precautionary liquidity management, not risk-taking.[21]

### 3.5 Use of funds and lending behavior

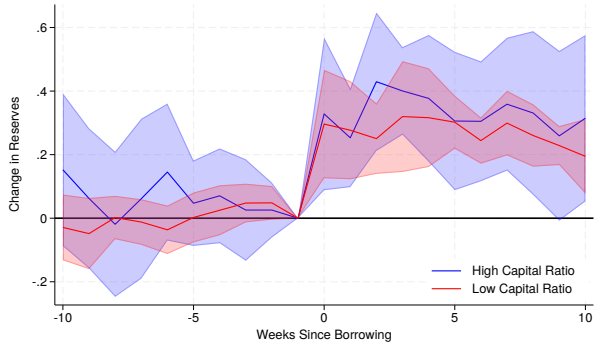
The local projections show that BTFP funds were held as reserves in the aggregate. But aggregate patterns could mask heterogeneity: less-capitalized banks might use the funds to acquire riskier assets. Following Drechsler *et al.* (2016), we interact BTFP borrowing with an indicator for whether a bank's adjusted tangible common equity ratio (marking securities and loans to market as in Jiang *et al.*, 2023) falls below 3 percent.

Figure 10 presents the results. Panels (a)–(d) split by capitalization: both high- and low-capital banks accumulate reserves by similar amounts following BTFP borrowing (panel a). The slightly lower intermediate-term reserve accumulation at less-capitalized banks reflects their greater decline in core deposits after accessing the facility (panel b). Well-capitalized banks show a small, statistically insignificant increase in lending (panel c); less-capitalized banks instead increase securities holdings modestly (panel d), consistent with using BTFP to avoid selling securities at a loss rather than expanding credit risk.

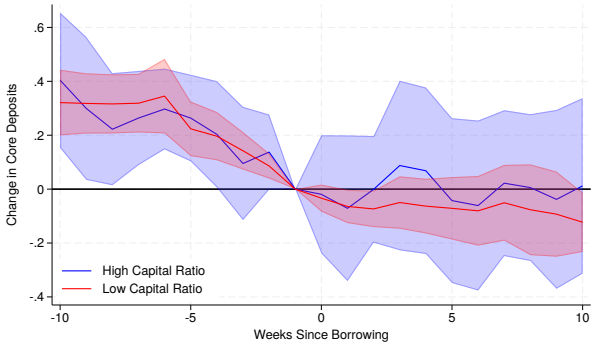
Panels (e)–(h) disaggregate by loan type. The increase in loan balances at well-capitalized banks is principally C&I lending (panel e). For loan categories that experienced greater strains in 2023—CRE and consumer loans—there is no increase in balances after BTFP borrowing at either high- or low-capital banks (panels g–h). Over a longer horizon (2022Q4 to 2024q4), borrowing banks do not appear to increase risky lending or long-term securities holdings relative to non-borrowers.

[21] One potential concern for our local projection estimates is related to the possibility that a given bank $i$ that is a repeat BTFP borrower enters both the treatment and control group as it borrows twice during the sample period. However, this concern is unlikely to bias our results, given that we obtain similar estimates to those in Figure 9 when restricting the sample to banks that borrow at most once from the BTFP (available upon request). Another potential concern is related to cases in which a given bank $i$ that borrowers from the BTFP enters the treatment group, while a different bank $j$ that borrowers a few weeks earlier or later during the sample period enters the control group. The fact that BTFP draws from non-repeat borrowers are concentrated within two consecutive weeks in late-March 2023 alleviates this concern, see the Appendix Figures A8.

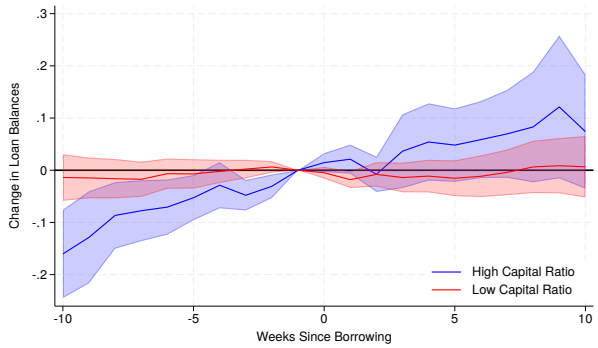
Figure 10: Use of BTFP Funds by Capitalization and Loan Type



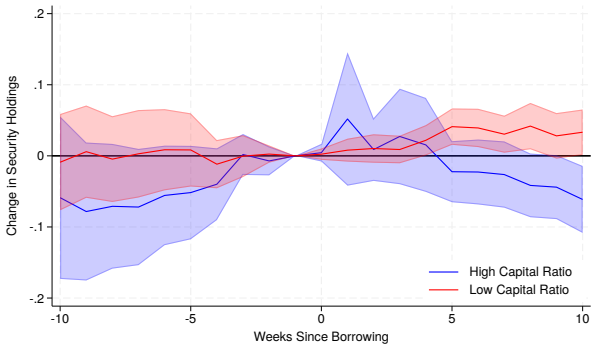

(a) Reserves



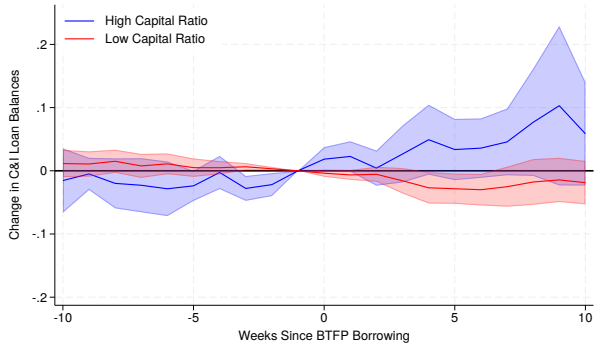

(b) Core deposits



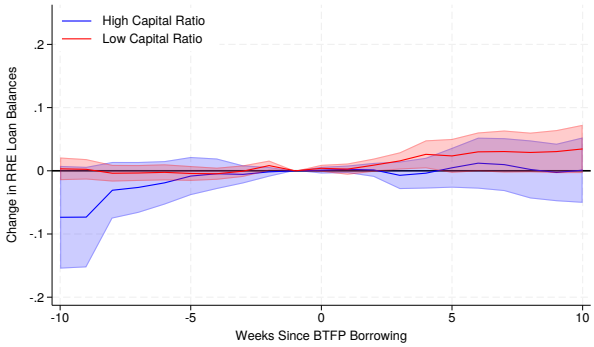

(c) Total loans



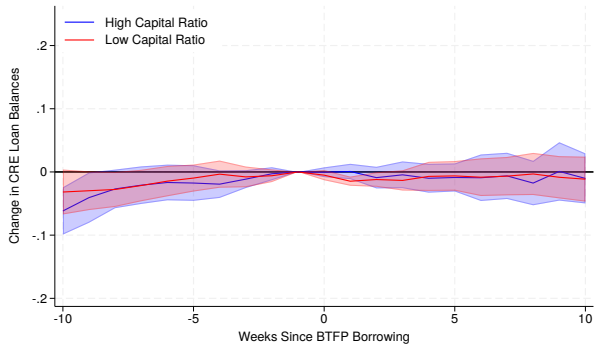

(d) Securities



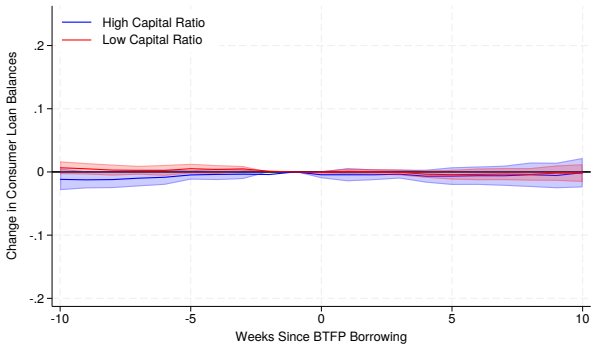

(e) C&I loans




(f) RRE loans




(g) CRE loans




(h) Consumer loans



*Notes: Local projection estimates surrounding a $1 increase in BTFP borrowing. Panels (a)–(d): changes in reserves, core deposits, total loans, and securities by capitalization. Panels (e)–(h): changes in C&I, RRE, CRE, and consumer loans by capitalization. Blue lines: banks with adjusted tangible common equity above*

A competing explanation for the absence of credit-risk expansion is that strict supervision constrained borrowers. We test this hypothesis by splitting less-capitalized banks by regulator: those supervised by the Federal Reserve System versus those supervised by the FDIC or OCC. If intra-agency coordination between BTFP lending and supervision dampened moral hazard, we would expect less credit expansion among Fed-supervised banks. Less-capitalized banks supervised by the FDIC or OCC—where no such coordination exists—also do not expand risky lending after BTFP borrowing (Appendix Figure A9). This evidence is suggestive against a supervision-driven explanation, though we note that the observed differences may partly reflect underlying bank characteristics rather than regulatory effects.

