Monetary Tightening, Bank Fragility, and Emergency Liquidity Support*

David Glancy Felicia Ionescu Elizabeth Klee
Antonis Kotidis Michael Siemer Andrei Zlate

September 14, 2026

Abstract

We explore the tension between a central bank's monetary policy and financial stability goals in the context of the Federal Reserve's 2022–2023 rate hike cycle, the March 2023 bank runs, and the Bank Term Funding Program (BTFP). In our framework, rate hikes reduce the cash a bank can raise against safe government securities under a market-value lending rule; par valuation preserves that capacity when withdrawals rise. The BTFP lent at par against securities marked down by rate increases. Banks with deposit outflows and large securities losses used it most, borrowing was associated with reserve accumulation, and operational readiness was a key determinant of usage. We find no detectable expansion of risky lending around draws; in the model, new private lending does not change the payoff on pledged government securities. Once expected rate cuts pushed new BTFP loan rates below the rate on reserves, existing borrowers were more likely to take out additional loans.

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

*Authors' contact details: David Glancy, email: David.P.Glancy@frb.gov. Felicia Ionescu, email: felicia.ionescu@frb.gov. Elizabeth Klee, email: elizabeth.c.klee@frb.gov. Antonis Kotidis, email: antonis.kotidis@frb.gov. Michael Siemer, email: Michael.Siemer@frb.gov. Andrei Zlate (corresponding author), email: Andrei.Zlate@frb.gov. A previous draft circulated under the title "How to stop a bank run: The 2023 banking turmoil and the Bank Term Funding Program". We thank our discussants Matthieu Chavaz, Erica Jiang, Sehwa Kim, Aakriti Mathur, Clément Mazet-Sonilhac, Win Monroe, Fabienne Schneider, and Elizaveta Sizova; Mark Carlson, Virginia Lewis, David Lowe, Matt Malloy, Francis Martinez, and Alexandros Vardoulakis; as well as seminar and conference participants at Federal Reserve Board, the 2025 Day Ahead Conference on Financial Markets and Institutions, Yale School of Management Program on Financial Stability, the Bank of England, the Bank of Mexico, the 9th Bristol Workshop on Banking and Financial Intermediation, Society of Economic Dynamics, and the Conference of Romanian Academic Economists from Abroad. Meghan Carpenter, Oliver Hyman-Metzger, and Bohan Wang provided outstanding research assistance. The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Board of Governors or anyone in the Federal Reserve System.

1 Introduction

In the spring of 2023, amid the largest bank failures since 2008, the Federal Reserve continued raising interest rates. After the policy rate had risen 450 basis points between March 2022 and February 2023, banks holding long-duration government securities faced large mark-to-market losses, funded by uninsured deposits. The resulting fragility materialized in March 2023: On March 10, Silicon Valley Bank (SVB) told regulators to expect $100 billion in withdrawals that day—approximately 60 percent of its deposits. It failed that day, and Signature Bank failed on March 12. Rather than cutting rates, on March 12 the Federal Reserve created the Bank Term Funding Program (BTFP), alongside a guarantee of the failed banks' deposits and other measures. By late July, the Fed completed 525 basis points of tightening—pursuing disinflation and financial stability simultaneously.

The March 2023 episode provides a direct setting in which to explore the tension between a central bank's monetary policy and financial stability goals. The classical doctrine on runs is sharp: lend freely against good collateral at a penalty rate (Bagehot, 1873), and through government securities rather than private credit, so support does not become credit allocation (Goodfriend and King, 1988). However, neither framework addresses how to intervene when the pursuit of monetary policy objectives precipitates the run. The Tinbergen (1952) principle offers a prescription — use separate instruments for inflation stabilization and financial stability — but provides limited operational guidance for liquidity facility design when rate increases create balance sheet stress.

In this paper, we examine how a central bank can address interest-rate related runs while continuing to pursue its inflation objective. We develop a framework for banks' funding choices after interest-rate increases mark down their securities, building on Jiang *et al.* (2023), Allen and Carletti (2008), and Allen *et al.* (2009a). The facility's collateral valuation, pricing, access arrangements, and eligibility rules determine which funding options a bank can use and what they cost. We then use bank- and transaction-level data to ask whether the program reached the vulnerable banks, whether operational readiness governed take-up, and whether it had unintended consequences. We also examine how emergency lending interacts with monetary policy transmission through the deposit channel (Drechsler *et al.*, 2017a). To our knowledge, this is the first empirical evaluation of a central bank lending facility restricted to the government securities favored by Goodfriend and King (1988). The BTFP lent to individual banks, whereas their proposal calls for open-market purchases. Our analysis complements Jiang *et al.* (2023): they characterize the vulnerability that prompted the runs, and we characterize the margins used to manage it.

Our paper proceeds in three parts. In the first part, we provide background on the conditions that characterized the March 2023 run. This included a rapid rise in interest rates over an 18 month period, a subsequent decline in interest rate expectations, significant unrealized losses on banks' government securities holdings, and a buildup of uninsured deposits. We also describe the BTFP

and its terms and conditions. The BTFP lent for up to a year against government collateral valued at par rather than at its marked-down price, at a fixed rate set as a spread over the one-year OIS at origination, through existing discount-window infrastructure. For banks facing unrealized losses on safe assets, par valuation made those losses less binding for liquidity. When used to replace deposit outflows, a BTFP advance substitutes fixed-rate term debt for runnable funding. The BTFP was open to depository institutions eligible for primary credit. Operational readiness varied among eligible banks.

In the second part, building on Jiang *et al.* (2023), Allen and Carletti (2008), and Allen *et al.* (2009a), we develop a tractable framework of rate-driven liquidity needs and facility access. A recurring question about the 2023 turmoil is whether it was a liquidity or a solvency crisis. For a duration markdown on safe assets, the framework separates three tests: whether the bank can fund today's withdrawals, whether it is solvent at market prices, and whether it can pay every claim at maturity. The markdown lowers the cash a bank can raise at market value without lowering the security's payoff, and it raises direct withdrawals at banks with loss-sensitive uninsured funding.

A market-value lending rule loses capacity as prices fall. A par rule preserves capacity at the face value of eligible collateral, provided the bank has timely access. If other sources can meet the cash need, the bank uses the facility when the saving in funding costs exceeds the fixed cost of first use. If other sources fall short but total capacity covers the need, facility use is necessary. New risky loans neither change the payoff on pledged government securities nor add BTFP capacity. With spare capacity, carry is worthwhile when expected earnings on the position exceed facility interest, other variable costs, balance-sheet costs, and any unpaid fixed costs.

In the third part of the paper, we document how deposit outflows vary with uninsured funding and securities losses. We then organize the evidence around four model implications: targeted take-up, operational readiness, narrow collateral, and carry. Because the BTFP was introduced alongside a guarantee of the failed banks' deposits and other March 12 measures, its aggregate effect cannot be separately identified. We examine borrowing patterns associated with securities losses, collateral, pricing, and operational readiness.

Our five results are as follows. First, the run was concentrated. Deposit outflows during the acute window rose with the interaction of uninsured-deposit reliance and unrealized securities losses: a bank at the 75th percentile of securities losses lost about 5 cents per dollar of uninsured deposits, against 2 cents at the 25th. By contrast, the interaction of uninsured funding with commercial real estate exposure was not statistically significant, despite contemporaneous stress in that sector. The distinction matters for facility design: par valuation can offset the liquidity consequences of a markdown on safe assets but cannot restore payments lost to credit defaults.

Second, BTFP borrowing was more responsive to outflows at banks with larger securities losses.

A bank at the 75th percentile of losses covered about 20 cents of every dollar of outflows with BTFP funds, against 12 cents at the 25th. This result is amplified for regional banks, which also sustained an aggregate confidence shock: those at the 75th percentile of losses covered more than 60 cents of every dollar of deposit outflows through the BTFP.

Third, banks with prior discount-window preparation used the BTFP sooner. Banks that had pre-positioned collateral at the discount window, whose infrastructure the BTFP inherited, tapped the facility faster. Conditional on securities losses and uninsured funding, operationally-ready banks covered roughly 30 cents per dollar of outflows through BTFP borrowing, while high-loss banks without operational readiness drew down reserves instead. These comparisons also control for other balance-sheet characteristics. Readiness was not randomly assigned, so they do not measure the causal effect of easier access.

Fourth, we find no detectable expansion of consumer, commercial real estate, or residential lending around BTFP draws, even among less-capitalized banks. The model limits the central bank's exposure through pledged government securities and leaves banks' lending choices unspecified. While we cannot rule out that BTFP funds were fungible with other bank resources, the behavioral patterns are consistent with the collateral restriction limiting risk-taking.

Fifth, borrowing rose as the BTFP rate fell below the interest rate on reserve balances (IORB) in late 2023. Banks already using the BTFP were more likely to take out new loans, and borrowing also increased among credit unions. In the model, prior borrowers can face lower unpaid access costs. Within eight weeks, the Federal Reserve set a floor for new advances at IORB on the day of origination.

Finally, we examine monetary transmission through the deposit channel (Drechsler *et al.*, 2017b). Comparing deposit pricing across borrowers and non-borrowers, we find that BTFP borrowers facing outflows raised six-month certificate-of-deposit rates more aggressively than comparably stressed non-borrowers, by about 29 against 10 basis points. The backstop did not sever overall monetary policy transmission, but it did shift the margin on which stressed banks adjusted. For borrowers with effective BTFP access, central bank liquidity preserved profitability and enabled deposit rate increases to preserve the deposit base. The BTFP dampened the deposit channel for vulnerable banks, allowing the majority of the banking system to respond to policy tightening while preserving financial stability.

Our evaluation of the BTFP highlights several design considerations for emergency facilities. First, par valuation restores capacity lost to a markdown on safe assets but cannot restore an impaired payoff. Second, an emergency facility needs procedures that let eligible banks use it promptly. Operationally ready banks used the BTFP sooner. Third, limiting collateral to government securities kept new private loans from expanding facility capacity. Fourth, a fixed loan

rate can fall below the rate paid on reserves. The Federal Reserve's floor removed that spread on new advances at origination. Fourth, fixed-rate structures created time-varying incentives that ultimately required adjustment to prevent arbitrage. Fifth, emergency facilities interact with ongoing monetary policy—in this case, BTFP borrowers raised deposit rates more than non-borrowers, dampening transmission for those institutions while it continued through the broader system.

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).[1] Allen and Gale (2004) and Allen *et al.* (2009b) 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 to government securities: The BTFP lent to individual banks against only government collateral, valued at par, and used existing discount-window infrastructure. We find no detectable expansion of risky lending around draws and document later borrowing associated with the IORB–BTFP spread. 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 spillover 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 context of the Paycheck Protection Program Liquidity Facility.

[1] 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.

Bank runs and interest rate risk. In the Diamond and Dybvig (1983) framework, runs arise because bank assets are illiquid: forced liquidation destroys value, creating a self-fulfilling run. Recent work shows that runs can occur even when assets are fully liquid and high-quality if interest rate increases reduce their market value below par (Drechsler *et al.*, 2026; 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 cases, 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 builds on this work by analyzing how banks substituted across funding sources—BTFP borrowing, reserve drawdowns, non-Fed wholesale funding, and deposit pricing. Our deposit-pricing evidence also connects to the deposits channel of monetary policy (Drechsler *et al.*, 2017b). BTFP borrowers and non-borrowers differed in how they adjusted deposit rates.

The 2023 banking turmoil. A 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.

The paper proceeds as follows. Section 2 describes the setting and the BTFP's design. Section 3 sets out the framework, which takes the withdrawal response as its measured input and organizes four implications—targeted take-up, operational readiness, narrow collateral, and carry. Sections 4 brings them to the data, Section 5 examines deposit-rate adjustment, and Section 6 concludes.

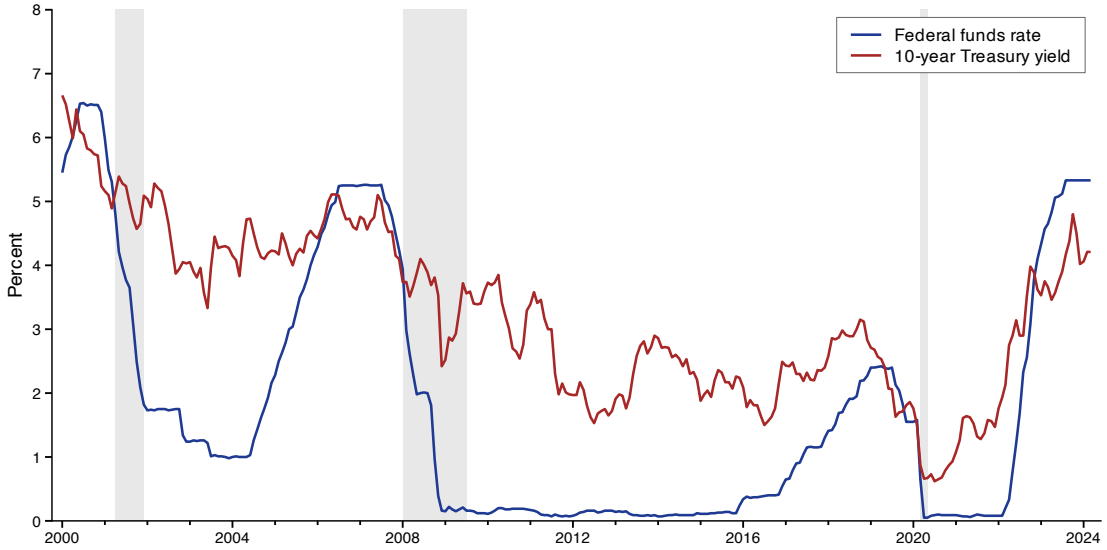
2 Background

2.1 The setting

In the wake of the COVID-19 pandemic, inflation started to rise in mid-2021, reflecting supply-chain disruptions, government stimulus, and other factors. In response to the inflation, in the spring of 2022, the Federal Reserve began to tighten monetary policy, and continued its tightening through mid-2023 (Figure 1). By the end of the tightening cycle, the Federal Reserve had raised the target range for the federal funds rate by over 500 basis points, and the policy rate reached a level not

seen in over 15 years. Longer-term interest rates also increased substantially, with the yield on the 10-year Treasury security moving up by 300 basis points.

Figure 1: Federal funds rate and 10-year Treasury yield



Notes: Monthly observations from January 2000 to the most recent FRED release. Shaded vertical bands denote NBER-dated recessions. Source: Federal Reserve Economic Data (FRED), series FEDFUNDS and GS10.

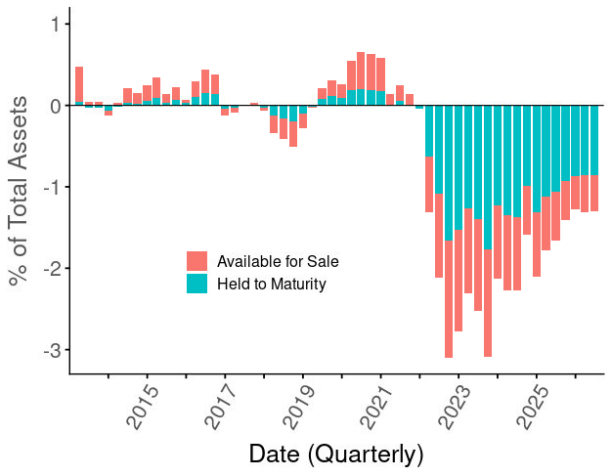
As a result of these changes in yields, banks accumulated significant unrealized losses on securities holdings (Figure 2, panel a). Some banks allocate securities into two categories for regulatory purposes: held to maturity (HTM), for which unrealized losses do not immediately affect bank capital, and available-for-sale (AFS), for which losses do affect capital. Both of these categories of securities experienced notable losses, totaling close to 3 percent of bank assets. Meanwhile, banks turned more intensively to funding assets with uninsured deposits, especially the regional banks with total assets between $10 and $250 billion in total assets (Figure 2, panel b). These two vulnerabilities had little linear correlation across banks (Figure A2). In contrast to the pick-up in unrealized securities losses reflecting banks' exposure to interest rate risk, credit performance was relatively benign in 2023, notwithstanding some pickup in delinquencies and charge-offs for commercial real estate loans (Figure 2, panel c).

2.2 The run

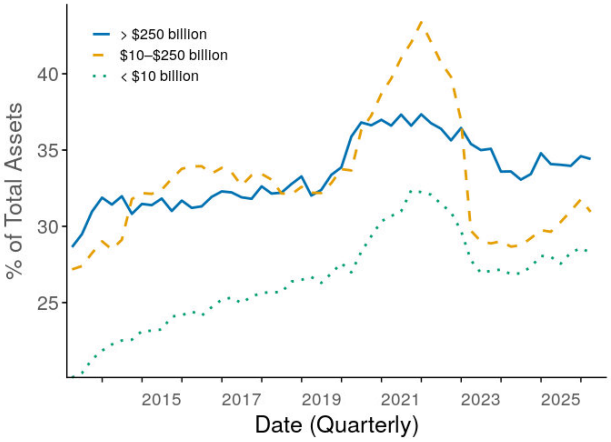
By early 2023, banks had become vulnerable along two dimensions: larger unrealized securities losses and greater reliance on uninsured deposit funding. The combination of unrealized losses and reliance on uninsured deposits culminated in runs in March 2023 and the failures of SVB and Signature Bank. 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 2, panel d).

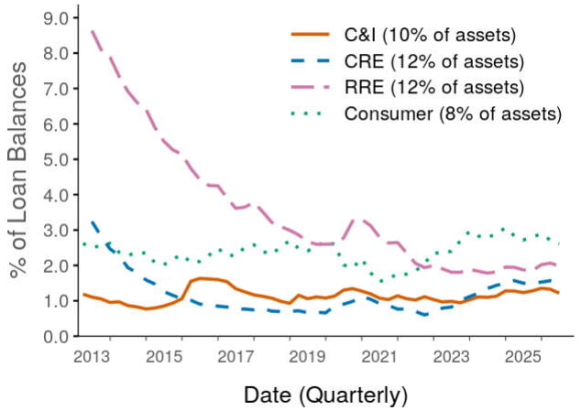
Figure 2: Bank Vulnerabilities and Deposit Outflows



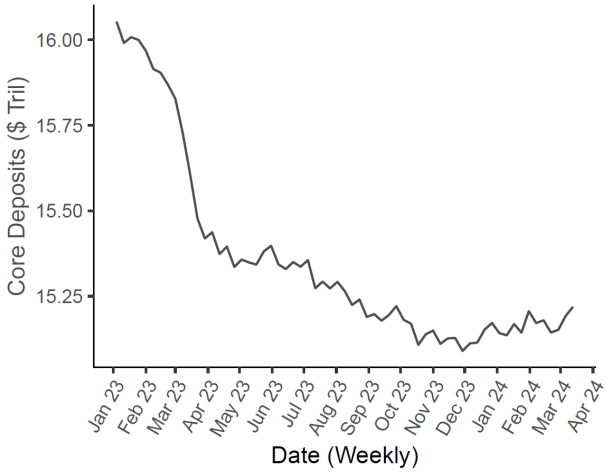
(a) Unrealized securities losses



(b) Uninsured deposits by bank size



(c) Loan delinquencies and non-accruals



(d) Core deposit outflows

Note: Panel (a) shows unrealized securities losses as a percent of total assets—held-to-maturity (HTM), in green, and available-for-sale (AFS), in red—for all U.S. commercial banks at the quarterly frequency from 2013:Q1 to 2026:Q2. Panel (b) shows uninsured deposits as a percent of total assets by bank size, while panel (c) shows loan delinquencies and non-accruals as a percent of loan balances of each type (commercial & industrial, commercial real estate, residential real estate, and consumer) for the same sample of banks and the same interval; the share of loan balances of each type in banks' total assets as of 2022:Q4 is listed in the legend. Panel (d) shows the levels of core deposits for U.S. domestically-chartered commercial banks at the weekly frequency from January 2023 to March 2024. Source: author calculations, Call Reports, H.8.

2.3 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 Board announced the establishment of the BTFP under section 13(3) of the Federal Reserve Act. In addition, the Federal Reserve and other agencies took actions to protect depositors and maintain confidence in the banking sector. On March 12, the Federal Deposit Insurance Corporation (FDIC), and the Federal Reserve announced the FDIC would guarantee uninsured deposits at SVB and Signature Bank under the statutory systemic risk exception to least-cost resolution.

The BTFP was available to depository institutions that were eligible for primary credit at the Federal Reserve's discount window. The design of the program and the terms of the BTFP were specifically tailored to address interest rate risk—the key vulnerability that destabilized banks' deposit franchises. The borrowing rate was set at 10 basis points over the one-year OIS rate, which reflects market's expectations about the path of monetary policy one year ahead. Regulation A requires emergency credit to carry a penalty rate relative to normal market conditions, while providing liquidity during stress and encouraging repayment as conditions normalize. 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.[2] 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 kept the cost of using the facility low.

The BTFP only accepted government-guaranteed securities eligible for purchase in open market operations.[3] 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, 2009b). Operationally, the BTFP was set up within a day on existing discount window infrastructure.

The idea behind the BTFP'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. A bank that replaces deposit outflows with BTFP borrowing substitutes fixed-rate term debt for runnable funding. If it holds the proceeds as remunerated reserves, it funds a floating-rate asset with debt that reprices annually.

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

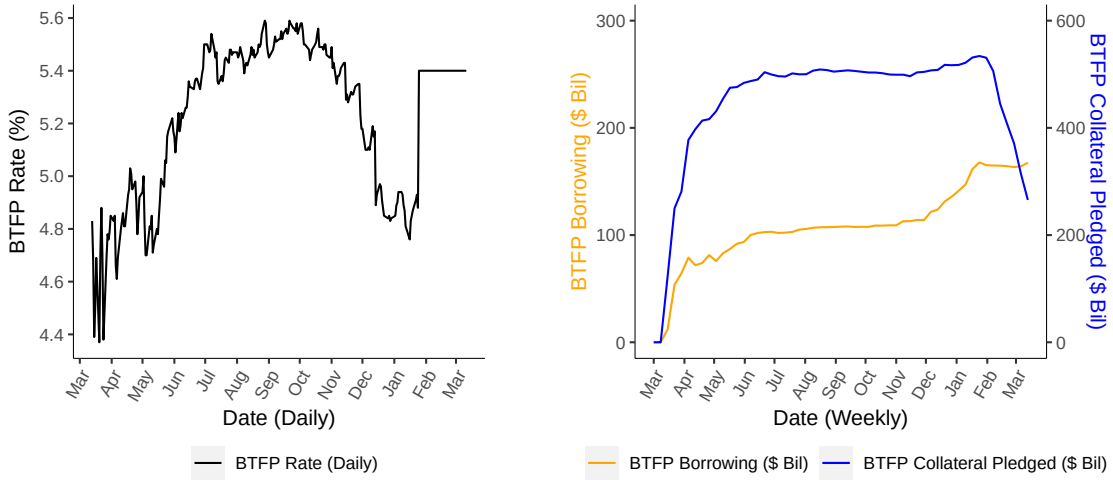
[3] Depository institutions needed to own these securities as of March 12, 2023.

FHLBs offer longer-term funding and apply collateral haircuts. Their valuation rules differ by collateral type and district, so borrowing capacity can fall with market values. The Federal Reserve's discount window accepts a wider range of collateral, but its loans carry a floating rate (the top of the federal funds target range) and terms of up to 90 days.[4]

While the tension between monetary tightening and bank fragility is not new, the March 2023 episode differed in kind. For example, the early-1980s savings-and-loan crisis was also related to monetary tightening. However, it emerged as thrifts earned low fixed rates on long-term mortgages while paying rising market rates on deposits—an earnings squeeze, rather than as a liquidity run on still-sound safe collateral. Their impaired assets were illiquid whole mortgages, not marketable safe securities pledgeable at par, and their losses ultimately ran through credit. The policy response accordingly ran through the thrift regulatory and insurance apparatus (deregulation, accounting forbearance, FSLIC support, delayed and later RTC resolution) and Federal Home Loan Bank advances, rather than as a par-collateral backstop suitable to a run on safe securities.

Figure 3 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 3: 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.

[4]Between March 12 and October 31, 2023, the discount window also applied zero haircuts to BTFP-eligible collateral; however, it continued to value collateral at the fair market value rather than the par value.

3 BTFP model

A rate shock lowers the market value of safe long-duration assets, can raise withdrawals by uninsured depositors, and can force a bank with thin reserves to sell at a depressed price. A facility that advances more than market value against the same collateral lets the bank borrow rather than sell. We model this mechanism in a reduced-form, three-date framework that combines the rate-loss and uninsured-withdrawal channel in Jiang *et al.* (2023) with the gap between interim market price and maturity payoff emphasized by Allen and Carletti (2008). On the facility side, the closest comparison is the long-term Fed loan in Drechsler *et al.* (2026, Internet Appendix, Section XI.B). We study a general advance schedule covering market-linked rates, valuation floors, and par lending, with the BTFP as the par case.

The analysis is positive: it asks how collateral valuation, pricing, and operational access shape the funding of a cash need when the facility accepts safe securities but not risky loans. Figure 4 summarizes the sequence. Proofs are in the appendix. The online appendix gives a conditional withdrawal-stage result.

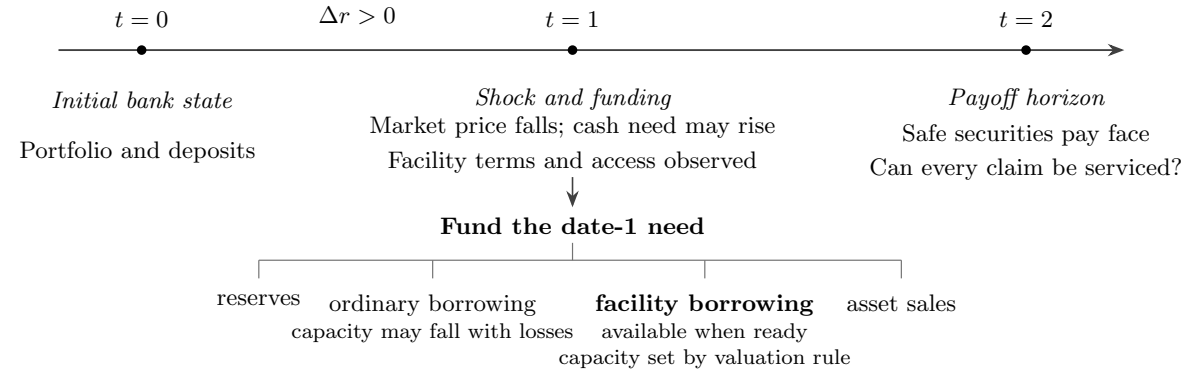


Figure 4: **Model overview.** A rate shock can raise the date-1 cash need and reduce loss-sensitive borrowing capacity. The facility's valuation rule determines its capacity against eligible safe collateral.

3.1 Setup

Balance sheet. There are three dates, $t \in \{0, 1, 2\}$. Bank i has a unit mass of depositors, each with one dollar on deposit at $t = 0$, so the deposit base is one. It holds reserves $x_i \in (0, 1)$ and $V_i \equiv 1 - x_i$ units of a safe long-duration security that can be sold at $t = 1$ and pays one per unit at $t = 2$. Let p_i denote its date-1 price per unit of face. Thus V_i is both the portfolio's face amount and its promised date-2 payoff, while $p_i V_i$ is its date-1 market value. For tractability, every unit of V_i is initially unencumbered and eligible for the facility. It can be sold or pledged, but not both,

as the shared-collateral constraint below imposes.[5]

Ordinary secured borrowing relies on a separate effective collateral pool. Let $A_i^O > 0$ denote its fixed, haircut-adjusted face equivalent after the ordinary lender's eligibility and encumbrance restrictions and after removing any overlap with V_i.[6]

We summarize operational readiness by the readiness date $\tau_i \in \{0, 1, 2\}$, the first model date by which the bank's documentation and infrastructure are complete. Operational access at $t = 1$ is the indicator $I_i^{\text{op}} \equiv \mathbf{1}\{\tau_i \leq 1\}$, so $\tau_i = 2$ means that the bank is not ready for the funding decision.[7]

Rate shock. A rate shock $\Delta r \geq 0$ lowers the $t = 1$ price to

$$p_i = e^{-D_i \Delta r}, \tag{1}$$

where $D_i > 0$ is the bank's duration exposure and $\ell_i \equiv 1 - p_i$ is the percentage markdown from par. The exponential form is a stylized duration approximation consistent with the rate-loss mechanism in Jiang *et al.* (2023). The bank's securities loss in the model's normalization is

$$L_i \equiv V_i \ell_i = V_i(1 - p_i) = V_i\big(1 - e^{-D_i \Delta r}\big). \tag{2}$$

The markdown ℓ_i measures the loss per dollar of face value, whereas L_i also reflects the size of the securities portfolio.[8] The security is safe: the rate shock lowers its date-1 price p_i and leaves its date-2 payoff unchanged.

Deposits and withdrawals. Bank i promises $d_i > 0$ to each depositor who withdraws at $t = 1$, fixed before the shock. The payment can exceed one when it includes promised interest. Motivated by the stochastic date-1 liquidity demand in Allen *et al.* (2009a), we model withdrawals in reduced form. A mass $\bar{\lambda}_i \in (0, 1)$ of depositors withdraws at $t = 1$ whatever the shock. Among the remaining depositors, a mass $u_i \in [0, 1 - \bar{\lambda}_i)$ is uninsured, and a share $\kappa(L_i)$ of them makes a loss-sensitive withdrawal, where κ is a common, increasing schedule of the bank's securities loss, with $\kappa(0) = 0$.

[5] Full eligibility is a normalization: V_i denotes the safe pool satisfying the modeled facility's scope and ownership rules, not every security on an actual bank balance sheet. BTFP collateral also had to be owned as of March 12, 2023 (Board of Governors of the Federal Reserve System, 2024).

[6] A_i^O is a collateral-capacity primitive, not book or market value and not an additional asset in the normalization $x_i + V_i = 1$. In the fully market-linked special case below, its borrowing capacity is $p_i A_i^O$. Any physical collateral eligible at both lenders is assigned to one pool before A_i^O and V_i are measured, so it cannot back both loans.

[7] The data show banks becoming ready during the program. We take τ_i as given at the funding choice and omit the setup cost or delay that rationalizes non-readiness. Whether a ready bank uses the facility is governed by the fixed first-use cost introduced with the funding costs below. Prior collateral pledging proxies for operational readiness but was not a BTFP requirement.

[8] Because the deposit base is normalized to one, L_i is measured per dollar of deposits. If the same loss is reported per dollar of total assets, it equals L_i times the ratio of deposits to assets. The comparative statics below hold that ratio fixed within a bank type.

This direct margin captures withdrawals driven by outside options or private motives that we do not model. The remaining uninsured depositors may also withdraw because they expect others to do so. The online appendix treats that coordination margin separately.[9] Direct withdrawals are

$$\lambda_i = \bar{\lambda}_i + u_i \kappa(L_i). \tag{3}$$

For a positive rate shock, a larger or more duration-sensitive securities portfolio raises L_i, while uninsured funding determines how strongly withdrawals respond:

$$\frac{\partial^2 \lambda_i}{\partial u_i \, \partial L_i} = \kappa'(L_i) > 0. \tag{4}$$

In the reduced form, uninsured funding and securities losses are complements.

Cash need. The bank's gross cash need is the payment to direct withdrawers plus other current demands $o_i \geq 0$:

$$q_i \equiv \lambda_i d_i + o_i. \tag{5}$$

The need is measured before reserves are used.

Assumption 3.1. (i) State at the funding choice. *Reserves x_i, the securities portfolio $V_i = 1 - x_i$ and its duration D_i, the ordinary-collateral pool A_i^O, and the deposit parameters $(\bar{\lambda}_i, u_i, d_i)$ are fixed at $t = 0$. Other current demand o_i, the first-use cost ε_i, the operational status implied by τ_i, and the facility terms are observed by $t = 1$, before the bank chooses how to fund its cash need. Comparative statics with respect to securities losses hold these objects fixed.* (ii) Withdrawal schedule. *The function κ is common across banks, continuously differentiable, independent of facility availability, and satisfies $\kappa(0) = 0$, $\kappa' > 0$, and $\kappa(L) \in [0, 1]$ for $L \in [0, 1)$.* (iii) Costs and horizon. *Each funding source has a constant, finite resource cost per dollar of date-1 cash, measured at a common date-2 horizon that the advance term or assured refinancing reaches, and the facility's promised gross repayment per dollar, $\phi_i \geq 1$, is fixed at origination.*

Current cash capacity does not depend on the repayment horizon.[10]

The facility's advance schedule α gives the cash advanced per dollar of collateral face value as a function of the market price. We write $a_i \equiv \alpha(p_i) \in (0, 1]$ for its value at bank i's realized price and use α itself only when comparing schedules in Section 3.2.