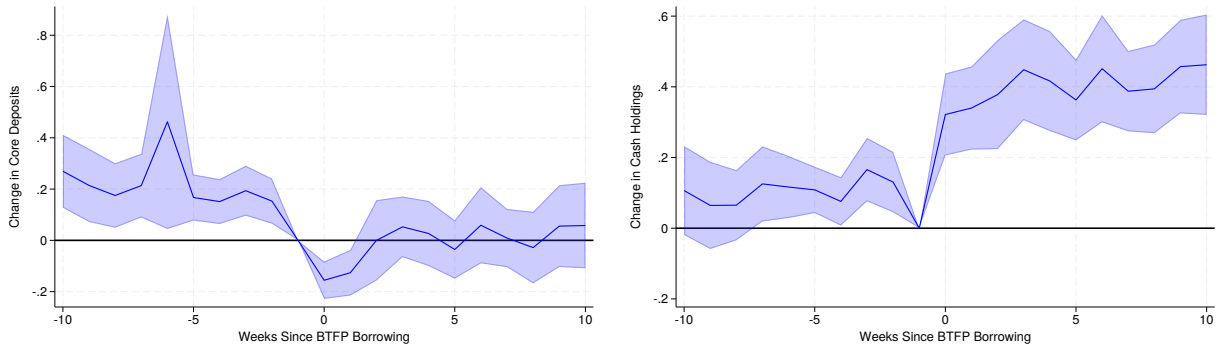
We do not find evidence that vulnerable banks used BTFP funds to expand risky credit. Instead, borrowers used fixed-rate term BTFP debt to accumulate floating-rate reserves, reducing interest rate risk rather than adding credit risk. This pattern is consistent with narrow collateral limiting the scope for risk-taking through the facility.

## 4 Unintended consequences: arbitrage

We next analyze unintended consequences associated with the BTFP by focusing on a second wave of borrowing. Between November 29, 2023 and January 24, 2024, the BTFP rate fell below the interest on reserve balances (IORB), creating a risk-free arbitrage opportunity: banks could borrow at the BTFP and hold the proceeds as reserves at the Fed, earning a positive spread with no credit or interest rate risk. During this eight-week window, aggregate BTFP outstanding rose from $114 billion to $168 billion.

Figure 11 presents local projection estimates of the relationship between BTFP borrowing and balance sheet changes during the arbitrage period. The left panel shows that core deposit declines before borrowing were modest relative to the stress period (see Figure 9, panel a). The right panel reveals that BTFP borrowing is followed by a sharp increase in reserves—about 40 cents per dollar of borrowing—that remains elevated through at least the next 10 weeks (slightly larger than in Figure 9, panel c). While the reserve response is even larger than during the stress period, the motivation differs. During the spring of 2023, banks borrowed for precautionary reasons; during the later period, arbitrage incentives likely dominated.

Figure 11: Changes in Core Deposits and Cash Holdings around BTFP Borrowing, Arbitrage Period




*Notes: The charts show the dynamic relationship between banks' weekly core deposits (left) or cash holdings (right) around a change in BTFP borrowing during the arbitrage incentive period (November 29, 2023 to January 24, 2024). The coefficients show the relationship at various horizons (in dollars) surrounding a $1 increase in BTFP borrowing in the presence of week fixed effects.*

Cross-sectional regressions confirm that borrowing during this period was predicted by existing-borrower status, not deposit outflows or balance sheet vulnerabilities (Appendix Table A10). The only difference from our baseline specification is the inclusion of an indicator for whether a bank had BTFP borrowings outstanding at the start of the interval. This variable proxies for nonpecuniary costs of using the program: banks that had previously borrowed had already incurred any fixed costs associated with gaining access, and their participation would be disclosed regardless of additional borrowing. BTFP borrowing was no longer responsive to deposit outflows—along either the extensive or intensive margin—while existing-borrower status strongly predicted additional BTFP borrowing along the extensive margin. While securities losses in levels are positively correlated with BTFP borrowings, their interaction with deposit outflows is not statistically significant. In contrast, non-Fed wholesale borrowing continued to respond to deposit outflows during this period, similar to earlier in the year.

Credit unions provide additional evidence. They accounted for about one-third of total BTFP borrowing. At no point during 2023 did ex ante reliance on uninsured deposits or securities losses predict deposit outflows among credit unions (Appendix Table A11). Yet credit unions engaged in arbitrage-motivated borrowing that was about 2.5 times more intensive than banks. During the arbitrage window, credit unions deposited approximately 94 cents per dollar of BTFP borrowing as reserves, compared to about 40 cents for banks (Appendix Tables A12 and A13).

Arbitrage-motivated borrowing factored into the Federal Reserve Board's decision to floor the BTFP rate at the IORB rate in effect on the day of loan origination, effective January 24, 2024. This technical adjustment eliminated the risk-free spread, halting the burst of late-2023 activity. Borrowing slowed through March 2024, at which point the BTFP stopped originating new loans.

The arbitrage episode highlights the limits of fixed-rate emergency lending once acute stress has

passed. A facility designed to stabilize a specific vulnerability can become attractive for reasons unrelated to that vulnerability when relative pricing changes. In the BTFP, that distortion took the form of reserve arbitrage rather than credit expansion, and the Federal Reserve closed it within eight weeks by flooring the program rate at IORB. The episode therefore qualifies, rather than overturns, the case for narrow collateral design: narrow design appears to have limited credit-risk concerns, but pricing rules matter once market conditions normalize.

# 5 Conclusion

This paper studies how the Bank Term Funding Program shaped banks' adjustment to the March 2023 banking stress. The evidence points to three conclusions. First, the banks most exposed to the interaction of uninsured deposit funding and unrealized securities losses experienced the largest deposit pressure. Second, the BTFP operated as a targeted backstop for that vulnerability: borrowing was concentrated among exposed banks and was used primarily to replace lost deposits and build reserves rather than to expand lending. Third, operational readiness mattered for effective access. Banks with pre-positioned discount-window collateral tapped the facility sooner and adjusted more through central-bank liquidity and less through reserve depletion. Separately, non-BTFP borrowing banks facing deposit outflows raised deposit rates more aggressively than BTFP borrowers facing similar outflows, consistent with weaker deposit-rate pass-through for BTFP borrowers during the stress period.

These findings speak to both emergency-facility design and monetary transmission during episodes of rate-driven fragility. The BTFP's narrow collateral perimeter—restricted to government-backed securities valued at par—appears to have limited the scope for credit-risk expansion. But narrow collateral alone was not enough. Standing operational infrastructure shaped whether a formally eligible bank could use the backstop quickly enough to matter during acute stress. At the same time, by allowing some banks to absorb funding pressure through central-bank liquidity rather than deposit repricing, the facility appears to have altered the speed at which tightening passed through the deposit channel during stress. When the program's fixed-rate pricing later became favorable relative to reserve remuneration, borrowing also became partly arbitrage-driven, underscoring that pricing rules must adjust as stress subsides.

The broader lesson is that emergency facilities are defined not only by their collateral and pricing terms, but also by the operational infrastructure through which they are delivered. The external validity of this lesson is naturally bounded: narrow collateral works when the underlying vulnerability is concentrated in government-backed securities, as it was in March 2023. A facility accepting only government collateral at par would not have been effective during the 2008 Global Financial Crisis, when the stress originated in private credit markets. This distinction bounds

the applicability of the government-collateral approach: restricting eligible collateral to safe assets can address interest-rate-driven fragility, as Goodfriend and King (1988) envisioned, but not stress originating in private credit markets. The BTFP's effectiveness reflects a specific alignment: both the vulnerability and the eligible collateral were government-backed, so a liquidity tool could address what appeared to be a solvency problem. This alignment would not hold for credit-based shocks, where the vulnerable asset cannot serve as a narrow collateral.

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# A Appendix

## A.1 Framework: formal results

This appendix collects the formal equilibrium definition, proofs of all results in Section 2.2, and two corollaries on selective and arbitrage borrowing.

**Notation recap.** The bank invests $x \in (0,1)$ in reserves (return $\rho \geq 1$) and $1-x$ in long assets (return $R > 1$). The mark-to-market price is $P(\Delta r) = R \cdot e^{-D\Delta r}$, where $D$ is the weighted-average duration of the securities portfolio. The deposit rate $d > 1$ is set by competitive pricing against the depositors' outside option $r_{mm} \geq 1$. The withdrawal rate is $\lambda(\Delta r) = \bar{\lambda} + u\kappa(1 - P/R)$ with $\kappa(0) = 0$, $\kappa' > 0$, and $\kappa\colon [0,1] \to [0,1]$; this governs the interior response while the no-run condition holds. When the no-run bound fails, a discrete regime shift gives $\lambda = \bar{\lambda} + u$ (full uninsured run). The bank is ex-ante solvent: $R(1-x) + \rho x \geq d$. When a facility with lending rate $\phi$ and access cost $\varepsilon > 0$ is available, the bank's $t = 2$ budget constraint becomes $R(1-x) \geq \phi(\bar{\lambda}d - x) + (1-\bar{\lambda})d + \varepsilon$.

### Equilibrium definition

**Definition A.1** (Equilibrium)**.** An equilibrium is a tuple $(a, d, \lambda, y, b)$ where $a \in \{0,1\}$ is the facility access decision, such that:

(i) $d$ satisfies the competitive pricing condition: $\lambda d + (1-\lambda)d \cdot P^{\text{eff}}/R = r_{mm}$, where $P^{\text{eff}} = \max(P, \underline{P})$ if $a = 1$ and $P^{\text{eff}} = P$ if $a = 0$;

(ii) $\lambda$ is determined piecewise:

$$\lambda = \begin{cases} \bar{\lambda} + u\kappa(1 - P^{\text{eff}}/R) & \text{if } r_{mm} \leq x + P^{\text{eff}}(1-x) \quad \text{(no-run region)}, \\ \bar{\lambda} + u & \text{if } r_{mm} > x + P^{\text{eff}}(1-x) \quad \text{(run)}; \end{cases}$$

(iii) $(y, b)$ maximize the bank's $t = 2$ residual equity, $R(1-x-y) + \rho \max\{x - (\lambda d - b - Py), 0\} - \phi b - (1-\lambda)d - \varepsilon \cdot a$, subject to the liquidity constraint $x + b + Py \geq \lambda d$ and the collateral constraint $b \leq a \cdot \underline{P}(1-x-y)$;

(iv) $a$ solves the bank's access decision: the bank pays the fixed cost $\varepsilon$ and accesses the facility if doing so yields weakly higher continuation value than the laissez-faire alternative (see Corollary A.2 for a sufficient condition).