[9] Here $\bar{\lambda}_i$ plays the role of the always-withdrawing type in Goldstein and Pauzner (2005). In the partial-insurance extension of Ahnert *et al.* (2026), insured depositors do not run and a lower interim asset value raises the run threshold among the uninsured. The online appendix holds direct withdrawals fixed and gives conditions under which capacity, service, and a term premium make waiting dominant.

[10] In the three-date model, an initial term followed by assured refinancing or a policy extension can span the interval to $t = 2$. If the bank fails earlier, the secured lender can instead collect and hold the pledged safe securities until they pay.

The bank's problem. At $t = 1$, after its cash need, facility terms, and operational status are observed, the bank chooses a reserve drawdown ρ_i, ordinary secured borrowing n_i (for most banks, FHLB advances), facility borrowing b_i, and sale proceeds σ_i. Let K_i^O denote the ordinary borrowing capacity specified in Section 3.2. Raising σ_i through a sale uses σ_i/p_i units of the security, while borrowing b_i uses b_i/a_i units as collateral. The shared-collateral constraint prevents the same security from being sold and pledged.

Funding costs. Each source supplies one dollar at $t = 1$, and we measure its cost in date-2 resources net of the dollar itself.[11] A facility dollar requires gross repayment ϕ_i at $t = 2$, so its cost is $c_i^F = \phi_i - 1$. The bank index allows facility terms to differ across banks. Ordinary borrowing has cost $c_i^O \geq 0$ on the terms available to bank i, including interest and proportional fees. Drawing down reserves costs the interest on reserve balances (IORB) forgone over the horizon, $c^R \geq 0$, which we take as common across banks. Selling enough face to raise one dollar at the date-1 price sacrifices $1/p_i$ of date-2 payoff, so the sale cost is $c_i^S = 1/p_i - 1 = (1 - p_i)/p_i$, which rises with the markdown. The price is fixed with respect to the bank's own sale.[12] We impose no strict ranking among these marginal costs. Conditional on operational readiness, first use also carries a bank-specific fixed participation cost $\varepsilon_i \geq 0$, capturing internal approval and nonpecuniary costs of access (Armantier *et al.*, 2015; Ennis, 2019). When total costs tie, a bank that has not yet paid this cost does not enter. Conditional on participation, equal marginal costs rank reserves, ordinary borrowing, facility borrowing, and sales, in that order. The bank funds its need at least cost:

$$
\begin{aligned}
\min_{\rho_i, n_i, b_i, \sigma_i} \quad & c^R \rho_i + c_i^O n_i + c_i^F b_i + c_i^S \sigma_i + \varepsilon_i \mathbf{1}\{b_i > 0\} \\
\text{subject to} \quad & \rho_i + n_i + b_i + \sigma_i = q_i, \\
& 0 \leq \rho_i \leq x_i, \quad 0 \leq n_i \leq K_i^O, \\
& 0 \leq b_i \leq I_i^{\text{op}} a_i V_i, \quad \sigma_i \geq 0, \\
& \frac{\sigma_i}{p_i} + \frac{b_i}{a_i} \leq V_i.
\end{aligned}
\tag{6}
$$

[11] Because every feasible plan raises the same need q_i, subtracting the one-unit baseline from every source changes each plan's cost by the same amount and leaves the funding choice unchanged. Every cost is evaluated at the same horizon, so no separate discount factor appears. A common one would only rescale the objective. The fixed first-use cost is measured in the same units as variable-cost savings. It affects whether the facility is used and does not enter terminal service.

[12] Fire-sale price pressure (Allen and Gale, 2004; Brunnermeier and Pedersen, 2009a) and the public signal a sale sends (Choi *et al.*, 2023) would add to the private cost of selling. The borrowing-versus-sale mechanism does not need them.

Let $\Delta_i^F \geq 0$ denote the saving from facility access: the reduction in the bank's variable funding cost when facility borrowing is available.[13]

The need is fundable when

$$q_i \leq x_i + K_i^O + \max\{p_i,\, I_i^{\text{op}} a_i\} V_i, \tag{7}$$

where I_i^{op} is the operational-access indicator and the last term values the safe portfolio at the higher of its sale price and its available advance rate. When the need is fundable, the bank uses the facility exactly when the saving from facility access exceeds the fixed cost of first access,

$$b_i > 0 \iff \Delta_i^F > \varepsilon_i. \tag{8}$$

At par, a bank that uses the facility draws on reserves and the two loans in increasing marginal-cost order. It sells no securities when sales cost more than facility borrowing. Appendix A.2.1 gives the rule for a general advance schedule.

3.2 Par-value lending and funding capacity

Facility and funding capacity. Ordinary secured capacity may stay flat or fall as securities losses deepen. We allow any nonnegative schedule $K_i^O(L_i)$ that is weakly decreasing in the loss, with the fully market-linked case as the polar benchmark:

$$K_i^O(L_i) = p_i A_i^O = \left(1 - \frac{L_i}{V_i}\right) A_i^O. \tag{9}$$

In that case a one-percent price decline cuts ordinary capacity by one percent. A flat schedule is the other extreme.[14]

Against the safe pool V_i, a market-value facility advances the collateral's market value, while a par facility such as the BTFP advances its face. Before accounting for operational access, the

[13] Formally, conditional on the need being fundable, let $\mathcal{C}_i^{-F}$ be the minimum variable cost in (6) with $b_i \equiv 0$ and $\mathcal{C}_i^{+F}$ the minimum with b_i free, both excluding the fixed cost. When the no-facility problem is infeasible, set $\mathcal{C}_i^{-F} = +\infty$ and hence $\Delta_i^F \equiv \mathcal{C}_i^{-F} - \mathcal{C}_i^{+F} = +\infty$; otherwise $\Delta_i^F \in [0, +\infty)$ because the facility-open problem minimizes over a larger set. The infinity convention lets the participation rule below cover both discretionary use and necessary use: if the need cannot be met without the facility, any finite first-use cost is worth paying.

[14] FHLBank collateral valuation varies by collateral type and district. The FHFA reports that FHLBanks apply haircuts to either market value or unpaid principal balance, that practices differ across FHLBanks, and that effective haircuts on most security types rose after 2021 largely because rate-driven market-value declines reduced borrowing capacity (Federal Housing Finance Agency, 2023, pp. 4, 11–12).

advance schedule $\alpha(p)$ gives facility capacity[15]

$$K_i^F(p_i;\alpha) = \alpha(p_i)V_i. \tag{10}$$

Operational access determines whether the bank can use this capacity: the amount available at $t = 1$ is $I_i^{\text{op}} K_i^F(p_i;\alpha)$. Conditional on access, the extra cash a schedule provides over selling the same collateral is the part of the advance above the market price:

$$\Delta K_i(p_i;\alpha) = [\alpha(p_i) - p_i]^+ V_i. \tag{11}$$

Because sales and facility borrowing draw on the same securities, total cash capacity equals the portfolio's market value plus the extra cash available through facility access:[16]

$$\overline{g}_i^{\text{sec}}(p_i;\alpha) = p_i V_i + I_i^{\text{op}} \Delta K_i(p_i;\alpha). \tag{12}$$

This is the last term of (7), split into market value and the valuation gain. Holding operational access and safe collateral V fixed, the table compares how much date-1 cash each rule makes available, with haircut $\delta \in [0,1)$ and floor $\underline{a} \in [0,1]$.

Rule	$\alpha(p)$	Extra cash with access	Schedule slope $\alpha'(p)$
Market value, no haircut	p	0	1
Market value, haircut δ	$(1-\delta)p$	0	$1-\delta$
Valuation floor $\underline{a}$	$\max\{p, \underline{a}\}$	$(\underline{a} - p)^+ V$	1 if $p > \underline{a}$; 0 if $p < \underline{a}$
Par, no haircut	1	$(1-p)V$	0

The floor schedule has a kink at $p = \underline{a}$, where its derivative is undefined.

When the security trades below par, selling one dollar of face value or borrowing against it at market value raises only p_i dollars at date 1. A par facility advances one dollar. Par lending therefore keeps facility capacity from falling with the market price. The BTFP schedule is $\alpha_B(p) \equiv 1$, so facility capacity in (10) is V_i rather than $p_i V_i$. With operational access, the resulting capacity gain is exactly the securities loss on that collateral,

$$W_i \equiv (1 - p_i)V_i = L_i. \tag{13}$$

A par advance resembles the price-stabilizing intervention in Allen *et al.* (2009a): it lets a bank raise cash without selling safe securities at a depressed price. Open-market operations supply

[15] Arseneau *et al.* (2025) decompose the BTFP–discount-window cost differential into a collateral-valuation and an interest-rate component. The schedule captures the former.

[16] Appendix A.2.1 derives this expression from the joint problem in which facility borrowing and asset sales draw on the same securities.

liquidity to the market as a whole, whereas the modeled facility leaves the market price unchanged and funds banks according to their access and eligible collateral, which they retain under a lien (Goodfriend and King, 1988).

No schedule in the model advances more than face, $\alpha(p) \leq 1$, so par provides the most date-1 capacity. For a positive markdown, a rule delivers the full gain W_i exactly when it advances at par at the realized price. This ranks current capacity, not welfare.

Substitution toward the facility. Why does a larger securities loss shift the marginal dollar of funding from ordinary borrowing toward the facility? Two forces drive the result: ordinary capacity may contract with the loss while par-valued facility capacity does not, and selling becomes dearer. If ordinary borrowing is cheaper, the bank uses it first. When a larger loss reduces ordinary capacity, it shifts the next dollar toward the facility. If the facility is cheaper, a larger loss makes funding without it weakly dearer and weakly raises the value of paying the access cost. Under either cost ordering, the shift may be zero, but it does not reverse.

Proposition 3.2 (Substitution toward the facility)**.** *Let the securities loss L vary on a common interval $\mathcal{I}$ on which $0 < L < V$ for every bank type. For each type i, fix a reserve use $\bar{\rho}_i$ that is feasible throughout $\mathcal{I}$ and define the remaining need as $\widetilde{q}_i(L) = q_i(L) - \bar{\rho}_i$; we suppress type subscripts below. Hold fixed the cross-sectional distribution of bank types. Within each type, V and the first-use cost ε are fixed, while $\widetilde{q}(L)$ is weakly increasing in the loss, as in (5). Let ordinary capacity $K^O(L) \geq 0$ be weakly nonincreasing; the fully market-linked special case is $K^O(L) = (1 - L/V)A^O$. Hold fixed operational access at $I^{\text{op}} = 1$, par facility capacity $K^F \equiv V > 0$, ordinary borrowing cost $c^O \geq 0$, and facility cost $c^F = \phi - 1 \geq 0$. For every type and loss exposure, suppose the remaining need is interior, $0 < \widetilde{q}(L) < K^F$. Let the sale cost $c^S(L)$ be nondecreasing and exceed both borrowing costs on $\mathcal{I}$. With the model's costs, this last restriction is equivalent, within each type, to*

$$\frac{L}{V} > \max\left\{1 - \frac{1}{\phi}, \frac{c^O}{1 + c^O}\right\} \qquad \text{throughout } \mathcal{I}.$$

Assume the cross-sectional distributions are absolutely continuous, with no mass at kinks or first-use thresholds. Then, for any $L_2 \geq L_1$ in $\mathcal{I}$,

$$\beta^b(L_2) \geq \beta^b(L_1), \tag{14}$$

$$\beta^n(L_2) \leq \beta^n(L_1), \tag{15}$$

$$\Pr\left(\Delta^F(\widetilde{q}(L_2), L_2 \mid \bar{\rho}) > \varepsilon\right) \geq \Pr\left(\Delta^F(\widetilde{q}(L_1), L_1 \mid \bar{\rho}) > \varepsilon\right), \tag{16}$$

where $\beta^j(L) = \mathbb{E}[\partial j / \partial \widetilde{q}]$ is the derivative of source j's use with respect to need, taken at each bank within its own facility-use status and averaged over the fixed distribution of types. The term

$\Delta^F(\widetilde{q}, L \mid \bar{\rho})$ *is the saving from facility access at the fixed reserve use, defined in* (31). *See Appendix A.3 for the proof.*

The result does not require the facility to be cheaper than ordinary borrowing. Holding need fixed isolates the capacity and sale-cost channels. The loss-sensitive withdrawals in (5) reinforce them. The inequalities are weak because a larger loss need not change a bank's funding mix until ordinary capacity binds or the saving from facility access exceeds the fixed cost. Even then, sales can absorb part of the adjustment, so the shift toward the facility need not be one-for-one. Within the proposition's domain, once ordinary borrowing and sales can no longer fund a remaining need that is still below par facility capacity, the facility becomes necessary. That region persists at larger losses, so the weak monotonicities extend to the most stressed banks.

3.3 Solvency versus liquidity

Fundability, solvency, and service. Fundability asks whether current capacity covers the bank's date-1 need. Market-value solvency asks whether assets marked at the date-1 price cover its claims. Terminal service asks whether the selected funding plan leaves enough date-2 resources to pay every claim. Par surplus values the securities at face and deducts the current cash need: $\Omega_i = x_i - q_i + \mathcal{A}_i + V_i - C_i^0$, where $\mathcal{A}_i$ is other terminal resources net of credit losses and C_i^0 is claims remaining after date-1 payments, excluding new ordinary and facility loans ((22)). Market-value surplus instead values the securities at p_i, giving $\Omega_i^m = \Omega_i - (1 - p_i)V_i$.[17] For any feasible funding plan, terminal surplus is

$$E_i \equiv \Omega_i + c^R(x_i - \rho_i) - c_i^O n_i - c_i^F b_i - c_i^S \sigma_i, \qquad \text{terminal service} \iff E_i \geq 0. \tag{17}$$

Retained reserves earn IORB, while ordinary and facility borrowing add interest claims and a sale sacrifices the security's payoff.

Holding the cash need and other nonvaluation inputs fixed, a rate-driven markdown on safe long-duration securities lowers Ω_i^m but leaves Ω_i and the date-2 payoff unchanged. The same markdown can also raise the cash need through loss-sensitive withdrawals, which lowers Ω_i when terminal claims are held fixed. The markdown can also prevent current funding by shrinking market-linked borrowing capacity and making sales more costly. Positive par surplus therefore need not imply fundability or market-value solvency. Nor does market-value solvency guarantee terminal service: ordinary-loan interest, facility interest, and sale losses can exhaust the surplus preserved at date 1.[18]

[17] The appendix derives the service identity below from terminal resources and claims. The condition $\Omega_i^m \geq 0$ is the framework's counterpart to the mark-to-market solvency measure in Jiang *et al.* (2023).

[18] Lemma A.1(c) specializes (17) to the reserves-first shared-collateral problem with ordinary borrowing suppressed.

Buying time against duration risk. A par facility buys time against a duration markdown, not against a credit loss. The BTFP is the application: its par valuation let banks borrow against eligible Treasury and agency securities rather than sell them after a rate-driven markdown. In the model, the facility term or assured refinancing carries the position to date 2, when the safe security pays face and the markdown has run off. A facility dollar used in place of a sale replaces the forced-sale loss $(1 - p_i)/p_i$ with interest $\phi_i - 1$, so terminal service still requires enough par surplus to cover the chosen plan in (17). A credit impairment is different: waiting cannot restore the missing payoff, and a par advance may exceed the collateral's eventual collectible value.[19] Par lending can bridge an intact payoff; it cannot make impaired collateral whole.

3.4 Design levers

Valuation. The advance schedule $\alpha(p)$ governs collateral valuation: it gives the cash advanced against collateral with one dollar of face value when its market price is p. This lever separates the facility from borrowing against the same securities at market value, privately or at the discount window. Under a market-linked schedule, capacity shrinks with the markdown while par capacity holds; this difference can shift funding toward the facility even when its rate is no lower.

Pricing. Gross promised repayment ϕ_i governs pricing. Pricing does not change capacity, but a higher repayment weakly lowers the saving from facility access, Δ_i^F, and can make the first-use condition in (8) harder to satisfy. The inequality $c_i^F < c^R$ opens a carry margin over the model's common horizon. We take the rate as given.[20]

Operational access. The readiness date τ_i determines whether the operational-access indicator $I_i^{\text{op}} = \mathbf{1}\{\tau_i \leq 1\}$ switches on facility capacity at $t = 1$. Conditional on readiness, the fixed first-use cost ε_i determines whether discretionary access becomes use. Formal eligibility, operational access, and use are distinct margins.