When conditions (i)–(iv) yield $r_{mm} \leq x + P^{\text{eff}}(1-x)$, the no-run outcome obtains. Under par valuation ($\underline{P} = R$) with $a = 1$, the model selects the no-run outcome: $P^{\text{eff}} = R$, $\lambda = \bar{\lambda}$, $d = r_{mm}$, $y^* = 0$, and $b^* = \max\{0, \bar{\lambda} r_{mm} - x\}$. The collateral floor $\underline{P} = R$ is a direct policy parameter, not a belief, so depositors' evaluation at $P^{\text{eff}} = R$ does not depend on coordinating expectations. For a bank with $a = 0$ (counterfactual losses do not exceed $\varepsilon$), the equilibrium reverts to the laissez-faire case, and runs may occur when $r_{mm} > x + P(1-x)$.

### Proofs

*Derivation of the no-run bound ((6)).* When $\lambda d \leq x$, reserves cover all early withdrawals without asset sales and the no-run condition holds trivially. When $\lambda d > x$, the bank sells $y = (\lambda d - x)/P$ units. Under Assumption 2.1, the late-depositor continuation payoff is pinned down by the marked-to-market residual estate. Substituting the recovery rule into the condition for late depositors to

weakly prefer waiting (continuation value $\geq d$):

$$\frac{R\big[(1-x)-(\lambda d-x)/P\big]}{1-\lambda}=\frac{R[x+P(1-x)]-R\lambda d}{(1-\lambda)P}.$$

For late depositors to weakly prefer waiting, this must exceed $d$:

$$x+P(1-x)\geq \lambda d+(1-\lambda)d\cdot\frac{P}{R}.$$

Substituting competitive pricing ((4)) gives $x+P(1-x)\geq r_{mm}$, which is (6). If the bound fails, all uninsured depositors prefer early withdrawal—a run. □

*Proof of Proposition 2.3.* In the no-run region, $\lambda=\bar{\lambda}+u\kappa(1-P/R)$. Using $P=Re^{-D\Delta r}$:

$$\begin{aligned}\frac{\partial\lambda}{\partial u}&=\kappa\big(1-e^{-D\Delta r}\big)>0,\\ \frac{\partial\lambda}{\partial D}&=u\kappa'\big(1-e^{-D\Delta r}\big)\,e^{-D\Delta r}\Delta r>0,\\ \frac{\partial^2\lambda}{\partial u\,\partial D}&=\kappa'\big(1-e^{-D\Delta r}\big)\,e^{-D\Delta r}\Delta r>0,\end{aligned}$$

using $\Delta r>0$, $D>0$, $u>0$, $\kappa>0$ on $(0,1]$ (which follows from $\kappa(0)=0$ and $\kappa'>0$ by the mean value theorem), $\kappa'>0$, and $e^{-D\Delta r}\in(0,1)$. □

*Proof of Theorem 2.5. (a)* By assumption, counterfactual fire-sale losses exceed $\varepsilon$, so the bank credibly accesses the facility. Depositors observe $\underline{P}=R$ and evaluate at $P^{\text{eff}}=R$, giving $\kappa(1-R/R)=0$ and $\lambda=\bar{\lambda}$. Conditional on access, $\underline{P}=R>P$ implies pledging dominates selling, so $y^*=0$. Competitive pricing then gives $d=r_{mm}$.

*(b)* Borrowing $b^*=\max\{0,\bar{\lambda}r_{mm}-x\}$ satisfies liquidity. When $b^*>0$: at $t=2$, maturity yields $R(1-x)$; repayment requires $R(1-x)\geq\phi(\bar{\lambda}r_{mm}-x)+(1-\bar{\lambda})r_{mm}+\varepsilon$, which is the $t=2$ budget constraint with $d=r_{mm}$. The facility is repaid in full because the period-2 budget constraint ensures that the bank's maturity value covers $\phi b^*$ together with late-depositor claims and the access cost. When $b^*=0$ ($x\geq\bar{\lambda}r_{mm}$): the bank benefits from the announcement effect but does not borrow; the facility has no exposure. The carry result in Remark 2.6 follows immediately: at $\phi=\rho$, a bank that borrows and retains reserves faces zero net spread. □

### Corollaries

**Corollary A.2** (Selective borrowing)**.** *Banks borrow from the facility only when the avoided fire-sale losses exceed the fixed cost of accessing it. Let $\lambda^{nf}$ denote counterfactual withdrawals absent the facility and $y_{\min}=(\lambda^{nf}d-x)/P$ the counterfactual fire-sale volume. A sufficient condition for borrowing is $(R-P\phi)y_{\min}\geq\varepsilon$, $\lambda^{nf}d>x$, and $P\phi<R$ (the facility repayment cost per unit of avoided fire sale is below maturity value).*

*Proof.* Without the facility, fire sales of $y_{\min}$ units forgo $Ry_{\min}$ at maturity. Borrowing $b=Py_{\min}$ and repaying $\phi b$ at $t=2$ yields net gain $(R-P\phi)y_{\min}-\varepsilon$. The bank borrows when this is positive. □

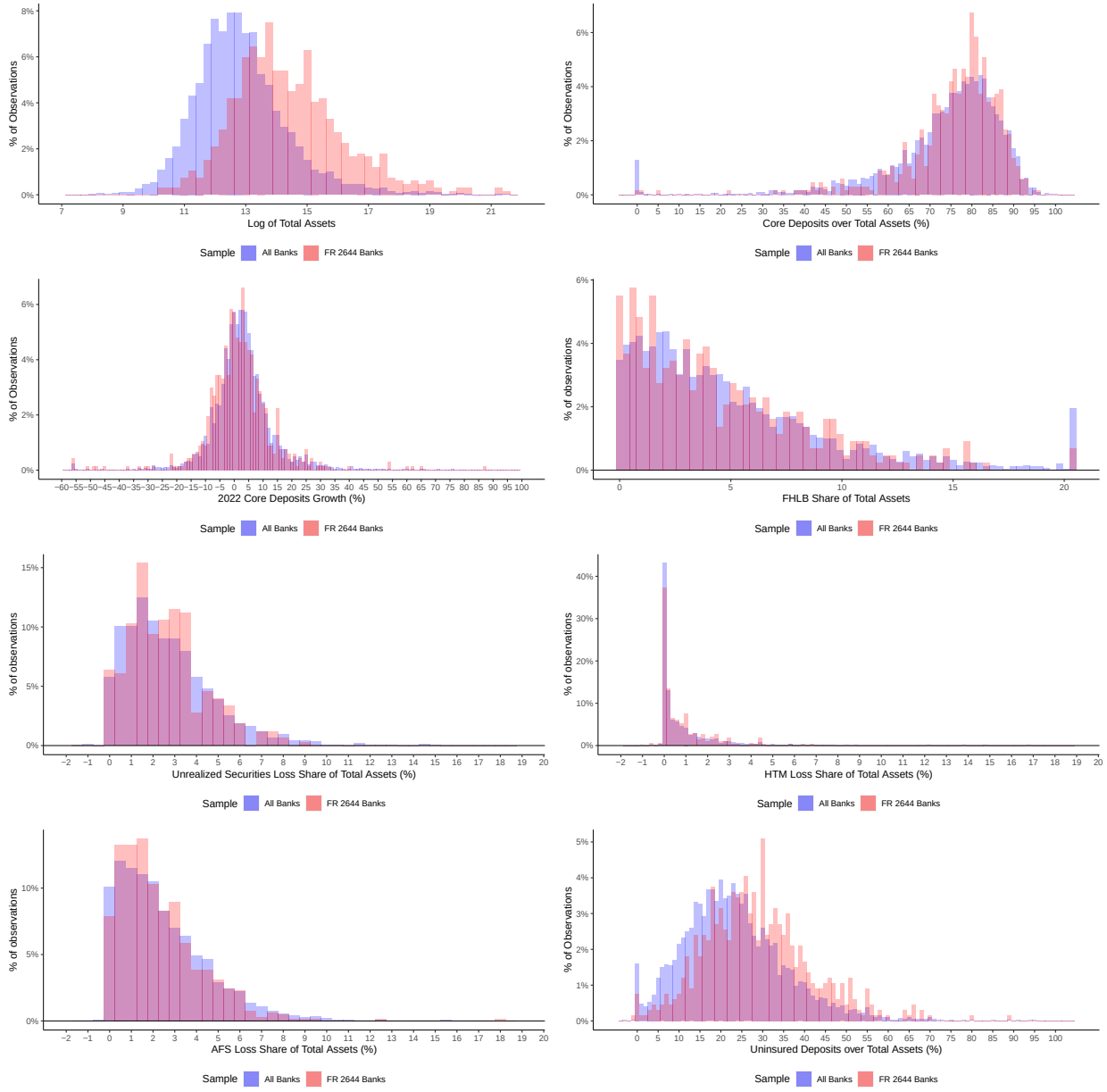
**Corollary A.3** (Arbitrage borrowing)**.** *When the facility lending rate $\phi$ falls below the return on reserves $\rho$, banks borrow to earn the spread. If $\rho>\phi$: (a) banks already borrowing engage in carry*

*borrowing up to spare collateral capacity (the access cost $\varepsilon$ is sunk); (b) banks not yet borrowing do so only if the carry profit $(\rho - \phi)\underline{P}(1-x)$ exceeds $\varepsilon$. If $\rho \leq \phi$, no carry borrowing occurs.*