Collateral scope and term. The model keeps collateral eligibility fixed: all safe securities V_i are eligible, while new risky loans are not. Limiting collateral to securities used in open-market operations also reduces the credit-allocation component emphasized by Goodfriend and King (1988), although the instrument remains a loan to an individual bank. Remark A.2 considers admitting

The online appendix separately derives endpoint conditions for late-depositor service and full facility repayment (Lemma A.6) and then a conditional withdrawal-stage equilibrium (Proposition A.8).

[19] With minimal pledge, if full collection yields only a fraction $1 - \chi_i$ of face, total collectible value is at least the advance amount only when the advance rate is no larger than $1 - \chi_i$; see Appendix A.4.

[20] If the stigma part of the fixed cost rises when only distressed banks borrow, a dynamic the framework does not model, selection can become adverse selection (Ennis, 2019): a rate competitive with private funding broadens the pool and dilutes the distress signal.

risky loans. Term has no separate parameter in the three-date model: the horizon convention assumes that the advance or assured refinancing bridges the date-1 need to the safe payoff at date 2. For example, primary credit at the discount window could run for up to 90 days and a BTFP advance for up to one year (Arseneau *et al.*, 2025). Longer terms reduce rollover risk while an expected temporary markdown unwinds.[21]

Discount window. We do not include the discount window as a second facility in the funding problem. It could be represented by a different advance schedule α, repayment ϕ_i, readiness date τ_i, first-use cost ε_i, collateral scope, and term; a joint choice between the BTFP and the discount window would also require their distinct collateral pools. The comparison here isolates the par-valuation mechanism that distinguishes the BTFP.

3.5 Testable implications

The central exposure combines uninsured funding with securities losses: by (4), direct withdrawals become more sensitive to the loss as the uninsured share rises.

Implication 1: targeted take-up. Among operationally ready banks, a larger securities loss weakly raises the response of facility borrowing to the funding need, weakly lowers the response of ordinary borrowing, and weakly raises the probability of facility use (Proposition 3.2). Each response is evaluated within the bank's own participation status, at fixed reserve use, for a fixed distribution of bank types, while remaining need is positive and below par facility capacity and selling is dearer than either borrowing source. Across banks, the comparison conditions on portfolio size and the other characteristics that jointly determine securities losses and funding choices.

At a given securities loss, entry contributes a nonnegative term to the facility-borrowing response and a nonpositive term to the ordinary-borrowing response to additional funding need (Appendix A.3.1). These entry contributions need not strengthen with losses, so the model does not sign the loss interaction in borrowing-amount regressions.

Implication 2: operational readiness. Readiness activates facility capacity. For a par facility, this raises the cash available from sales and facility borrowing together by $W_i = L_i$, the securities loss in (13). Conditional on overall fundability, a ready bank must use the facility if nonfacility sources cannot fund the shortfall. Otherwise, it uses the facility only when the variable-cost saving exceeds the fixed first-use cost. Once the bank uses the facility, the fixed first-use cost does not affect its draw. Readiness alone does not sign reserve use.

[21] If the advance matures before the markdown closes and refinancing is unavailable, it defers rather than eliminates the funding problem.

Implication 3: narrow collateral. Because pledged safe securities pay face, new risky lending changes neither their payoff nor facility capacity. With a par advance, full collection, and only the minimum face pledged, total secured recovery equals the advance amount. When $\phi_i > 1$, the remaining unsecured deficiency is equal in amount to the contracted interest. Full collateral coverage requires overpledging; otherwise the deficiency is payable from other bank resources. If risky loans were instead eligible at face, credit losses could reduce collectible collateral value below the advance amount, a channel that narrow collateral removes regardless of how the bank spends the cash (Appendix A.4).

Implication 4: carry. The date-1 problem caps borrowing at the current need and cannot generate carry. In the post-stress extension, a bank may instead borrow against spare capacity and hold the proceeds as reserves. It does so when the expected earnings on the chosen position, net of facility interest, other linear costs, and the cost of carrying a larger balance sheet over the same horizon, exceed the fixed costs it has not yet paid (Proposition A.4).[22] A positive spot spread alone is insufficient. Prior facility use weakly lowers the threshold by eliminating the first-access cost.

4 Empirics

This section brings the framework's implications to bank- and transaction-level data.

4.1 Data

We combine four data sets covering the SVB shock, BTFP borrowing, and subsequent changes in bank behavior.

Our first and highest-frequency data set contains transaction-level borrowing information from the Bank Term Funding Program.[23] These are loan-level data that 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 trace the interaction of the BTFP with run dynamics at the start of our sample and test for any moral hazard behavior associated with BTFP borrowing once the acute stress of March 2023 abated.

[22] Borrowing to hold reserves expands assets without adding capital and uses leverage capacity. Banks of all sizes face a minimum leverage ratio, and during the BTFP period qualifying community banks could instead meet a community bank leverage ratio above 9 percent (Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, and Federal Deposit Insurance Corporation, 2019). The appendix represents the cost of balance-sheet expansion with a convex function.

[23] These data are made available to the public pursuant to section 11(s) of the Federal Reserve Act. These data are available at https://www.federalreserve.gov/financial-stability/bank-term-funding-program.htm.

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).[24] The FR 2644 provides detailed asset-side classifications (loan types, securities, cash) and liability-side balances (core deposits, large time deposits, wholesale borrowings).[25] We isolate Federal Reserve borrowing (discount window and BTFP) from other wholesale borrowings, which are predominantly FHLB advances.[26]

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 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.

Finally, for exercises involving credit unions, we draw on a separate sample of credit union Call Reports from the National Credit Union Administration and BTFP transaction data.

In total, our cross-sectional sample contains 668 banks over a period from March 8 to May 3, 2023. Table 1 provides summary statistics. On average, banks saw roughly a 2.2 percentage point drop in the share of assets funded with deposits. Twelve percent of the sample borrowed from the BTFP, with an average increase in BTFP borrowing over the eight-week window of around 57 basis points of bank assets. Non-Fed borrowing increased slightly more as a share of bank funding, at 72 basis points of bank assets. Uninsured deposits funded an average of 29 percent of bank assets.

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.

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

[25] "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.

[26] Discount window and BTFP data are daily; we aggregate to weekly using the FR 2644 timing convention (Wednesday close of business). For the FR 2644 banks in our sample, which excludes failed banks, discount window borrowing was minimal during the stress period, so most of their Fed borrowing was from the BTFP. Cipriani *et al.* (2024) also show that a small fraction of run banks borrowed from the discount window during stress.

Table 1: Summary Statistics

Variable	Mean	Std. Deviation	25th Perc.	Median	75th Perc.	Observations
Outcomes:						
ΔCore Deposits/Assets	-1.665	3.085	-3.189	-1.821	-0.326	668
ΔCore Deposits^{-}/Assets	-2.204	2.145	-3.189	-1.821	-0.326	668
ΔCore Deposits^{+}/Assets	0.539	1.593	0.000	0.000	0.000	668
0/1 BTFP borrowing	0.124	0.330	0.000	0.000	0.000	668
ΔBTFP/Assets	0.566	1.974	0.000	0.000	0.000	668
ΔDiscount window/Assets	-0.003	0.435	0.000	0.000	0.000	668
ΔNon-Fed borrowing/Assets	0.718	2.915	-0.009	0.000	1.809	668
ΔLarge time dep./Assets	0.863	1.376	0.134	0.649	1.405	668
ΔReserves/Assets	0.090	3.773	-0.816	0.091	1.078	668
ΔSecurities/Assets	-0.169	1.125	-0.295	-0.005	0.190	668
Vulnerabilities:						
Uninsured deposits/Assets	28.568	12.758	19.622	27.543	35.531	668
Securities losses/Assets	2.626	1.976	1.198	2.342	3.627	668
HTM losses/Assets	0.399	0.902	0.000	0.000	0.287	668
AFS losses/Assets	2.227	1.915	0.821	1.779	3.118	668
CRE loans/Assets	28.452	16.314	16.704	27.722	38.874	668
Assets:						
ΔLoans/Assets	0.922	1.557	0.193	0.764	1.584	668
Liquid assets/Assets	30.996	15.871	19.557	27.963	40.145	668
Liabilities and Capital:						
2022 Dep. growth	3.248	11.403	-3.198	2.439	7.616	668
FHLB advances/Assets	3.013	4.075	0.000	1.356	4.858	668
Avg. funding cost	0.797	0.561	0.443	0.682	1.006	668
Tier 1 capital/Assets	10.304	2.899	8.780	9.686	11.009	668
Bank Size Groups:						
Community bank	0.816	0.388	1.000	1.000	1.000	668
Regional bank	0.162	0.368	0.000	0.000	0.000	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.

4.2 Empirical Strategy

We examine which banks borrowed, how borrowing varied with securities losses and readiness, how balance sheets changed around draws, and how later borrowing related to the interest-rate spread. 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 tests whether outflows rise more with uninsured funding at banks with larger securities losses. 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.

4.3 Deposit outflows and bank vulnerabilities

Securities losses We begin by identifying the banks that were vulnerable to deposit outflows and hence the banks the BTFP was designed to reach. We focus on cross-sectional regressions predicting changes in core deposits in the eight weeks between March 8 and May 3, the window that contains the SVB collapse and was the height of the banking turmoil.

We regress the change in core deposits on bank-specific risk factors measured as of 2022Q4:

$$\frac{\Delta\text{Deposits}_{i,t,t'}}{\text{Assets}_{i,t}} = \beta_1 \frac{\text{Uninsured deposits}_{i,22q4}}{\text{Assets}_{i,22q4}} + \beta_2 \frac{\text{Securities Losses}_{i,22q4}}{\text{Assets}_{i,22q4}} + \gamma' X_{i,t} + \varepsilon_{i,t} \tag{18}$$

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). $X_{i,t}$ 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.[27]

Table 2 presents the results. Columns 1–2 use total securities losses, showing that reliance on uninsured deposits is associated with 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 adds the interaction: outflows rise more with uninsured deposits at banks with larger securities losses. 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 pattern is consistent with the model's withdrawal

[27] 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.

rule.[28]

Columns 3–4 divide securities losses into its 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.

Alternative hypothesis: Commercial real estate Our hypothesis is that deposit outflows reflected losses on securities, and that par lending let banks meet those outflows without selling the marked-down securities. The rate hikes, along with the pandemic and associated changes in working and living patterns, led to weaker demand for commercial real estate and an associated pickup in CRE-related delinquencies. Given the contemporaneous stresses, and because many of the smaller banks that borrowed from the BTFP also carried significant real estate exposures, columns 5–6 explore the relationship between CRE exposures and deposit outflows. 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. In addition, in the Appendix Table A2, the interaction of uninsured deposits with CRE loan delinquencies and non-accruals—which picked up somewhat in 2023 as shown in Figure 2—is not statistically significant, while the interaction with securities losses remains significant.[29]

[28] The robustness results in the Appendix Table A4 do not support the idea of a non-linear effect of securities losses in driving the impact of uninsured deposits on outflows.

[29] While delinquencies for commercial & industrial and residential loans also appear to amplify the link between uninsured deposits and core deposit outflows, they do not reduce the statistical or economic significance of securities losses.

Table 2: Core Deposit Outflows

	$\frac{\Delta \text{Deposits}}{\text{Assets}}$					
	Securities losses		HTM, AFS		Alternative hypothesis: CRE	
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{\text{Uninsured deposits}}{\text{Assets}}$	-0.034**	-0.008	-0.034**	-0.006	-0.030**	-0.006
	(0.013)	(0.022)	(0.014)	(0.022)	(0.014)	(0.035)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.012*				-0.012*
		(0.006)				(0.006)
$\times \frac{\text{HTM losses}}{\text{Assets}}$				-0.031***		
				(0.011)		
$\times \frac{\text{AFS losses}}{\text{Assets}}$				-0.009		
				(0.006)		
$\times \frac{\text{CRE loans}}{\text{Assets}}$						0.000
						(0.001)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.022	0.362**			0.019	0.362**
	(0.081)	(0.156)			(0.081)	(0.155)
$\frac{\text{HTM losses}}{\text{Assets}}$			0.014	1.014***		
			(0.141)	(0.298)		
$\frac{\text{AFS losses}}{\text{Assets}}$			0.024	0.283*		
			(0.080)	(0.158)		
$\frac{\text{CRE loans}}{\text{Assets}}$					-0.011	-0.014
					(0.010)	(0.023)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.137	0.146	0.137	0.151	0.138	0.148
Observations	668	668	668	668	668	668

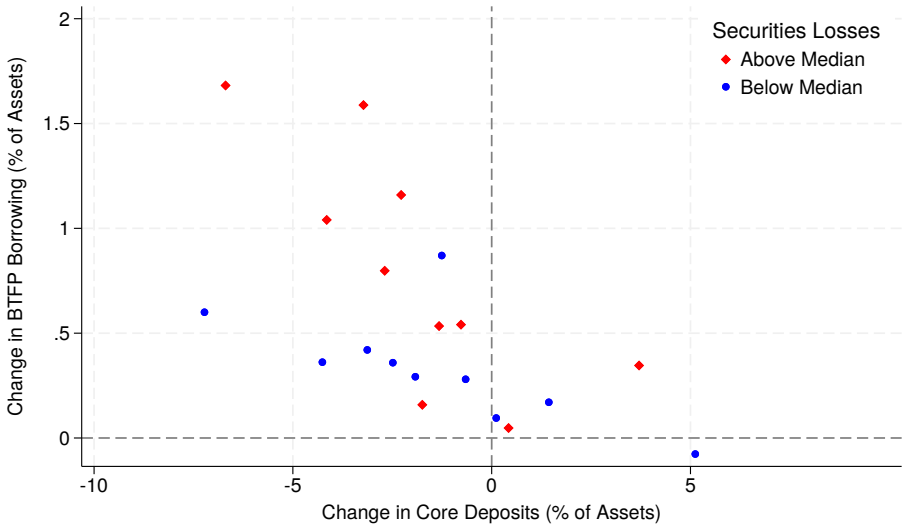
*Notes: The table shows results from cross-sectional regressions of changes in banks' core deposits relative to beginning of period total assets ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$) over the interval March 8—May 3, 2023 on uninsured deposits, total securities losses, HTM and AFS losses, CRE loans, contemporaneous loan growth ($\Delta Loans_{i,t,t'}/Assets_{i,t}$), liquid asset holdings (the sum of cash, federal funds, reverse repo and securities holdings), deposit growth in 2022, FHLB advances, average funding cost (annualized interest expense as a percent of total liabilities), tier 1 capital-to-assets ratio, 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 A1. 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 A3 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. In Panel B, the eight-week intervals post-SVB show no predictive power of uninsured deposits or securities losses for deposit outflows.

4.4 Implication 1: 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 5 provides a nonparametric binscatter plot of the relationship between BTFP funding and deposit changes from March 8 to May 3, 2023. This plot shows a negative relationship between negative deposit changes (i.e., outflows) and BTFP borrowing, which vanishes for positive deposit changes (i.e., inflows). Furthermore, the relationship between deposit outflows and BTFP borrowing is steeper for banks with larger securities losses (in red diamonds), suggesting those banks tapped BTFP funding relatively more to replace outflows.

Figure 5: Binscatter of BTFP Funding vs. Deposit Changes by Securities Loss Group



Note: The chart shows a binscatter plot of banks' changes in BTFP funding (vertical axis) as a function of banks' changes in deposits (horizontal axis). 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.

Hypothesis: BTFP 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. We also consider borrowing from other wholesale funding sources, which predominantly consist of FHLB advances, as our measure of non-Fed borrowings excludes borrowing from the discount window.[30] Variation in discount window borrowing was minimal during this period. While

[30]Since wholesale borrowings include funding from sources other than FHLBs, we use the term "non-Fed borrowings" to refer to it.

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.