*Proof.* Liquidity borrowing $b_{\text{liq}} = \max\{0, \bar{\lambda} r_{mm} - x\}$; $\varepsilon$ is incurred once. If $\rho > \phi$: (a) when $b_{\text{liq}} > 0$, $\varepsilon$ is sunk and carry is profitable up to $\underline{P}(1-x) - b_{\text{liq}}$; (b) when $b_{\text{liq}} = 0$, carry requires $(\rho - \phi)\underline{P}(1-x) \geq \varepsilon$. If $\rho \leq \phi$, carry profit is non-positive. □

## A.2 Sample representativeness

Figure A1: Sample Representativeness

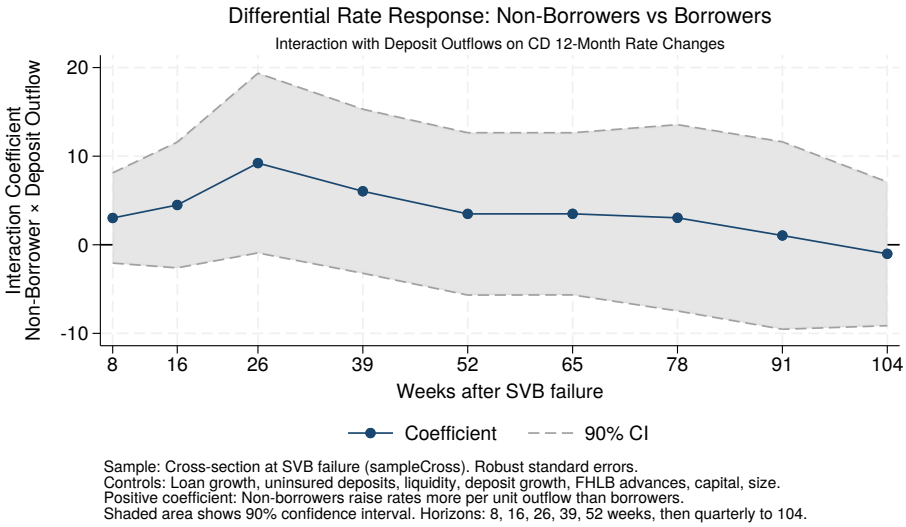



*Note:* The figure shows the distribution of various balance sheet characteristics for all commercial banks (4,746 banks, shown in blue) and the subset of banks in our sample (668 banks, shown in orange).

## A.3 Deposit pricing

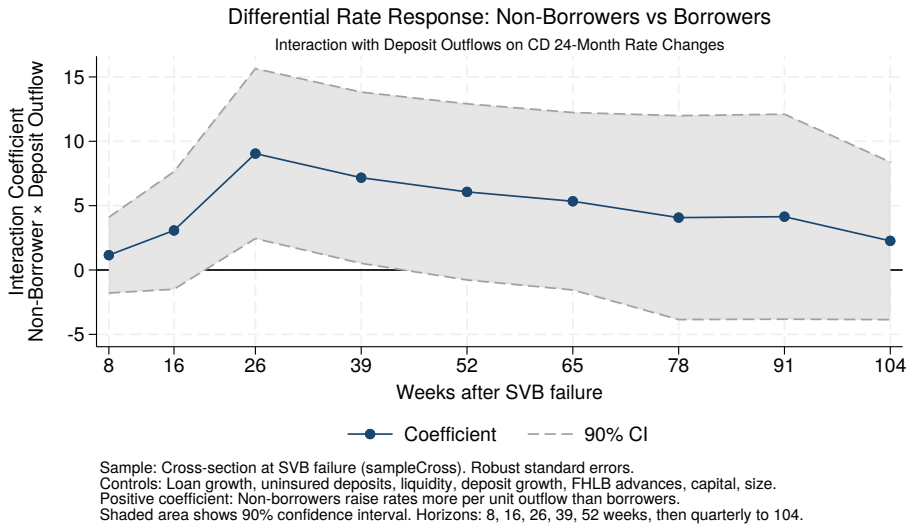
The deposit pricing analysis in Section 3.3 focuses on 6-month CD rates in the main text. Here we report results for 12-month and 24-month maturities, as well as robustness checks across control specifications for all three maturities. The maturity structure of the results is informative: the 6-month rate differential is strong and persistent, the 12-month rate shows no differential (consistent with the BTFP's one-year tenor influencing pricing at that horizon, though other explanations are possible), and the 24-month rate differential reopens, suggesting the BTFP's pricing influence was bounded by its term structure.

Figure A2: Non-Borrower × Deposit Outflow Interaction: 12-Month CD Rate



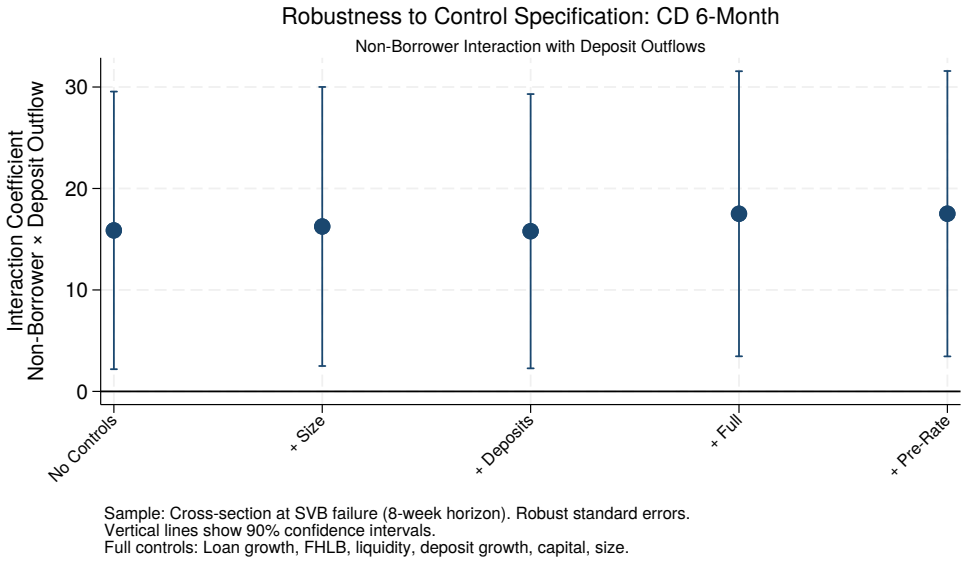

*Notes:* Coefficient on the interaction between non-borrower status and deposit outflows at various horizons after SVB failure for 12-month CD rates. 90% confidence intervals shown.

Figure A3: Non-Borrower × Deposit Outflow Interaction: 24-Month CD Rate



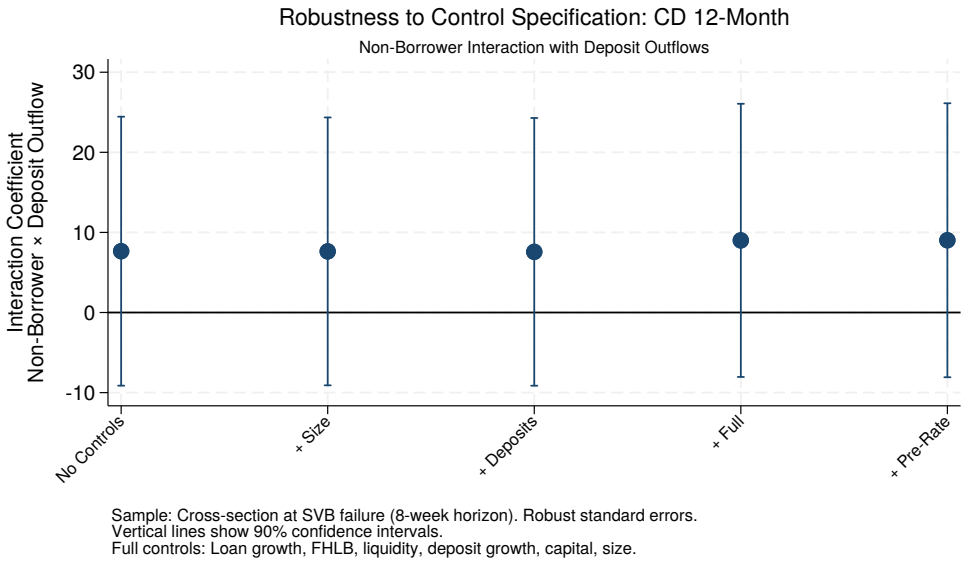

*Notes:* Coefficient on the interaction between non-borrower status and deposit outflows at various horizons after SVB failure for 24-month CD rates. 90% confidence intervals shown.