To investigate funding sources, we replace the left-hand side of (18) with changes in non-deposit borrowing or reserve balances and add core deposit changes as an explanatory variable. For BTFP borrowing, we examine how deposit outflows and bank vulnerabilities relate to whether a bank borrows and how much it borrows. 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:

$$\begin{aligned}\frac{\Delta Y_{i,t,t'}}{\text{Assets}_{i,t}} = \beta_1 \frac{\Delta\text{Deposits}^{-}_{i,t,t'}}{\text{Assets}_{i,t}} + \beta_2 \frac{\Delta\text{Deposits}^{+}_{i,t,t'}}{\text{Assets}_{i,t}} + \beta_3 \frac{\text{Securities Losses}_{i,22q4}}{\text{Assets}_{i,22q4}} \\ + \beta_4 \frac{\text{Uninsured deposits}_{i,22q4}}{\text{Assets}_{i,22q4}} + \gamma' X_{i,t} + \varepsilon_{i,t},\end{aligned} \tag{19}$$

where $\Delta\text{Deposits}^{-}_{i,t,t'} = \min\{0, \Delta\text{Deposits}_{i,t,t'}\}$ and $\Delta\text{Deposits}^{+}_{i,t,t'} = \max\{0, \Delta\text{Deposits}_{i,t,t'}\}$. β_1 measures how banks meet a one-dollar deposit outflow; β_2 measures how banks respond to inflows.

Table 3 presents the results. 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 percentage point 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 percentage point 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.

Columns 4–6 relate BTFP borrowing amounts to deposit outflows and bank vulnerabilities. Banks that did not borrow enter with zero, so the regressions capture both participation and amounts among borrowers. 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 are consistent with borrowing to meet realized outflows and with precautionary funding at banks with larger 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.

Once again, in columns 3 and 6, the interaction of deposit outflows with CRE loan exposures is not statistically significant, while the securities-loss interaction remains robust. The pattern suggests that BTFP liquidity successfully targeted stress related to interest rate risk rather than credit risk, with the latter reflected by CRE exposures.[31]

Alternative hypothesis: FHLB advances 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.[32] 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. Par valuation preserves BTFP capacity as securities losses deepen, while selling becomes more costly and ordinary borrowing capacity can fall. The estimates are consistent with that substitution mechanism, but they do not separate collateral valuation from funding demand or other contract differences.

[31] Similarly, in the Appendix Table A6, the interaction between deposit outflows and delinquencies and non-accruals is not statistically significant for any loan category in explaining BTFP funding (columns 1-10). In contrast, banks with greater credit risk in C&I and CRE loan portfolios appear to have used more non-Fed borrowings to cover deposit outflows (columns 11-15).

[32] Non-Fed borrowing is predominantly FHLB advances. FHLB advances are not a neutral private benchmark. Their secured priority in receivership can reduce recoveries available to other claimants, including the FDIC as receiver. We do not model that receivership externality, our empirical contrast focuses on the different collateral valuation rules that shape borrowing capacity during stress.

Table 3: Wholesale Borrowing

	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	0.002	-0.162***	-0.073	-0.012	-0.401***	-0.498***	-0.437***
	(0.007)	(0.008)	(0.011)	(0.053)	(0.057)	(0.089)	(0.067)	(0.104)	(0.149)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.006**	-0.007**		-0.036*	-0.036**		0.039	0.039
		(0.003)	(0.003)		(0.018)	(0.018)		(0.024)	(0.024)
$\times \frac{\text{CRE loans}}{\text{Assets}}$			-0.001			-0.002			-0.002
			(0.000)			(0.003)			(0.004)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.034***	0.016	0.015	0.210***	0.104	0.101	0.093	0.207**	0.209**
	(0.007)	(0.011)	(0.011)	(0.050)	(0.070)	(0.070)	(0.063)	(0.099)	(0.101)
$\frac{\text{CRE loans}}{\text{Assets}}$			-0.000			0.001			0.005
			(0.001)			(0.006)			(0.014)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.002*	0.002*	0.002	0.014**	0.014**	0.012*	-0.001	0.000	-0.002
	(0.001)	(0.001)	(0.001)	(0.006)	(0.006)	(0.007)	(0.009)	(0.009)	(0.010)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.084	0.092	0.096	0.102	0.108	0.111	0.170	0.173	0.177
Observations	668	668	668	668	668	668	668	668	668

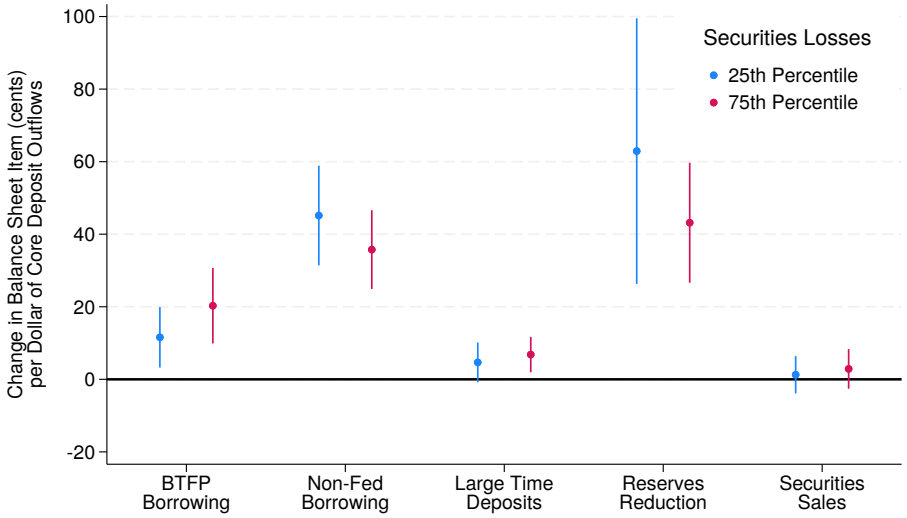
*Notes: The table shows results from cross-sectional regressions of changes in banks' BTFP borrowings and non-Fed borrowings (wholesale borrowings that exclude BTFP and discount window) over the interval March 8—May 3, 2023 on contemporaneous core deposit growth ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), total securities losses, CRE loans, uninsured deposits, contemporaneous loan growth ($\Delta Loans_{i,t,t'}/Assets_{i,t}$), liquid asset holdings (the sum of cash, federal funds, reverse repo and securities holdings), deposit growth in 2022, FHLB advances, average funding cost (annualized interest expense as a percent of total liabilities), tier 1 capital-to-assets ratio, 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. 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 A5. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

Figure 6 displays the full set of adjustment margins evaluated at the 25th and 75th percentiles of securities losses based on evaluating specifications similar to those in (19). Coefficients are reported in Appendix Table A7. 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.[33] 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 losses are statistically significant for BTFP borrowing.[34]

[33]Based on the results in Appendix Table A7, the marginal effect is computed as $\hat{\beta}_1 + \hat{\gamma} \times \frac{\text{Securities Losses}}{\text{Assets}}$, where $\hat{\beta}_1$ and $\hat{\gamma}$ are the coefficient estimates on deposit outflows and deposit outflows interacted with securities losses, respectively. The size of confidence intervals depends on the standard error of the marginal effect, computed as $[Var(\hat{\beta}_1) + (\frac{\text{Securities Losses}}{\text{Assets}})^2 \times Var(\hat{\gamma}) + 2 \times \frac{\text{Securities Losses}}{\text{Assets}} \times Cov(\hat{\beta}_1, \hat{\gamma})]^{1/2}$, multiplied by the confidence level critical value.

[34]The Appendix Table A8 shows similar results for specifications in which core deposit outflows and inflows are replaced, in a spline regression approach, with positive and negative in excess loan growth, respectively. Excess loan

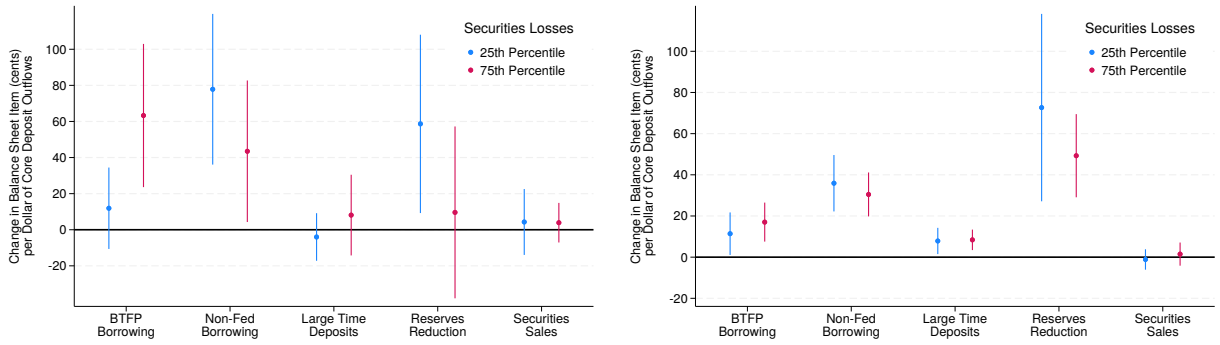
Figure 6: How Banks Fund Core Deposit Outflows



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 (19).

Figure 7 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.[35]

Figure 7: 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 6.

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 A5 summarizes the results.

[35]The robustness results in Appendix Table A9 confirm that for regional banks larger securities losses amplified the substitution between deposit outflows and BTFP borrowing. However, the results in Table A10 do not support the idea of a non-linear effect of securities losses in driving the substitution between deposit outflows outflows and BTFP borrowing.

Collateral pledging. As Figure 3 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 is associated with 18, 49, and 5 cents more total pledging, respectively, 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 these securities.[36] 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)
$\times \frac{\text{HTM loss}}{\text{Assets}}$								
$\times \frac{\text{AFS loss}}{\text{Assets}}$		0.174+		0.067		0.045+		0.062
		(0.134)		(0.084)		(0.030)		(0.062)
$\frac{\text{HTM loss}}{\text{Assets}}$	0.493**		0.333**		0.129*		0.032	
	(0.215)		(0.163)		(0.066)		(0.054)	
$\frac{\text{AFS loss}}{\text{Assets}}$	0.433***	0.357	0.288***	0.084	0.111**	0.105	0.034*	0.168
	(0.089)	(0.367)	(0.081)	(0.268)	(0.049)	(0.090)	(0.018)	(0.136)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	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 contemporaneous deposit outflows ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), HTM and AFS securities losses, and the same controls like in Table 3. The spline regression approach differentiates between banks with positive and negative core deposits growth; the table reports the coefficients for negative deposit growth and interactions with HTM and AFS securities losses. Columns 1–2 report total collateral; columns 3–8 separate total collateral into MBS/CMO, agency debt, and Treasury securities. $^+$, *, **, *** denote significance at 20%, 10%, 5%, and 1%.

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

[36] When rates increase, the duration of a fixed income instrument should decline, tempering losses to a degree. However, agency MBS effectively have an embedded prepayment option, reflecting incentives for the mortgage borrower, whose loan is packaged in the MBS. when rates increase, borrowers are less likely to prepay a mortgage, which lengthens the duration of the loan and therefore the agency MBS. Consequently, price declines and securities losses are magnified relative to a Treasury security or other instrument without an embedded prepayment option.

more heavily on BTFP funding, especially regional banks. Several factors could account for this reliance, including precautionary demand for liquidity, less liquid initial assets, and the additional capacity supplied by par valuation.

4.5 Implication 2: Operational readiness

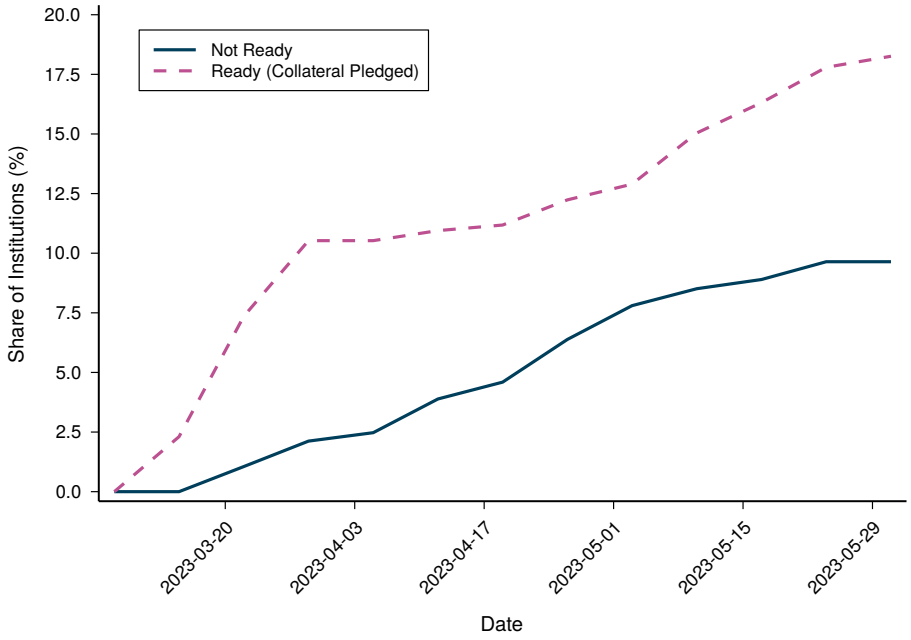
The BTFP relied on existing discount-window infrastructure. Banks that were "operationally ready"—defined as a bank with collateral pledged at the discount window as of March 8 or had borrowed from the discount window in the previous five years–could access BTFP funds in as little as 15 minutes, while banks not having done these things may have needed more time to access the BTFP. Consequently, readiness is a useful proxy for the ability to use the facility quickly during acute stress. In addition, operational readiness helps to distinguish the BTFP from other interventions. When the BTFP was established, other government actions to stop the bank runs were taken, including invoking the systemic risk exception and guaranteeing the deposits of SVB and Signature Bank.

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 for BTFP borrowing. It also provides support for the claim that the BTFP had a distinct role in addressing the March 2023 stress, separate from the systemic risk exception.

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.

Takeup speed by operational readiness. Figure 8 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 8: BTFP Takeup Speed by Operational Readiness

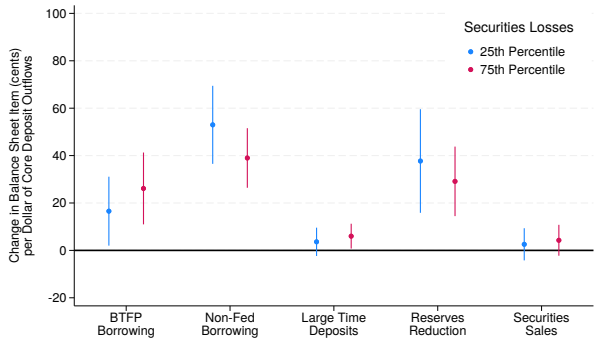


Notes: Cumulative share of eventual BTFP borrowers that initiated first borrowing, by week since program launch (March 12, 2023). Banks are split by operational readiness (prior collateral pledged at discount window as of March 8, 2023).

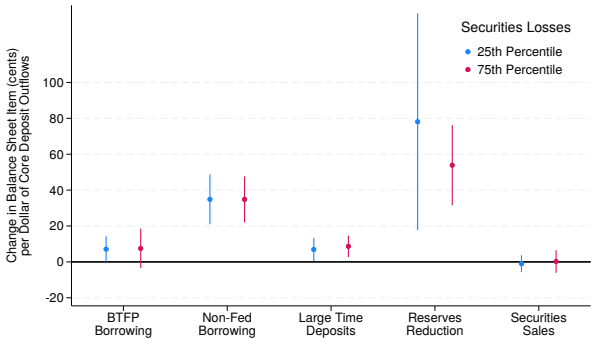
Funding by operational readiness. Operational readiness is not randomly assigned, and we do not interpret the resulting estimates as causal in a narrow sense.

Figure 9 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.

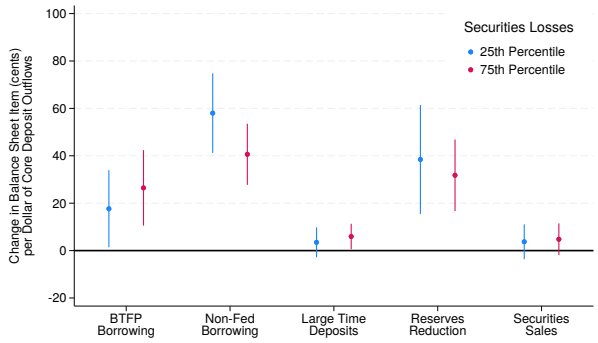
Figure 9: How Banks Fund Deposit Outflows, By Operational Readiness



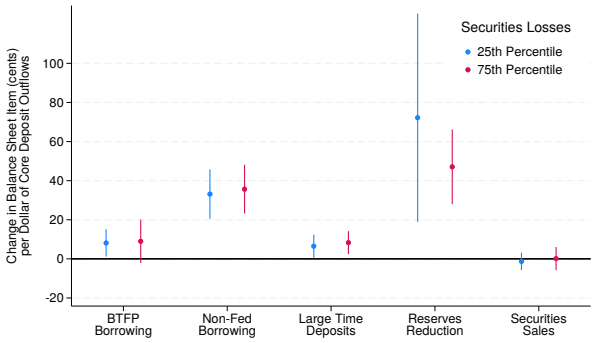
(a) Collateral pledged at the discount window



(b) No collateral pledged at the discount window



(c) Past borrowing from the discount window



(d) No past borrowing from the discount window

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 6.