Figure A4: Robustness to Control Specification: 6-Month CD Rate Response



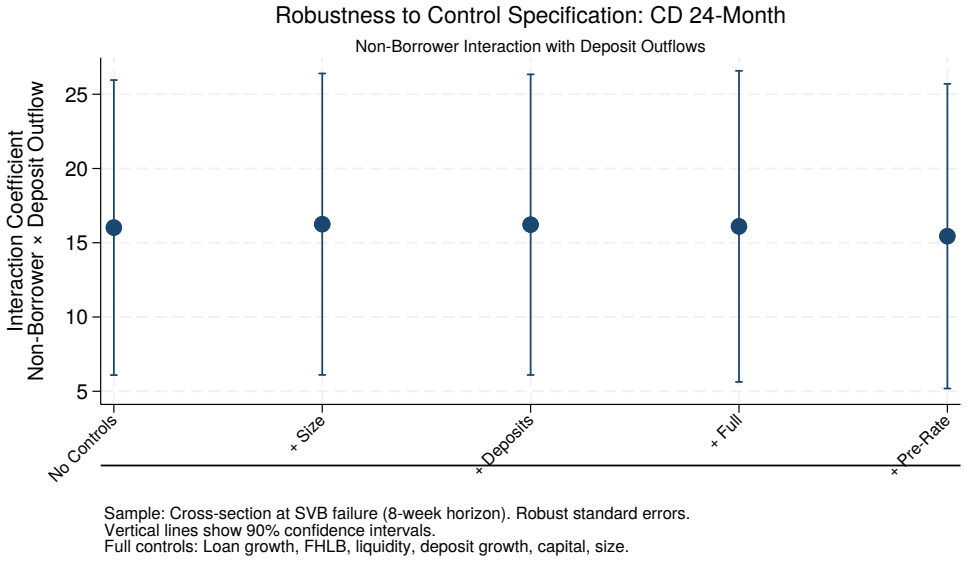

*Notes:* Estimated coefficient on Non-Borrower × Deposit Outflow from progressively richer control specifications. Dependent variable is the 26-week change in posted 6-month CD rates. Error bars represent 90% confidence intervals using robust standard errors.

Figure A5: Robustness to Control Specification: 12-Month CD Rate Response



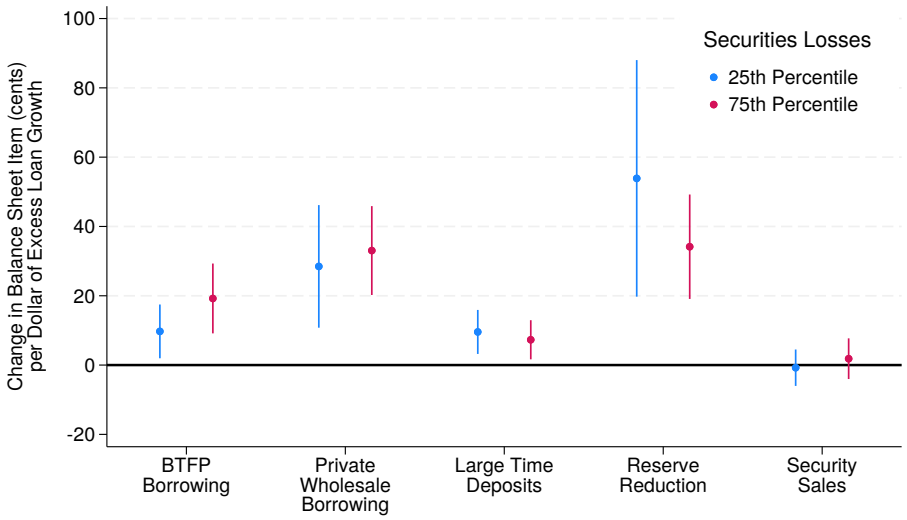

*Notes:* Estimated coefficient on Non-Borrower × Deposit Outflow from progressively richer control specifications. Dependent variable is the 26-week change in posted 12-month CD rates. Error bars represent 90% confidence intervals using robust standard errors.

Figure A6: Robustness to Control Specification: 24-Month CD Rate Response



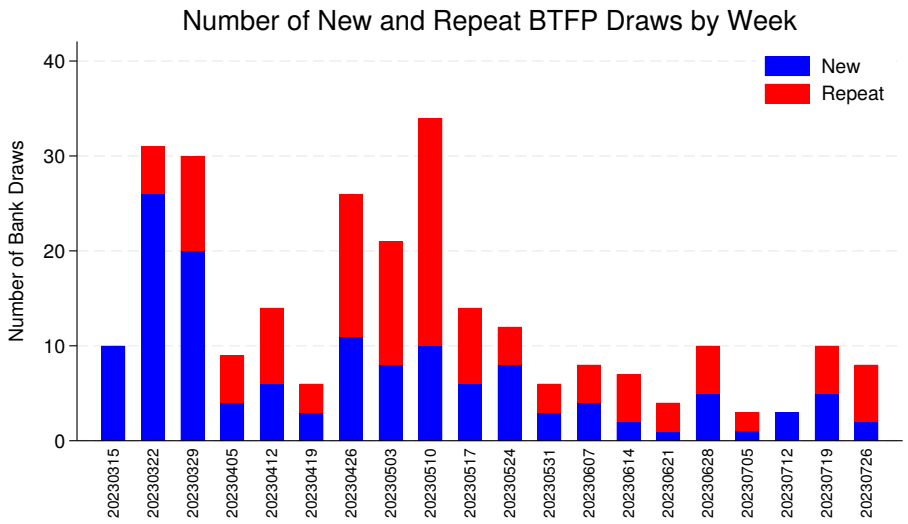

*Notes:* Estimated coefficient on Non-Borrower × Deposit Outflow from progressively richer control specifications. Dependent variable is the 26-week change in posted 24-month CD rates. Error bars represent 90% confidence intervals using robust standard errors.

Figure A7: How Banks Fund Excess Loan Growth



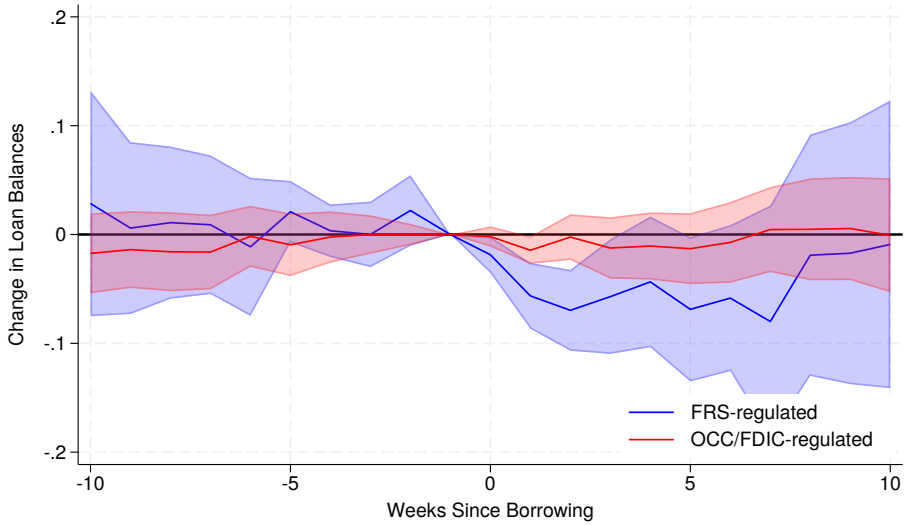

*Notes: The chart presents estimates of how much various funding sources are used (in cents) to meet a $1 increase in funding needs (as measured by excess loan growth). Blue dots (lines) present point estimates (95% confidence intervals) for overall usage. Red dots and lines present equivalent estimates for a bank at the 75th percentile in securities losses as a share of assets.*

Figure A8: How Banks Draw on BTFP




*Note: The chart shows the number of draws on BTFP by banks each week. It distinguishes between new darws (in blue) and repeat draws (in red) by any given bank over the sample period.*

Figure A9: BTFP Usage by Less-Capitalized Banks and Regulatory Authority




*Notes: The chart shows changes in lending surrounding a change in BTFP borrowing as a share of assets, while differentiating across less-capitalized banks depending on whether they are regulated by (i) the Federal Reserve System (FRS) or (ii) either the OCC or the FDIC. Less-capitalized banks have an adjusted tangible common equity ratio below 3%.*

## A.4 Additional tables and figures

Table A1: Summary Statistics

| Variable | Mean | Std. Deviation | 25th Perc. | Median | 75th Perc. | Observations |
|---|---|---|---|---|---|---|
| ΔCore Deposits/Assets | -1.66 | 3.09 | -3.19 | -1.82 | -0.33 | 668 |
| ΔCore Deposits$^{-}$/Assets | -2.20 | 2.15 | -3.19 | -1.82 | -0.33 | 668 |
| 0/1 BTFP Borrowing | 0.12 | 0.33 | 0.00 | 0.00 | 0.00 | 668 |
| ΔBTFP/Assets | 0.57 | 1.97 | 0.00 | 0.00 | 0.00 | 668 |
| ΔNon-Fed Borrowing/Assets | 0.72 | 2.91 | -0.01 | 0.00 | 1.81 | 668 |
| Uninsured Deposits/Assets | 28.57 | 12.76 | 19.62 | 27.54 | 35.53 | 668 |
| Securities losses/Assets | 2.63 | 1.98 | 1.20 | 2.34 | 3.63 | 668 |
| HTM loss/Assets | 0.40 | 0.90 | 0.00 | 0.00 | 0.29 | 668 |
| AFS loss/Assets | 2.23 | 1.92 | 0.82 | 1.78 | 3.12 | 668 |
| CRE/Assets | 28.45 | 16.31 | 16.70 | 27.72 | 38.87 | 668 |
| ΔLoans/Assets | 0.92 | 1.56 | 0.19 | 0.76 | 1.58 | 668 |
| Tier 1 Capital/Assets | 10.30 | 2.90 | 8.78 | 9.69 | 11.01 | 668 |
| Liquid Assets/Assets | 31.00 | 15.87 | 19.56 | 27.96 | 40.14 | 668 |
| Avg. Funding Cost | 0.80 | 0.56 | 0.44 | 0.68 | 1.01 | 668 |
| 2022 Dep. Growth | 3.25 | 11.40 | -3.20 | 2.44 | 7.62 | 668 |
| FHLB Advances/Assets | 3.01 | 4.08 | 0.00 | 1.36 | 4.86 | 668 |
| Community Bank | 0.82 | 0.39 | 1.00 | 1.00 | 1.00 | 668 |
| Regional Bank | 0.16 | 0.37 | 0.00 | 0.00 | 0.00 | 668 |

*Notes: The table presents summary statistics for the main variables used in the analysis. Units are percentage points besides for the bank size dummy variables.*

Table A2: Determinants of Core Deposit Outflows—Full Set of Controls

| | $\frac{\Delta\text{Deposits}}{\text{Assets}}$ | | | | | |
|---|---|---|---|---|---|---|
| | Total loss | | HTM, AFS | | HTM, AFS, CRE | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | -0.034* | -0.008 | -0.034* | -0.006 | -0.030* | -0.004 |
| | (0.013) | (0.022) | (0.014) | (0.022) | (0.014) | (0.035) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.012* | | | | |
| | | (0.006) | | | | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | | -0.031** | | -0.032** |
| | | | | (0.011) | | (0.011) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | | -0.009 | | -0.009 |
| | | | | (0.006) | | (0.006) |
| $\times \frac{\text{CRE loans}}{\text{Assets}}$ | | | | | | 0.000 |
| | | | | | | (0.001) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.022 | 0.362* | | | | |
| | (0.081) | (0.156) | | | | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.014 | 1.014** | 0.020 | 1.049** |
| | | | (0.141) | (0.298) | (0.141) | (0.295) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.024 | 0.283* | 0.018 | 0.280* |
| | | | (0.080) | (0.158) | (0.081) | (0.158) |
| $\frac{\text{CRE loans}}{\text{Assets}}$ | | | | | -0.011 | -0.016 |
| | | | | | (0.010) | (0.023) |
| $\frac{\Delta\text{Loans}}{\text{Assets}}$ | 0.259** | 0.258** | 0.259** | 0.249* | 0.260** | 0.250* |
| | (0.099) | (0.099) | (0.099) | (0.099) | (0.099) | (0.099) |
| $\frac{\text{Tier 1 Capital}}{\text{Assets}}$ | 0.086 | 0.079 | 0.086 | 0.082 | 0.093 | 0.089 |
| | (0.056) | (0.056) | (0.056) | (0.057) | (0.059) | (0.060) |
| $\frac{\text{Liquid Assets}}{\text{Assets}}$ | -0.023 | -0.023* | -0.023 | -0.023 | -0.029* | -0.030* |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.015) | (0.014) |
| Avg. Funding Cost | 0.542 | 0.587* | 0.542 | 0.582* | 0.495 | 0.522 |
| | (0.349) | (0.348) | (0.348) | (0.350) | (0.351) | (0.369) |
| 2022 Dep. Growth | 0.042** | 0.042** | 0.042** | 0.041** | 0.041** | 0.040** |
| | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) | (0.015) |
| $\frac{\text{FHLB Advances}}{\text{Assets}}$ | 0.047 | 0.049 | 0.047 | 0.052 | 0.051 | 0.056 |
| | (0.037) | (0.038) | (0.037) | (0.039) | (0.038) | (0.039) |
| Community Bank | 0.627 | 0.537 | 0.621 | 0.506 | 0.807 | 0.725 |
| | (0.908) | (0.895) | (0.911) | (0.906) | (0.940) | (0.926) |
| Regional Bank | 1.368 | 1.310 | 1.366 | 1.298 | 1.455 | 1.402 |
| | (0.950) | (0.943) | (0.952) | (0.951) | (0.961) | (0.959) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.137 | 0.146 | 0.137 | 0.151 | 0.138 | 0.154 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 |

*Notes: Same specification as Table 1 with the full set of controls reported. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A3: Determinants of Core Deposit Outflows—Non-linearity in Securities Losses

| | $\frac{\Delta \text{Deposits}}{\text{Assets}}$ | | | |
|---|---|---|---|---|
| | Non-linear effects with securities losses | | Non-linear effects with HTM losses | |
| | (1) | (2) | (3) | (4) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | -0.02 | -0.01 | -0.03* | -0.03 |
| | (0.01) | (0.02) | (0.02) | (0.02) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | -0.01** | | | |
| | (0.00) | | | |
| $\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec losses $<$ 90th percentile) | | -0.01** | | |
| | | (0.01) | | |
| $\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec losses $\geq$ 90th percentile) | | -0.01** | | |
| | | (0.00) | | |
| $\times \frac{\text{Loss HTM}}{\text{Assets}}$ | | | -0.03** | |
| | | | (0.01) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}} \times$ (HTM loss $<$ 90th percentile) | | | | -0.04** |
| | | | | (0.02) |
| $\times \frac{\text{HTM loss}}{\text{Assets}} \times$ (HTM loss $\geq$ 90th percentile) | | | | -0.03** |
| | | | | (0.01) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.37** | 0.37** | | |
| | (0.17) | (0.17) | | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.88** | 0.90** |
| | | | (0.36) | (0.36) |
| Bank controls | Yes | Yes | Yes | Yes |
| $R^2$ | 0.166 | 0.166 | 0.165 | 0.167 |
| Observations | 539 | 539 | 539 | 539 |
| P-value for coeff. equality test | | .74 | | .21 |

*Notes: Same specification as Table 1 allowing for non-linear effects of securities losses and HTM losses. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A4: Wholesale Borrowing—Full Set of Controls

| | 0/1 BTFP Borrowings | | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.028*** | -0.012 | -0.012 | -0.162*** | -0.073 | -0.070 | -0.401*** | -0.498*** | -0.501*** |
| | (0.007) | (0.008) | (0.009) | (0.053) | (0.057) | (0.059) | (0.067) | (0.104) | (0.105) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.006** | | | -0.036* | | | 0.039 | |
| | | (0.003) | | | (0.018) | | | (0.024) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.015* | | | -0.095 | | | 0.086 |
| | | | (0.008) | | | (0.085) | | | (0.066) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.005 | | | -0.025 | | | 0.030 |
| | | | (0.003) | | | (0.017) | | | (0.025) |
| $\frac{\Delta\text{Deposits}^+}{\text{Assets}}$ | -0.002 | 0.001 | 0.001 | 0.067 | 0.045 | 0.038 | -0.213** | -0.196 | -0.202 |
| | (0.009) | (0.008) | (0.008) | (0.106) | (0.079) | (0.074) | (0.087) | (0.148) | (0.151) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.002 | | | 0.009 | | | -0.006 | |
| | | (0.003) | | | (0.027) | | | (0.054) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.009 | | | -0.056 | | | -0.090 |
| | | | (0.007) | | | (0.061) | | | (0.082) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.001 | | | 0.022 | | | 0.011 |
| | | | (0.004) | | | (0.039) | | | (0.062) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.034*** | 0.016 | | 0.210*** | 0.104 | | 0.093 | 0.207** | |
| | (0.007) | (0.011) | | (0.050) | (0.070) | | (0.063) | (0.099) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.012 | | | 0.022 | | | 0.372* |
| | | | (0.026) | | | (0.202) | | | (0.202) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.018 | | | 0.124* | | | 0.179* |
| | | | (0.011) | | | (0.072) | | | (0.103) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.002* | 0.002* | 0.001 | 0.014** | 0.014** | 0.012** | -0.001 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.006) | (0.006) | (0.006) | (0.009) | (0.009) | (0.010) |
| $\frac{\Delta\text{Loans}}{\text{Assets}}$ | 0.011 | 0.010 | 0.011 | 0.066 | 0.063 | 0.073 | 0.261* | 0.266* | 0.270* |
| | (0.009) | (0.009) | (0.009) | (0.051) | (0.052) | (0.052) | (0.149) | (0.149) | (0.152) |
| $\frac{\Delta\text{Tier 1 Capital}}{\text{Assets}}$ | 0.002 | 0.002 | 0.002 | -0.001 | -0.003 | -0.002 | -0.001 | 0.001 | 0.001 |
| | (0.005) | (0.005) | (0.006) | (0.015) | (0.015) | (0.016) | (0.030) | (0.032) | (0.032) |
| $\frac{\text{Liquid Assets}}{\text{Assets}}$ | -0.002** | -0.001* | -0.001** | -0.006 | -0.005 | -0.006 | -0.044*** | -0.045*** | -0.046*** |
| | (0.001) | (0.001) | (0.001) | (0.004) | (0.004) | (0.004) | (0.008) | (0.008) | (0.009) |
| Avg. Funding Cost | 0.009 | 0.004 | 0.006 | 0.297 | 0.283 | 0.290 | -0.328 | -0.311 | -0.314 |
| | (0.022) | (0.022) | (0.022) | (0.193) | (0.201) | (0.200) | (0.233) | (0.235) | (0.236) |
| 2022 Dep. Growth | -0.001 | -0.002 | -0.001 | -0.019** | -0.020** | -0.020** | 0.007 | 0.009 | 0.009 |
| | (0.001) | (0.001) | (0.001) | (0.009) | (0.008) | (0.008) | (0.012) | (0.012) | (0.012) |
| $\frac{\text{FHLB Advances}}{\text{Assets}}$ | 0.006* | 0.006* | 0.006* | 0.039 | 0.041 | 0.040 | -0.015 | -0.018 | -0.019 |
| | (0.003) | (0.003) | (0.003) | (0.025) | (0.025) | (0.025) | (0.031) | (0.031) | (0.031) |
| Community Bank | 0.094** | 0.078** | 0.082* | 0.556* | 0.471 | 0.452 | -2.123*** | -2.030*** | -1.972*** |
| | (0.043) | (0.039) | (0.042) | (0.326) | (0.311) | (0.324) | (0.662) | (0.646) | (0.654) |
| Regional Bank | 0.083* | 0.068 | 0.069 | 0.583 | 0.508 | 0.508 | -1.052 | -0.970 | -0.884 |
| | (0.048) | (0.045) | (0.046) | (0.367) | (0.346) | (0.350) | (0.719) | (0.705) | (0.704) |
| Constant | -0.174** | -0.107 | -0.105 | -1.491** | -1.138* | -1.086* | 3.051*** | 2.664*** | 2.607*** |
| | (0.078) | (0.079) | (0.083) | (0.583) | (0.624) | (0.638) | (0.831) | (0.852) | (0.860) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.084 | 0.092 | 0.098 | 0.102 | 0.108 | 0.116 | 0.170 | 0.173 | 0.174 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 |