Table 5: Wholesale Borrowing and Reserves by Operational Readiness

	0/1 BTFP Borrowings		$\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$		$\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$		$\frac{-\Delta\text{Reserves}}{\text{Assets}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\frac{\Delta\text{Deposits}^-}{\text{Assets}}$	-0.012+	-0.013+	-0.073	-0.090+	-0.498***	-0.496***	-0.726**	-0.711**
	(0.008)	(0.008)	(0.057)	(0.059)	(0.104)	(0.105)	(0.297)	(0.295)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	-0.006**		-0.036*		0.039+		0.081	
	(0.003)		(0.018)		(0.024)		(0.067)	
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Ready)		-0.007**		-0.045**		0.040*		0.090+
		(0.003)		(0.020)		(0.024)		(0.069)
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Not ready)		-0.004		0.002		0.035		0.046
		(0.004)		(0.021)		(0.030)		(0.064)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.016+	0.017+	0.104+	0.116+	0.207**	0.205**	0.036	0.024
	(0.011)	(0.011)	(0.070)	(0.071)	(0.099)	(0.100)	(0.239)	(0.238)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.002*	0.001+	0.014**	0.010*	0.000	0.000	-0.000	0.004
	(0.001)	(0.001)	(0.006)	(0.006)	(0.009)	(0.010)	(0.016)	(0.017)
Bank controls and interactions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.092	0.094	0.108	0.121	0.173	0.173	0.220	0.223
Observations	668	668	668	668	668	668	668	668
P-value for coeff. equality test		.33		.01		.79		.06

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), as well as reserve reductions over the interval March 8—May 3, 2023 on contemporaneous deposit outflows ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), securities losses, and the same controls like in Table 3. 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. In columns 2, 4, and 6, the specification opens up the coefficient for negative deposit growth interacted with securities losses by banks' operational readiness status, defined by whether the bank had collateral pledged at the Discount Window as of March 8, 2023. 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 20%, 10%, 5%, and 1%, respectively.

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.

4.6 Implication 3: Narrow collateral and central bank exposure

In the framework, the collateral rule keeps new private lending from changing the pledged payoff or adding BTFP capacity. We use the data to examine separately whether borrowers changed their lending.

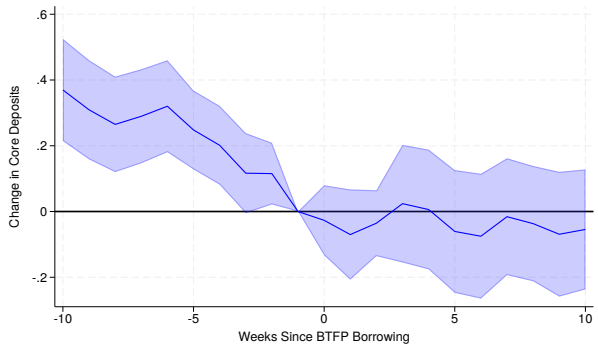
Local projections The cross-sectional evidence establishes which banks used the BTFP, how much they borrowed, and at what cost to those who lacked effective access. Cross-sectional regressions, however, cannot capture the timing of adjustment. We now use local projections to trace balance-sheet dynamics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

$$\frac{y_{i,t+h} - y_{i,t-1}}{Assets_{i,t-1}} = \beta^h \frac{\Delta BTFP_{i,t}}{Assets_{i,t-1}} + \tau_t^h + \epsilon_{i,t}^h \tag{20}$$

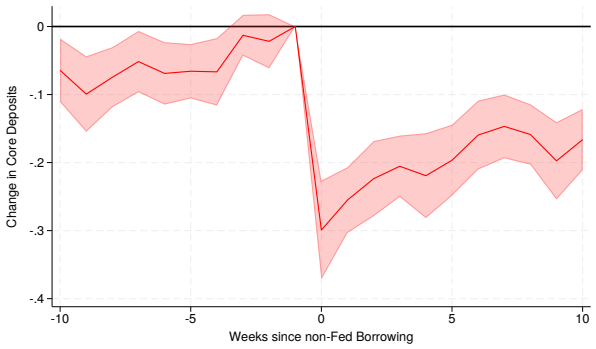
where τ_t^h is a week fixed effect and $\{\beta^h\}$ traces the path of balance sheet variables surrounding an increase in BTFP balances relative to banks that did not change borrowing in a particular week. We estimate an analogous specification for non-Fed borrowings. The sample covers t from March 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 10 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).

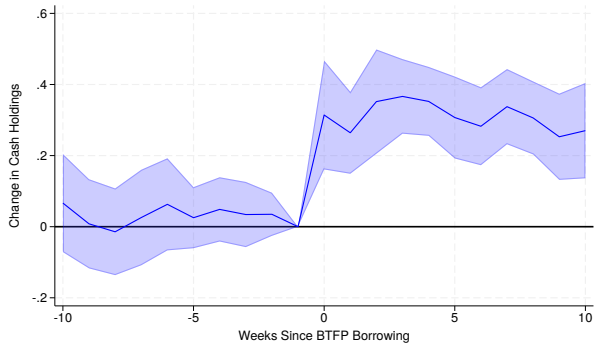
Figure 10: Balance-Sheet Dynamics around Borrowing



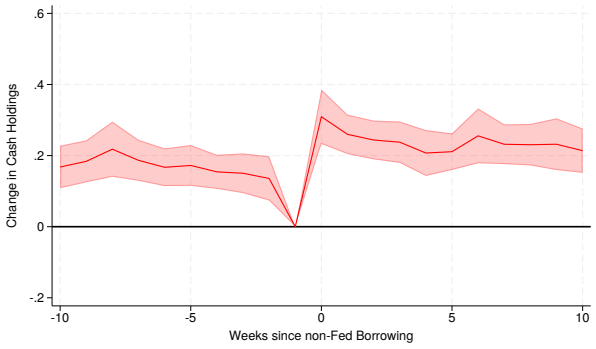
(a) Core deposits: BTFP



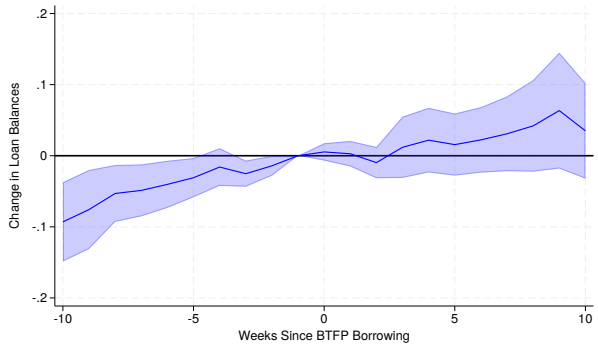
(b) Core deposits: non-Fed



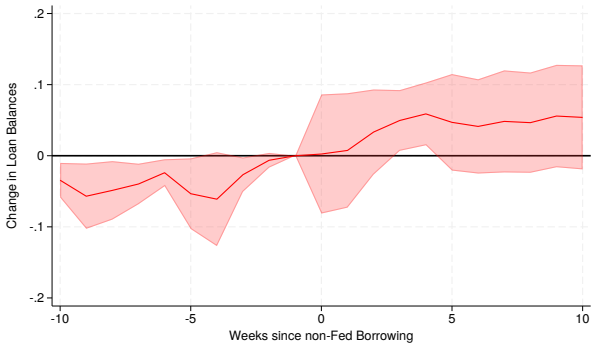
(c) Cash holdings: BTFP



(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.[37]

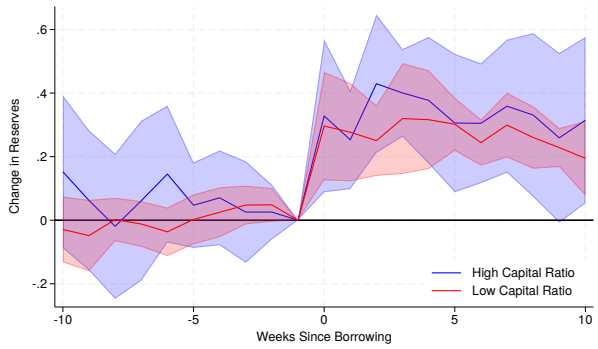
Use of funds and lending behavior The local projections show that BTFP funds were held as reserves in the aggregate. But aggregate patterns could mask heterogeneity: less-capitalized banks might use the funds to acquire riskier assets, which would constitute a form of moral hazard. Following Drechsler *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 11 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.

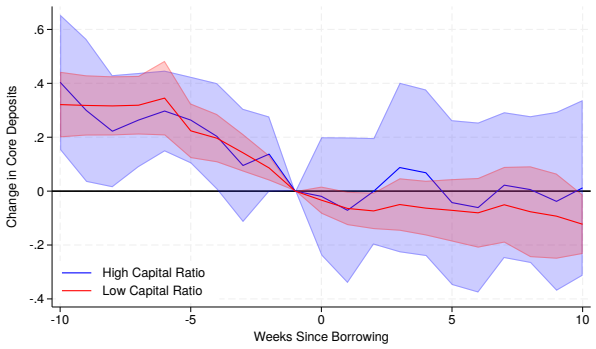
Panels (e)–(h) disaggregate by loan type. The increase in loan balances at well-capitalized banks is principally C&I lending (panel e). For loan categories that experienced greater strains in 2023—CRE and consumer loans—there is no increase in balances after BTFP borrowing at either high- or low-capital 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.

[37] 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 10 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 Figure A6.

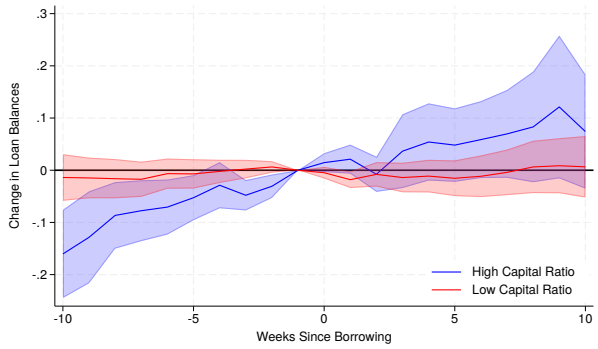
Figure 11: Use of BTFP Funds by Capitalization and Loan Type



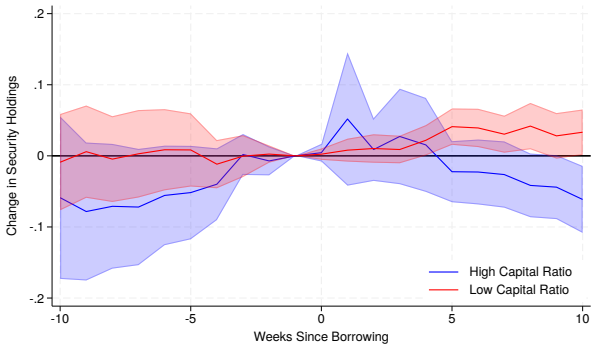
(a) Reserves



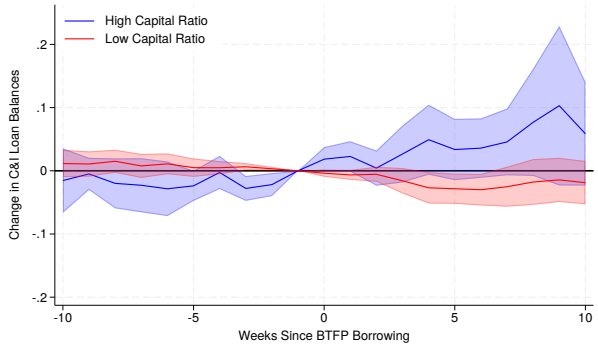
(b) Core deposits



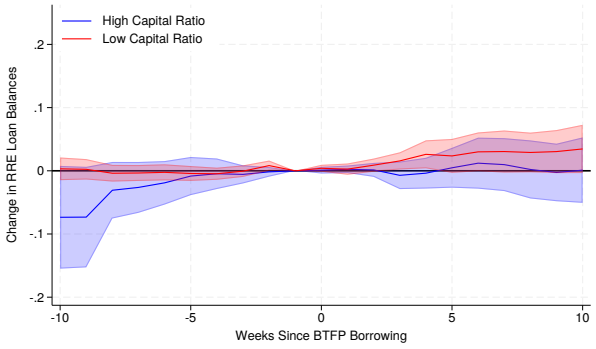
(c) Total loans



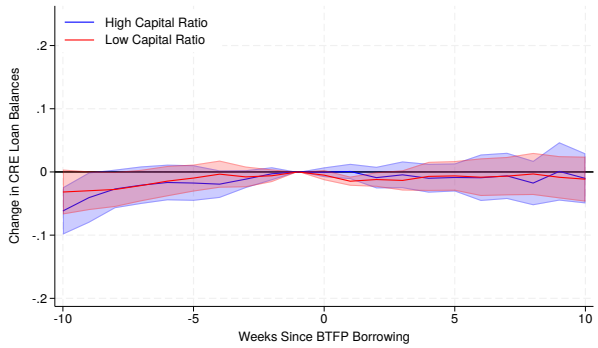
(d) Securities



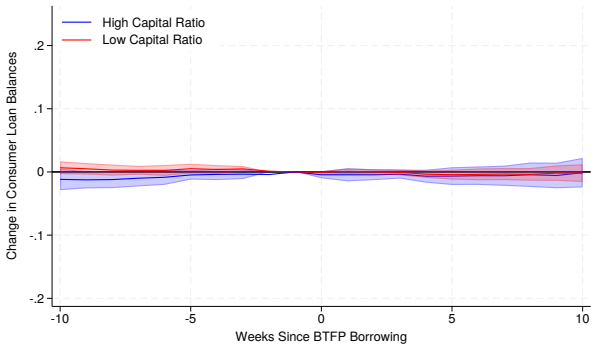
(e) C&I loans



(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 3%. Red lines: banks below 3%.

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 A8). 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.

Moral hazard can take forms other than risky lending, such as less hedging of interest rate risk or less reclassifications of AFS to HTM securities holdings. However, for the banks in our sample, the hedging of interest rate risk through interest rate swaps at the onset of 2023 banking stress was economically small and concentrated among the largest banks (see Granja *et al.* (2024), McPhail *et al.* (2023)). Moreover, the reclassifications of AFS to HTM securities inferred from Call report data like in Granja *et al.* (2024) slowed dramatically in 2023 for both BTFP and non-BTFP banks (see Appendix Figure A7).

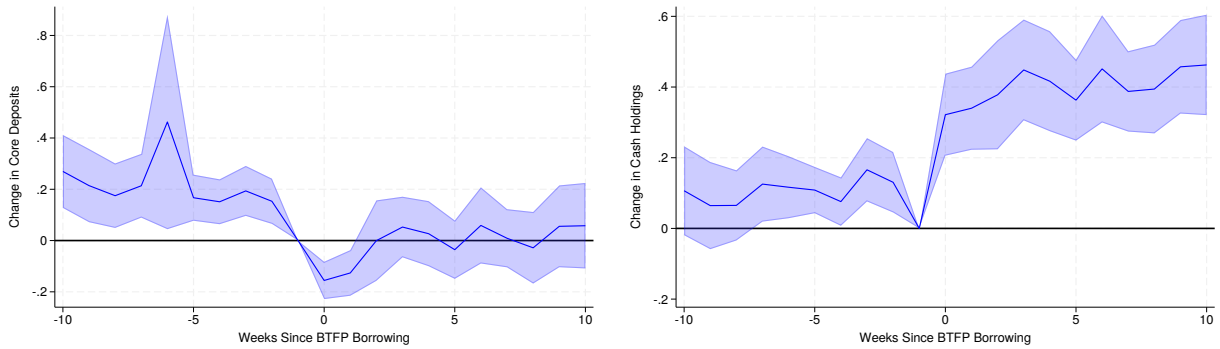
4.7 Implication 4: Carry

Initially, the BTFP priced one-year loans at one-year OIS plus 10 basis points, fixed at origination, while the interest on reserve balances (IORB) floated over the same horizon. Through summer 2023 the facility rate typically exceeded IORB. In late 2023, market expectations of 2024 rate cuts pushed one-year OIS below the still-elevated IORB, and new draws began pricing strictly below the reserve rate. The inversion ran from November 29, 2023 until January 24, 2024, when the Federal Reserve floored the loan rate at the IORB rate prevailing at origination. Over those eight weeks BTFP outstanding rose from $114 billion to $168 billion. Borrowing was followed by reserve accumulation while IORB exceeded the rate on new advances. The carry condition in Proposition A.4 requires spare collateral capacity. Expected earnings on the position must exceed facility interest, other variable costs, balance-sheet costs, and unpaid fixed costs.