*Notes: Same specification as Table 3 with the full set of controls reported. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A5: Pecking Order of Funding Sources

| | $\frac{\Delta BTFP\ Borrowings}{Assets}$ | $-\frac{\Delta Cash}{Assets}$ | $\frac{\Delta NonFed\ Borrowings}{Assets}$ | $\frac{\Delta LT.\ Dep.}{Assets}$ | $-\frac{\Delta Securities}{Assets}$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\frac{\Delta \text{Deposits}^-}{\text{Assets}}$ | -0.073 | -0.726** | -0.498*** | -0.036 | -0.005 |
| | (0.057) | (0.297) | (0.104) | (0.042) | (0.040) |
| $\times \frac{\text{Securities loss}}{\text{Assets}}$ | -0.036* | 0.081 | 0.039 | -0.009 | -0.007 |
| | (0.018) | (0.067) | (0.024) | (0.011) | (0.013) |
| $\frac{\text{Securities loss}}{\text{Assets}}$ | 0.104 | 0.036 | 0.207** | -0.005 | -0.052 |
| | (0.070) | (0.239) | (0.099) | (0.048) | (0.051) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.014** | -0.000 | 0.000 | -0.000 | 0.002 |
| | (0.006) | (0.016) | (0.009) | (0.004) | (0.003) |
| Bank controls | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.108 | 0.220 | 0.173 | 0.061 | 0.037 |
| Observations | 668 | 668 | 668 | 668 | 668 |

*Notes: Regressions of changes in various balance sheet items on deposit outflows, including securities losses both in levels and interacted with outflows. Same controls as Table 3.* $^{*}$, $^{**}$, $^{***}$ *denote significance at 10%, 5%, and 1%.*

Table A6: Funding of Excess Loan Growth

| | $\frac{\Delta BTFP\ Borrowings}{Assets}$ | $-\frac{\Delta Cash}{Assets}$ | $\frac{\Delta NonFed\ Borrowings}{Assets}$ | $\frac{\Delta LT.\ Dep.}{Assets}$ | $-\frac{\Delta Securities}{Assets}$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\frac{\Delta(\text{Loans-Deposits})^+}{\text{Assets}}$ | 0.051 | 0.632*** | 0.246* | 0.113*** | -0.024 |
| | (0.045) | (0.236) | (0.125) | (0.042) | (0.031) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | 0.039*** | -0.081 | 0.019 | -0.009 | 0.011 |
| | (0.015) | (0.057) | (0.026) | (0.012) | (0.011) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.066 | 0.094 | -0.019 | 0.075 | -0.076 |
| | (0.062) | (0.238) | (0.099) | (0.056) | (0.053) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.014** | 0.003 | 0.005 | -0.002 | 0.003 |
| | (0.006) | (0.016) | (0.010) | (0.005) | (0.003) |
| Bank controls | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.114 | 0.216 | 0.179 | 0.071 | 0.038 |
| Observations | 668 | 668 | 668 | 668 | 668 |

*Notes: Same specification as Table A5 replacing deposit outflows with excess loan growth. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A7: Wholesale Borrowing—Regional and Community Banks

| | 0/1 BTFP Borrowings | | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Panel A: Regional Banks | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.054*** | -0.004 | -0.007 | -0.393* | 0.156 | 0.073 | -0.782*** | -1.293*** | -1.094** |
| | (0.017) | (0.023) | (0.022) | (0.200) | (0.201) | (0.140) | (0.240) | (0.477) | (0.470) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.022*** | | | -0.244** | | | 0.229 | |
| | | (0.008) | | | (0.098) | | | (0.163) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.033*** | | | -0.386*** | | | 0.404*** |
| | | | (0.009) | | | (0.094) | | | (0.131) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.015 | | | -0.108 | | | -0.014 |
| | | | (0.013) | | | (0.129) | | | (0.209) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.069** | 0.032 | | 0.540** | 0.109 | | -0.204 | 0.230 | |
| | (0.032) | (0.031) | | (0.237) | (0.218) | | (0.275) | (0.326) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.016 | | | -0.456 | | | 0.874* |
| | | | (0.075) | | | (0.470) | | | (0.524) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.046 | | | 0.300 | | | -0.049 |
| | | | (0.034) | | | (0.213) | | | (0.360) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.001 | 0.001 | 0.002 | 0.006 | 0.006 | 0.010 | -0.016 | -0.017 | -0.022 |
| | (0.002) | (0.002) | (0.002) | (0.014) | (0.014) | (0.015) | (0.020) | (0.022) | (0.022) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.228 | 0.272 | 0.279 | 0.210 | 0.299 | 0.330 | 0.309 | 0.344 | 0.382 |
| Observations | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 108 |
| | Panel B: Community Banks | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.025*** | -0.010 | -0.010 | -0.141*** | -0.090 | -0.088 | -0.315*** | -0.357*** | -0.359*** |
| | (0.008) | (0.010) | (0.010) | (0.053) | (0.072) | (0.071) | (0.065) | (0.104) | (0.105) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | | -0.005 | | | -0.019 | | | 0.015 | |
| | | (0.003) | | | (0.018) | | | (0.025) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.007 | | | 0.029 | | | -0.010 |
| | | | (0.011) | | | (0.047) | | | (0.062) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.005 | | | -0.025 | | | 0.018 |
| | | | (0.003) | | | (0.017) | | | (0.026) |
| $\frac{\text{Securities losses}}{\text{Assets}}$ | 0.032*** | 0.017 | | 0.183*** | 0.128* | | 0.082 | 0.115 | |
| | (0.008) | (0.012) | | (0.051) | (0.076) | | (0.063) | (0.101) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.032 | | | 0.256* | | | 0.061 |
| | | | (0.035) | | | (0.155) | | | (0.211) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.016 | | | 0.110 | | | 0.120 |
| | | | (0.013) | | | (0.079) | | | (0.105) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.002 | 0.002 | 0.001 | 0.015* | 0.014* | 0.015* | 0.001 | 0.002 | 0.001 |
| | (0.001) | (0.001) | (0.001) | (0.008) | (0.008) | (0.008) | (0.011) | (0.011) | (0.012) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.073 | 0.079 | 0.083 | 0.110 | 0.112 | 0.114 | 0.129 | 0.131 | 0.132 |
| Observations | 545 | 545 | 545 | 545 | 545 | 545 | 545 | 545 | 545 |

*Notes: Same specification as Table 3 estimated separately for regional banks (Panel A, $10–250 billion assets) and community banks (Panel B, under $10 billion). *, **, *** denote significance at 10%, 5%, and 1%.*

Table A8: Wholesale Borrowing—High vs. Low Capital Banks

| | 0/1 BTFP Borrowings | | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Panel A: Low Capital Banks | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.037*** | -0.017 | -0.023* | -0.188** | -0.051 | -0.078 | -0.532*** | -0.677*** | -0.668*** |
| | (0.010) | (0.014) | (0.014) | (0.078) | (0.078) | (0.073) | (0.103) | (0.173) | (0.169) |
| $\times \frac{\text{Securities loss}}{\text{Assets}}$ | | -0.008 | | | -0.058 | | | 0.061 | |
| | | (0.006) | | | (0.038) | | | (0.051) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.021** | | | -0.154 | | | 0.144* |
| | | | (0.009) | | | (0.095) | | | (0.086) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.002 | | | -0.013 | | | 0.022 |
| | | | (0.006) | | | (0.032) | | | (0.054) |
| $\frac{\text{Securities loss}}{\text{Assets}}$ | 0.037*** | 0.018 | | 0.274*** | 0.140 | | 0.128 | 0.262 | |
| | (0.013) | (0.018) | | (0.101) | (0.123) | | (0.111) | (0.169) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | -0.005 | | | -0.161 | | | 0.634** |
| | | | (0.032) | | | (0.226) | | | (0.254) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.031 | | | 0.246** | | | 0.137 |
| | | | (0.019) | | | (0.120) | | | (0.176) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.000 | 0.000 | -0.000 | 0.005 | 0.004 | 0.003 | -0.004 | -0.004 | -0.008 |
| | (0.001) | (0.001) | (0.001) | (0.007) | (0.007) | (0.008) | (0.013) | (0.013) | (0.014) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.103 | 0.117 | 0.130 | 0.109 | 0.125 | 0.143 | 0.280 | 0.292 | 0.314 |
| Observations | 335 | 335 | 335 | 335 | 335 | 335 | 335 | 335 | 335 |
| | Panel B: High Capital Banks | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.018** | -0.004 | -0.004 | -0.126* | -0.064 | -0.065 | -0.317*** | -0.392*** | -0.395*** |
| | (0.009) | (0.011) | (0.011) | (0.068) | (0.088) | (0.089) | (0.085) | (0.130) | (0.130) |
| $\times \frac{\text{Securities loss}}{\text{Assets}}$ | | -0.005 | | | -0.024 | | | 0.029 | |
| | | (0.004) | | | (0.021) | | | (0.026) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.012 | | | 0.087 | | | -0.024 |
| | | | (0.013) | | | (0.081) | | | (0.103) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.007* | | | -0.033 | | | 0.033 |
| | | | (0.004) | | | (0.020) | | | (0.028) |
| $\frac{\text{Securities loss}}{\text{Assets}}$ | 0.033*** | 0.016 | | 0.189*** | 0.102 | | 0.043 | 0.150 | |
| | (0.009) | (0.014) | | (0.051) | (0.081) | | (0.070) | (0.126) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.090* | | | 0.603** | | | -0.160 |
| | | | (0.047) | | | (0.288) | | | (0.349) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.009 | | | 0.055 | | | 0.173 |
| | | | (0.014) | | | (0.078) | | | (0.131) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.003** | 0.003** | 0.003** | 0.022** | 0.022** | 0.021** | 0.004 | 0.005 | 0.005 |
| | (0.001) | (0.001) | (0.001) | (0.009) | (0.009) | (0.009) | (0.012) | (0.012) | (0.011) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.077 | 0.083 | 0.092 | 0.127 | 0.132 | 0.144 | 0.121 | 0.125 | 0.129 |
| Observations | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 |