Because IORB floats, the return to holding reserves against a fixed-rate advance changes over time. The January 2024 floor applied to new advances at origination. Outstanding loans kept their contracted rates, and future IORB remained variable.

Figure 12 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 10, 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 10, panel c). In spring 2023, reserve accumulation around BTFP draws was consistent with precautionary liquidity management. In the later period, borrowing coincided with a positive IORB–BTFP spread.

Figure 12: 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.

Banks with BTFP loans outstanding were more likely to take out new advances (Appendix Table A11). 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 A12). From November 15, 2023 to January 23, 2024, a dollar of additional BTFP borrowing was associated with 93.4 cents of

additional reserves at credit unions, compared with 34.5 cents at banks. Both estimates control for date and institution fixed effects (Appendix Tables A13 and A14). The estimated reserve response per dollar borrowed is about 2.7 times as large at credit unions.

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 episode shows the limits of fixed-rate term lending against a floating policy rate, but it does not imply that flooring at the contemporaneous IORB from the outset would have been preferable. The OIS-linked formula carried insurance value: markets adjust expectations of the policy path before the Fed acts, so an OIS-linked rate transmits expected easing to borrowers before the policy rate itself moves—useful if stress demands faster easing than the central bank is willing to deliver. A floor at the contemporaneous IORB removes that channel along with the arbitrage. The design lesson is conditional: a forward-looking benchmark is the right pricing rule at the onset of stress; a program should specify in advance a state-contingent switch to an IORB floor once acute conditions have passed. A possible implication of this analysis is that the BTFP's January 2024 adjustment could have been implemented earlier; pricing rules must be designed for the decline of stress as well as for its onset. That said, narrow collateral confined the late-program distortion to reserve arbitrage rather than credit expansion.

5 Deposit-rate adjustment among stressed borrowers

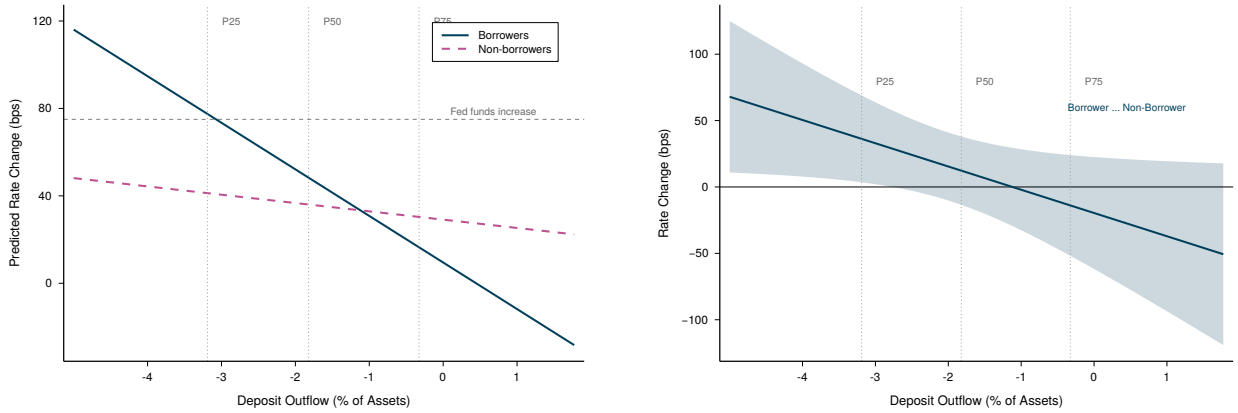
We document a complementary empirical observation on the deposit-rate margin: how banks priced deposits during the stress, and how that pricing varied with facility access. Borrower status is endogenous and we do not interpret these patterns as identifying a causal effect of BTFP access on deposit-rate pass-through. The estimating equation runs at multiple horizons h:

$$\begin{aligned}\frac{\Delta \text{CD Rate}_{i,t\to t+h}}{\text{bps}} = \beta_0^h &+ \beta_1^h \text{NonBorrower}_i + \beta_2^h \text{Outflow}_i^- + \beta_3^h (\text{NonBorrower}_i \times \text{Outflow}_i^-) \\ &+ \beta_4^h \text{Inflow}_i^+ + \beta_5^h \text{SecLoss}_i + \beta_6^h (\text{SecLoss}_i \times \text{Outflow}_i^-) \\ &+ \beta_7^h (\text{SecLoss}_i \times \text{Inflow}_i^+) + \beta_8^h \text{LoanGrowth}_{i,t\to t+8} \\ &+ \beta_9^h \text{UninsuredDep}_i + \mathbf{X}_i' \boldsymbol{\gamma}^h + \epsilon_i^h\end{aligned} \tag{21}$$

where $\text{Outflow}_i^- \equiv \min(0, \text{flow}_i) \leq 0$ is the signed-negative component of the 8-week forward deposit flow (zero for net inflows; negative-valued for net outflows, e.g., -1.82 for a 1.82% outflow), $\text{Inflow}_i^+ \equiv \max(0, \text{flow}_i) \geq 0$ is the signed-positive component (the flow is measured from t to $t+8$),

X includes liquidity ratio, 2022 deposit growth, FHLB advances, tier 1 capital ratio, and bank size indicators, and t denotes the BTFP announcement date (March 12, 2023).[38]

Figure 13 shows the differential rate response. At the median core deposit outflow of 1.82 percent of assets, the estimated 26-week increase in six-month CD rates was 7.2 basis points larger for BTFP borrowers than for non-borrowers. The comparison holds other bank characteristics fixed (Table A15). While the 12-month differential is not significantly different from zero, the 24-month differential is again positive for BTFP borrowers (see the Appendix Figures A3 and A4). [39]



(a) Rate Changes by Deposit Flow

(b) Differential Response

Figure 13

Note: Panel (a) shows predicted 6-month CD rate changes over 26 weeks following SVB failure (March 10 – September 2023) for BTFP borrowers versus non-borrowers, as a function of deposit outflows measured at 8 weeks post-SVB. The dashed horizontal line marks the 75 basis point increase in the federal funds rate over the same period. Panel (b) shows the differential response (borrower minus non-borrower) with 90% confidence intervals (shaded). Vertical dotted lines mark the 25th, 50th, and 75th percentiles of the deposit outflow distribution. Both panels evaluated at mean values of all other controls using full control specification. Based on regression in Table A15, 6-month CD columns.

The evidence links BTFP use to adjustments in reserves and other borrowing (Sections 4.3 and 4.4), as well as deposit pricing. At the median outflow, borrowers' estimated CD-rate increases exceeded those of non-borrowers with the same observed characteristics.

6 Conclusion

This paper evaluates how the Federal Reserve addressed its conflicting goals of monetary policy and financial stability during the 2023 stress. It explores the design and outcomes related to the Bank

[38] We focus the non-borrower interaction on deposit outflows (Outflow_i^-) because the sample contains too few BTFP borrowers experiencing deposit inflows (N=3-4) to reliably estimate differential responses for the inflow component.

[39] The calculation uses $\hat{\beta}_1^h$, $\hat{\beta}_2^h$, and $\hat{\beta}_3^h$ from Table A15, the coefficients on the non-borrower indicator, the outflow, and their interaction. The outflow term contributes 28.7 basis points for borrowers, $(-15.761) \times (-1.82)$. The non-borrower indicator and outflow terms contribute 21.5 basis points for non-borrowers, $15.971 + (-15.761 + 12.744) \times (-1.82)$. These component calculations omit common terms in the fitted rate changes, which cancel in the conditional difference of 7.2 basis points, $-\hat{\beta}_1^h - \hat{\beta}_3^h \times (-1.82)$.

Term Funding Program, and what its design implies for emergency liquidity more generally. The evidence points to three conclusions. First, the banks most exposed to the interaction of uninsured-deposit funding and unrealized securities losses faced the largest deposit outflows. Second, the BTFP operated as a targeted backstop for that vulnerability: borrowing concentrated among the exposed banks and was associated with deposit outflows and reserve accumulation. We find no detectable expansion of risky lending around draws. Third, banks with pre-positioned discount-window collateral used the BTFP sooner and relied less on reserve drawdowns. BTFP borrowers also raised six-month CD rates more than comparable non-borrowers at the median outflow, with an estimated gap of 7.2 basis points.

These findings bear on both facility design and monetary transmission during rate-driven fragility. Rate-driven declines in the market value of safe securities reduce the cash a bank can raise against them without reducing their payoff at maturity. Par lending preserves borrowing capacity against those securities. In the model, banks with timely access and enough eligible collateral can meet a given withdrawal need without selling at the depressed price. New private lending does not change the payoff on the pledged securities. In the data, banks with pre-positioned discount-window collateral used the BTFP sooner. The fixed-rate terms also created carry incentives as reserve remuneration overtook the facility rate.

The broader lesson is that an emergency facility is defined by its collateral and pricing terms, its limits are set by the nature of the shock, and its operational implementation interacts with both of these. Par valuation can restore borrowing capacity lost to a markdown on safe government securities. It cannot replace payments lost to credit defaults, as in the private-credit losses of the 2008 crisis. Lending at par against credit-impaired assets can leave collectible collateral value below the advance. Characterizing the *optimal* facility—pricing, floor, and eligibility jointly—is left to future work.

References

Ahnert, T., Bertsch, C., Leonello, A. and Marquez, R. (2026). Bank fragility and risk management, unpublished manuscript.

Allen, F. and Carletti, E. (2008). Mark-to-market accounting and liquidity pricing. *Journal of Accounting and Economics*, **45** (2-3), 358–378.

—, — and Gale, D. (2009a). Interbank market liquidity and central bank intervention. *Journal of Monetary Economics*, **56** (5), 639–652.

—, — and — (2009b). Interbank market liquidity and central bank intervention. *Journal of Monetary Economics*, **56** (5), 639–652.

— and Gale, D. (2004). Financial fragility, liquidity, and asset prices. *Journal of the European Economic Association*, **2** (6), 1015–1048.

Anbil, S., Carlson, M. and Styczynski, M.-F. (2023). The effect of the federal reserve's lending facility on ppp lending by commercial banks. *Journal of Financial Intermediation*, **55**, 101042.

Armantier, O., Ghysels, E., Sarkar, A. and Shrader, J. (2015). Discount window stigma during the 2007–2008 financial crisis. *Journal of Financial Economics*, **118** (2), 317–335.

Arseneau, D. M., Klee, E., Kotidis, A. and Siemer, M. (2025). *The Federal Reserve's Response to the 2023 Banking Turmoil: The Bank Term Funding Program*. Finance and Economics Discussion Series 2025-099, Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2025.099.

Bagehot, W. (1873). *Lombard Street: A Description of the Money Market*. London: Henry S. King and Co.

Board of Governors of the Federal Reserve System (2024). Bank Term Funding Program: Frequently asked questions. https://www.federalreserve.gov/financial-stability/files/bank-term-funding-program-faqs.pdf, updated January 24, 2024.

Brunnermeier, M. and Pedersen, L. (2009a). Market liquidity and funding liquidity. *The Review of Financial Studies*, **22** (6), 2201–2238.

— and Pedersen, L. H. (2009b). Market liquidity and funding liquidity. *The Review of Financial Studies*, **22(6)**, 2201–2238.

Caglio, C., Dlugosz, J. and Rezende, M. (2023). Flight to safety in the regional bank crisis of 2023.

Chang, B., Cheng, I.-H. and Hong, H. (2023). The fundamental role of uninsured depositors in the regional banking crisis, unpublished manuscript.

Choi, D. B., Goldsmith-Pinkham, P. and Yorulmazer, T. (2023). Contagion effects of the Silicon Valley bank run.

Cipriani, M., Eisenbach, T. M. and Kovner, A. (2024). Tracing Bank Runs in Real Time. *Federal Reserve Bank of New York Staff Reports*, **1104**.

Cookson, J. A., Fox, C., Gil-Bazo, J., Imbet, J. F. and Schiller, C. (2023). Social media as a bank run catalyst.

Cooperman, H. R., Duffie, D., Luck, S., Wang, Z. Z. and Yang, Y. (2023). Bank funding risk, reference rates, and credit supply. *Journal of Finance, forthcoming*.

Correia, S., Luck, S. and Verner, E. (2025). Failing banks*. *The Quarterly Journal of Economics*, p. qjaf044.

Diamond, D. W. and Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, **91** (3), 401–419.

Dietrich, D., Moessner, R. and Nelson, W. (2014). Central banks as lender of last resort: experiences during the 2007–2010 crisis and lessons for the future. *BIS Papers*, pp. 76–80.

Drechsler, I., Drechsel, T., Marques-Ibanez, D. and Schnabl, P. (2016). Who borrows

from the lender of last resort? *Journal of Finance*, **71(5)**, 1933–1974.

—, Savov, A. and Schnabl, P. (2017a). The deposits channel of monetary policy. *Quarterly Journal of Economics*, **132** (4), 1819–1876.

—, — and — (2017b). The Deposits Channel of Monetary Policy. *The Quarterly Journal of Economics*, **132(4)**, 1819–1876.

—, —, — and Wang, O. (2026). Deposit franchise runs. *The Journal of Finance*.

Ennis, H. and Weinberg, J. (2016). The role of central bank lending in the conduct of monetary policy. Federal Reserve Bank of Richmond *Economic Brief*, (16-12).

Ennis, H. M. (2019). Interventions in markets with adverse selection: implications for discount window stigma. *Journal of Money, Credit and Banking*, **51** (7), 1737–1764.

Federal Housing Finance Agency (2023). *Report on Collateral Pledged to Federal Home Loan Banks*. Tech. rep., Federal Housing Finance Agency, Division of Federal Home Loan Bank Regulation, prepared for the Senate Committee on Banking, Housing, and Urban Affairs and the House Committee on Financial Services. https://www.fhfa.gov/document/d/fhlb-c/collateral-pledged-to-fhlbanks-2023.

Freixas, X., Parigi, B. and Rochet, J.-C. (2004). The lender of last resort: a twenty-first century approach. *Journal of the European Economic Association*, **2** (6), 1085–1115.

Glancy, D., Gross, M. and Ionescu, F. (2020). How did banks fund C&I drawdowns at the onset of the COVID-19 crisis?

Goldstein, I. and Pauzner, A. (2005). Demand–deposit contracts and the probability of bank runs. *Journal of Finance*, **60** (3), 1293–1327.

Goodfriend, M. and King, R. G. (1988). Financial deregulation, monetary policy, and central banking. *Federal Reserve Bank of Richmond Economic Review*, **74** (3), 3–22.

Goodhart, C. (1987). Why do banks need a central bank? *Oxford Economic Papers*, pp. 75–89.

— and Schoenmaker, D. (1995). Institutional separation between supervisory and monetary agencies. *The Central Bank and the Financial System (MIT Press, Cambridge, MA)*.

Granja, J., Jiang, E. X., Matvos, G., Piskorski, T. and Seru, A. (2024). Book value risk management of banks: Limited hedging, HTM accounting, and rising interest rates. (NBER Working Paper No. 32293).

Haddad, V., Glaser-Hartman, B. and Muir, T. (2023). Bank Fragility When Depositors Are the Asset.

Jasova, M., Laeven, L., Mendicino, C., Peydro, J.-L. and Supera, D. (2023). Systemic risk and monetary policy: The haircut gap channel of the lender of last resort. *Review of Financial Studies*, **37(7)**, 2191–2243.