*Notes: Same specification as Table 3 estimated separately for low-capital banks (Panel A) and high-capital banks (Panel B), split at the median Tier 1 capital-to-assets ratio. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A9: Wholesale Borrowing - Non-linearity in Securities Losses

| | 0/1 BTFP Borrowings | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.01 | -0.01 | -0.07 | -0.03 | -0.50*** | -0.45*** |
| | (0.01) | (0.01) | (0.06) | (0.06) | (0.10) | (0.11) |
| $\times \frac{\text{Securities losses}}{\text{Assets}}$ | -0.01** | | -0.04* | | 0.04 | |
| | (0.00) | | (0.02) | | (0.02) | |
| $\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. Losses $<$ 90th percentile) | | -0.01** | | -0.06* | | 0.01 |
| | | (0.00) | | (0.03) | | (0.04) |
| $\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. Losses $\geq$ 90th percentile) | | -0.01* | | -0.03* | | 0.05** |
| | | (0.00) | | (0.02) | | (0.02) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.092 | 0.097 | 0.108 | 0.113 | 0.173 | 0.176 |
| Observations | 668 | 668 | 668 | 668 | 668 | 668 |
| P-value for coeff. equality test | | .15 | | .2 | | .12 |

*Notes: The table shows results from cross-sectional regressions of changes in banks' BTFP borrowings and non-Fed borrowings (wholesale borrowings that exclude BTFP and discount window) over the interval March 8—May 3, 2023 on contemporaneous deposit growth ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), uninsured deposits, HTM securities losses, contemporaneous loan growth ($\Delta Loans_{i,t,t'}/Assets_{i,t}$), tier 1 capital-to-assets ratio, liquid asset holdings (the sum of cash, federal funds, reverse repo and securities holdings), average funding cost (annualized interest expense as a percent of total liabilities), deposit growth in 2022, FHLB advances, and bank size indicators (i.e., community banks are ones with assets under \$10 billion in assets and regional banks ones with assets between \$10 and \$ 250 billion in assets) measured as of 2022:Q4. Core deposit and contemporaneous loan growth are winsorized at the 1 and 99 percent levels. All continuous variables are measured in percentage points (specifically, with the exception of 2022 deposit growth and average funding cost, measure variables as a percent of initial total assets). $^+$,*,** indicate significance at 10%, 5%, and 1%, respectively.*

Table A10: Wholesale Borrowing—Arbitrage Incentives

| | 0/1 BTFP Borrowings | | | $\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$ | | | $\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\frac{\Delta\text{Deposits}^-}{\text{Assets}}$ | -0.005 | -0.008 | -0.008 | -0.003 | -0.028 | -0.025 | -0.270*** | -0.253*** | -0.253*** |
| | (0.009) | (0.012) | (0.012) | (0.032) | (0.052) | (0.050) | (0.048) | (0.085) | (0.085) |
| $\times \frac{\text{Securities loss}}{\text{Assets}}$ | | 0.001 | | | 0.010 | | | -0.009 | |
| | | (0.005) | | | (0.022) | | | (0.026) | |
| $\times \frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.019* | | | 0.100* | | | -0.028 |
| | | | (0.010) | | | (0.056) | | | (0.050) |
| $\times \frac{\text{AFS loss}}{\text{Assets}}$ | | | -0.003 | | | -0.010 | | | -0.005 |
| | | | (0.006) | | | (0.020) | | | (0.027) |
| $\frac{\text{Securities loss}}{\text{Assets}}$ | 0.036*** | 0.037*** | | 0.090*** | 0.095** | | -0.041 | -0.076 | |
| | (0.008) | (0.011) | | (0.034) | (0.042) | | (0.043) | (0.064) | |
| $\frac{\text{HTM loss}}{\text{Assets}}$ | | | 0.089*** | | | 0.249** | | | -0.095 |
| | | | (0.025) | | | (0.112) | | | (0.155) |
| $\frac{\text{AFS loss}}{\text{Assets}}$ | | | 0.025** | | | 0.055 | | | -0.070 |
| | | | (0.012) | | | (0.044) | | | (0.064) |
| $\frac{\text{Uninsured Deposits}}{\text{Assets}}$ | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | -0.004 | -0.004 | -0.004 |
| | (0.001) | (0.001) | (0.001) | (0.004) | (0.004) | (0.004) | (0.005) | (0.005) | (0.005) |
| $\text{BTFP}_t > 0$ | 0.288*** | 0.288*** | 0.289*** | 0.232 | 0.230 | 0.230 | -0.063 | -0.073 | -0.075 |
| | (0.045) | (0.046) | (0.045) | (0.164) | (0.163) | (0.160) | (0.160) | (0.159) | (0.161) |
| Bank controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.164 | 0.164 | 0.178 | 0.033 | 0.035 | 0.049 | 0.122 | 0.125 | 0.125 |
| Observations | 672 | 672 | 672 | 672 | 672 | 672 | 672 | 672 | 672 |

*Notes: Cross-sectional regressions of BTFP borrowings and non-Fed borrowings over November 29, 2023 to January 24, 2024 on deposit growth, an indicator for outstanding BTFP loans at the start of the interval, and funding vulnerability measures. Same controls as Table 3. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A11: Determinants of Deposit Outflows—Credit Unions

| | $\frac{\Delta\text{Deposits}}{\text{Assets}}$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\frac{\text{Uninsured Dep.}}{\text{Assets}}_{22Q4}$ | 0.055** | 0.061** | 0.022 | 0.029 | 0.073*** | 0.086*** |
| | (0.022) | (0.025) | (0.017) | (0.020) | (0.024) | (0.028) |
| $\frac{\text{Loss MTM}}{\text{Assets}}_{22Q4}$ | 0.061*** | 0.074*** | 0.017 | 0.033* | 0.075*** | 0.104*** |
| | (0.020) | (0.027) | (0.015) | (0.017) | (0.026) | (0.035) |
| $\times \frac{\text{Loss MTM}}{\text{Assets}}_{22Q4}$ | | -0.005 | | -0.006 | | -0.011 |
| | | (0.006) | | (0.004) | | (0.007) |
| Constant | -1.724 | -1.732 | 2.521 | 2.512 | 0.144 | 0.128 |
| | (1.163) | (1.162) | (1.962) | (1.960) | (2.050) | (2.046) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.199 | 0.199 | 0.131 | 0.131 | 0.218 | 0.219 |
| N | 4793 | 4793 | 4764 | 4764 | 4764 | 4764 |

*Notes: Cross-sectional regressions of changes in credit unions' deposits on uninsured deposits, HTM securities losses, and controls. Estimated separately across quarters of 2023. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A12: Interest-Rate Arbitrage by Credit Unions

| | $\frac{\Delta\text{Reserves}}{\text{Assets}}$ | | | |
|---|---|---|---|---|
| | Mar 13-Nov 14 | | Nov 15 -Jan 23 | |
| | (1) | (2) | (3) | (4) |
| $\frac{\Delta\text{BTFP}}{\text{Assets}}$ | 0.853*** | 0.858*** | 0.933*** | 0.934*** |
| | (0.038) | (0.038) | (0.164) | (0.183) |
| Observations | 39,367 | 39,366 | 15,686 | 15,684 |
| R-squared | 0.134 | 0.134 | 0.229 | 0.231 |
| Date FE | Yes | Yes | Yes | Yes |
| RSSD FE | No | Yes | No | Yes |

*Notes: Regressions of daily changes in credit unions' reserves as a share of assets on daily changes in BTFP borrowing as a share of assets, for the pre-arbitrage (March 13–November 14, 2023) and arbitrage (November 15, 2023–January 23, 2024) periods. Standard errors clustered at the credit union level. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A13: Interest-Rate Arbitrage by Banks

| | $\frac{\Delta\text{Reserves}}{\text{Assets}}$ | | | |
|---|---|---|---|---|
| | Mar 13-Nov 14 | | Nov 15 -Jan 23 | |
| | (1) | (2) | (3) | (4) |
| $\frac{\Delta\text{BTFP}}{\text{Assets}}$ | 0.649*** | 0.652*** | 0.354* | 0.345* |
| | (0.068) | (0.068) | (0.181) | (0.196) |
| Observations | 27,959 | 27,958 | 10,393 | 10,393 |
| R-squared | 0.020 | 0.020 | 0.010 | 0.012 |
| Date FE | Yes | Yes | Yes | Yes |
| RSSD FE | No | Yes | No | Yes |

*Notes: Regressions of daily changes in banks' reserves as a share of assets on daily changes in BTFP borrowing as a share of assets, for the pre-arbitrage (March 13–November 14, 2023) and arbitrage (November 15, 2023–January 23, 2024) periods. Standard errors clustered at the bank level. *, **, *** denote significance at 10%, 5%, and 1%.*