—, Mendicino, C. and Supera, D. (2021). Policy uncertainty, lender of last resort and the real economy. *Journal of Monetary Economics*, **118**, 381–398.

Jiang, E. X., Matvos, G., Piskorski, T. and Seru, A. (2023). Monetary tightening and U.S. bank fragility in 2023: Mark-to-market losses and uninsured depositors. *Journal of Financial Economics*, **148** (3), 662–689.

McPhail, L., Schnabl, P. and Tuckman, B. (2023). Do banks hedge using interest rate swaps? (NBER Working Paper No. 31166).

Minoiu, C., Zarutskie, R. and Zlate, A. (2024). Motivating banks to lend? credit spillover effects of the main street lending program. *FEDS Working Paper 2021-078, Federal Reserve Board*.

Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, and Federal Deposit Insurance Corporation (2019). Regulatory capital rule: Capital simplification for qualifying community banking organizations. Final rule, Federal Register 84, 61776–61804, November 13, 2019, community bank leverage ratio framework,

effective January 1, 2020.

Rochet, J.-C. and Vives, X. (2004). Coordination failures and the lender of last resort: was bagehot right after all? *Journal of the European Economic Association*, **2** (6), 1116–1147.

Rose, J. (2023). Understanding the speed and size of bank runs in historical comparison. *Economic Synopses*, (12), 1–5.

Tinbergen, J. (1952). *On the Theory of Economic Policy*. Amsterdam: North-Holland.

Van Bekkum, S., Gabarro, M. and Irani, R. M. (2018). Does a larger menu increase appetite? collateral eligibility and credit supply. *Review of Financial Studies*, **31** (3), 943–979.

A Appendix

A.1 Funding problem and proof

The body treats ordinary borrowing as a separate effective collateral pool. Facility borrowing and sales instead draw on the same safe securities through the final constraint in (6). This section proves the funding conditions, characterizes that shared-collateral margin, proves Proposition 3.2, and separates current capacity from secured recovery.

Proof of the allocation conditions in (8). Sales and facility borrowing can jointly raise at most

$$p_i V_i + I_i^{\mathrm{op}}[a_i - p_i]^+ V_i.$$

Indeed, without access the bank can only sell the safe pool for $p_i V_i$. With access, assigning each unit of the security to its higher-cash use yields $\max\{p_i, a_i\}V_i$. Reserves and ordinary borrowing are separate continuous sources with capacities x_i and K_i^O, which proves (7). When nonempty, the feasible set is compact, and the objective is lower semicontinuous, including at $b_i = 0$, so a minimum exists.

Suppose first that the no-facility problem is feasible. If $\Delta_i^F > \varepsilon_i \geq 0$, then $\mathcal{C}_i^{+F} < \mathcal{C}_i^{-F}$, so every $\mathcal{C}_i^{+F}$-attaining plan uses the facility; otherwise it would be feasible for the no-facility problem at lower cost, a contradiction. Adding the fixed cost leaves $\mathcal{C}_i^{+F} + \varepsilon_i < \mathcal{C}_i^{-F}$, so positive use is selected. If $\Delta_i^F \leq \varepsilon_i$, every positive-use plan has total cost at least $\mathcal{C}_i^{+F} + \varepsilon_i \geq \mathcal{C}_i^{-F}$, and the participation tie-break selects no facility use. If the no-facility problem is infeasible, every feasible plan uses the facility. This proves (8). To establish the ordering of facility borrowing and sales for any $a_i > 0$, condition on reserves and ordinary borrowing and let h_i be the need left for the shared safe pool. Its variable cost is

$$c_i^S(h_i - b_i) + c_i^F b_i = c_i^S h_i + (c_i^F - c_i^S)b_i.$$

The bank therefore selects the largest feasible draw when $c_i^F \leq c_i^S$ and the smallest when $c_i^F > c_i^S$. Lemma A.1(b) gives the explicit endpoints when $a_i \geq p_i$.

When $a_i \geq p_i$ and $c_i^F \leq c_i^S$, any feasible safe-pool allocation satisfies $b_i + \sigma_i \leq a_i V_i$. Replacing it with facility borrowing of $b_i + \sigma_i$ and zero sales weakly reduces both collateral use and variable cost. Conditional on facility use, the fixed cost is unchanged, and the tie-break selects the sale-free allocation at equal costs. The remaining sources have independent capacities x_i, K_i^O, and $a_i V_i$, so increasing marginal-cost order solves their allocation. This includes the par, costly-sales case in the body. □

Terminal service in the four-source problem. Let $\mathcal{A}_i$ denote other terminal resources net of credit losses, and let C_i^0 denote terminal claims other than the new ordinary and facility loans, after accounting for any claims extinguished by the date-1 cash payments. Par surplus values the securities at face and deducts the current cash need:

$$\Omega_i \equiv x_i - q_i + \mathcal{A}_i + V_i - C_i^0. \tag{22}$$

For any feasible plan, terminal resources net of claims are

$$(1 + c^R)(x_i - \rho_i) + \mathcal{A}_i + V_i - \frac{\sigma_i}{p_i} - C_i^0 - (1 + c_i^O)n_i - \phi_i b_i.$$

Using the funding identity and the definitions of the marginal costs reduces this expression to (17). Retained reserves earn IORB, so reserve remuneration enters terminal service through $c^R(x_i - \rho_i)$.

The fixed first-use cost does not enter this identity, by the convention stated in the body.

A.2 Shared-collateral funding

To isolate the shared-collateral margin, suppress ordinary borrowing and use reserves first, which is consistent with the maintained tie-break when their cost is weakly lowest. Define

$$g_i \equiv (q_i - x_i)^+, \qquad V_i = 1 - x_i. \tag{23}$$

We study a positive post-reserve gap, $g_i > 0$. If $g_i = 0$, reserves meet the current need and neither a sale nor a bridge loan is required. Let $a_i \equiv \alpha(p_i)$ be the realized advance per dollar of collateral face value, and initially suppose

$$0 < p_i < 1, \qquad p_i \le a_i \le 1.$$

The restriction $a_i \ge p_i$ applies only to this bridge. Equation (12) also applies when the advance rate is below the market price, but such a facility adds no cash capacity beyond selling the collateral.

Let y_i be units of the safe security sold, so that the body's sale proceeds are $\sigma_i = p_i y_i$; let b_i^{br} be current cash borrowed and ζ_i units pledged. The current-allocation problem uses minimal pledge without loss: extra pledge raises no cash and weakly tightens non-overlap. Thus $\zeta_i = b_i^{\mathrm{br}}/a_i$, and feasibility is

$$p_i y_i + b_i^{\mathrm{br}} = g_i, \qquad 0 \le \zeta_i = \frac{b_i^{\mathrm{br}}}{a_i}, \qquad y_i + \zeta_i \le V_i, \qquad y_i \ge 0, \quad b_i^{\mathrm{br}} \ge 0. \tag{24}$$

Because $g_i > 0$, reserves-first funding sets $\rho_i = x_i$, ordinary borrowing is suppressed, and (22) becomes $\Omega_i = \mathcal{A}_i + V_i - C_i^0 - g_i$. Thus the par-value principal cost of the current gap is counted once. The sale and facility terms below are incremental losses relative to this baseline. Terminal surplus under the bridge is

$$\begin{aligned} E_i(y_i, b_i^{\mathrm{br}}) &= \Omega_i - (1 - p_i) y_i - (\phi_i - 1) b_i^{\mathrm{br}} \\ &= \Omega_i - \frac{1 - p_i}{p_i} g_i + \left(\frac{1}{p_i} - \phi_i \right) b_i^{\mathrm{br}}. \end{aligned} \tag{25}$$

The retained-reserve term in (17) is zero because $\rho_i = x_i$, which is why c^R does not appear in (25).

For $a_i > p_i$, the primitive constraints are equivalent to

$$\underline{b}_i(g_i; a_i) = \max\left\{ 0, \frac{a_i(g_i - p_i V_i)}{a_i - p_i} \right\} \le b_i^{\mathrm{br}} \le \min\{g_i, a_i V_i\} \equiv \overline{b}_i(g_i; a_i). \tag{26}$$

Lemma A.1 (Shared-collateral funding)**.** *Suppose $g_i > 0$, the safe payoff is certain, operational access is active, and the facility term reaches the payoff date or assured refinancing spans the interval.*

(a) If $0 < p_i < 1$ and $a_i > p_i$, the menu funds g_i if and only if

$$g_i \le \overline{g}_i(a_i) \equiv a_i V_i. \tag{27}$$

Sale alone funds g_i if and only if $g_i \le p_i V_i$. At $a_i = p_i$, the menu is feasible exactly when $g_i \le p_i V_i$, and feasible draws are $[0, \min\{g_i, p_i V_i\}]$.

(b) *Conditional on feasibility and with the first-use cost excluded or already sunk, the variable-cost-selected draw is*

$$b_i^{\mathrm{br}*} = \begin{cases} \overline{b}_i(g_i; a_i), & \phi_i \le 1/p_i, \\ \underline{b}_i(g_i; a_i), & \phi_i > 1/p_i, \end{cases} \qquad y_i^* = \frac{g_i - b_i^{\mathrm{br}*}}{p_i}, \tag{28}$$

where equality selects the maximal draw. At $a_i = p_i$, the same endpoint rule applies to its feasible interval.

(c) *Terminal service under this variable-cost-selected plan is possible if and only if current funding is feasible and*

$$\Omega_i \ge \frac{1 - p_i}{p_i} g_i + \left(\phi_i - \frac{1}{p_i}\right) b_i^{\mathrm{br}*}. \tag{29}$$

At $p_i = 1$, the bridge domain implies $a_i = 1$. Funding is feasible iff $g_i \le V_i$, with draws in $[0, \min\{g_i, V_i\}]$. The tie-break selects the maximal draw at $\phi_i = 1$ and zero borrowing at $\phi_i > 1$.

Proof. Substitute $y_i = (g_i - b_i^{\mathrm{br}})/p_i$ and $\zeta_i = b_i^{\mathrm{br}}/a_i$ into (24). For $a_i > p_i$, nonnegative sales, eligible pledge capacity, and non-overlap give (26); the interval is nonempty exactly under (27). At $a_i = p_i$, non-overlap reduces to $g_i \le p_i V_i$ independently of the draw. Equation (25) is affine in borrowing, which gives the selected endpoint and the service condition. The $p_i = 1$ statements follow directly. □

Equation (29) specializes the general service condition in (17) to the reserves-first bridge with ordinary borrowing suppressed. Market-value solvency alone does not generally imply it because market surplus is measured before the incremental sale and borrowing costs required to fund the current shortfall.

When sale alone is feasible, the variable-cost saving from access is

$$\Delta_i^{\mathrm{br}} = \left(\frac{1}{p_i} - \phi_i\right)^+ \min\{g_i, a_i V_i\}. \tag{30}$$

The bridge problem uses the facility if and only if $\Delta_i^{\mathrm{br}} > \varepsilon_i$ and selects no facility use at equality. On $p_i V_i < g_i \le \overline{g}_i(a_i)$, we set $\Delta_i^{\mathrm{br}} = +\infty$ because the no-facility problem has no feasible allocation: access is then required to fund the need. No allocation exists above menu capacity. For a general schedule this statement is pointwise; monotonicity in securities losses requires additional restrictions. For $\alpha_B(p) \equiv 1$, access value is weakly increasing over any loss support on which the need remains menu-feasible.

A.2.1 Advance schedules with shared collateral

Equation (12) follows by maximizing $p_i y_i + b_i^{\mathrm{br}}$ subject to $y_i + b_i^{\mathrm{br}}/a_i \le V_i$ and nonnegative choices. The maximum is $\max\{p_i, a_i\} V_i = p_i V_i + [a_i - p_i]^+ V_i$. The BTFP is the upper-bound schedule $a_i = 1$, which yields menu capacity V_i. A market-value rule with no haircut has $a_i = p_i$ and adds no capacity; a constant haircut $\delta \in [0, 1)$ has $a_i = (1 - \delta) p_i \le p_i$, strictly below market when $\delta > 0$, and likewise adds none. These comparisons hold the collateral pool, price, and access fixed and do not rank facility use.

For a general schedule, fix reserve use and ordinary borrowing. The variable-cost optimum in the shared safe pool takes the largest feasible facility draw when $c_i^F \le c_i^S$, or equivalently $\phi_i \le 1/p_i$,

and the smallest feasible draw when the inequality is reversed. Outside the par, costly-sales case, shared collateral can prevent a global ordering of sources by raw funding cost.

At $\phi_i = 1/p_i$, maximal draw is the access-enabled, sunk-use tie-break in Lemma A.1. When sale alone is feasible and the first-use cost has not been paid, the full problem selects no facility use—strictly for $\varepsilon_i > 0$ and by the participation tie-break for $\varepsilon_i = 0$.

A.3 Substitution toward the facility: proof

For each bank type i, fix a reserve adjustment $\bar{\rho}_i$ that is feasible throughout a common loss interval $\mathcal{I}$ on which $0 < L < V$ for every type. Holding $\bar{\rho}_i$ fixed is not a restriction in the focal case: when reserves are the cheapest source, $c^R \leq \min\{c^O, c^F\}$, and the bank is stressed throughout $\mathcal{I}$, so that $q_i(L) > x_i$, the cost-minimizing reserve use is $\bar{\rho}_i = x_i$ at every loss exposure. Remaining need is $\widetilde{q}_i(L) = q_i(L) - \bar{\rho}_i$. We suppress bank-type subscripts on capacities, costs, reserve use, and other primitives in the type-level expressions below, writing $\bar{\rho}$ for $\bar{\rho}_i$. Since $L = V(1-p)$, write $p(L) = 1 - L/V$. Ordinary capacity $K^O(L) \geq 0$ is weakly nonincreasing on $\mathcal{I}$; the fully market-linked special case is

$$K^O(L) = \left(1 - \frac{L}{V}\right) A^O, \qquad A^O > 0.$$

The proof uses the BTFP specialization: operational access is fixed at one, and facility capacity is $K^F \equiv V > 0$. Hold the cross-sectional distribution of bank types fixed. Within each type, V, ε_i, and the other primitives are fixed, while $\widetilde{q}_i(L)$ is weakly increasing. At every loss exposure, require $0 < \widetilde{q}_i(L) < K^F$. The cross-sectional distributions are absolutely continuous and put no mass at kinks or first-use thresholds. Costs $c^O \geq 0$ and $c^F \geq 0$ are fixed; $c^S(L)$ is nondecreasing and satisfies $c^S(L) > \max\{c^O, c^F\}$ throughout $\mathcal{I}$. Under these restrictions, the selected cost-minimizing allocation has zero asset sales whenever it uses the facility: it uses ordinary borrowing before the facility when $c^O \leq c^F$ and the facility alone when $c^F < c^O$. Because $\widetilde{q}_i(L) < V$, these allocations satisfy the shared-collateral constraint in (6).

At the fixed reserve adjustment $\bar{\rho}$, nonfacility funding capacity is

$$K^{-F}(L) \equiv K^O(L) + V - L.$$

When $\widetilde{q} \leq K^{-F}(L)$, the saving from facility access is

$$\Delta^F(\widetilde{q}, L \mid \bar{\rho}) = \begin{cases} [c^S(L) - c^F](\widetilde{q} - K^O(L))^+, & c^O \leq c^F, \\ (c^O - c^F)\min\{\widetilde{q}, K^O(L)\} + [c^S(L) - c^F](\widetilde{q} - K^O(L))^+, & c^F < c^O. \end{cases} \tag{31}$$

When $\widetilde{q} > K^{-F}(L)$, set $\Delta^F = +\infty$. Since the first-use cost is finite, this convention sets $I_i^e(L) = \mathbf{1}\{\varepsilon_i < \Delta^F(\widetilde{q}_i(L), L \mid \bar{\rho}_i)\}$ to one whenever ordinary borrowing and sales cannot meet the remaining need. If $c^O \leq c^F$,

$$n_i = \min\{\widetilde{q}_i(L), K^O(L)\}, \qquad b_i = I_i^e(L)(\widetilde{q}_i(L) - K^O(L))^+. \tag{32}$$

If $c^F < c^O$,

$$n_i = (1 - I_i^e(L))\min\{\widetilde{q}_i(L), K^O(L)\}, \qquad b_i = I_i^e(L)\widetilde{q}_i(L). \tag{33}$$

Proof of Proposition 3.2. First consider the region in which nonfacility funding is feasible, $\widetilde{q} \leq K^O(L) + V - L$, and hold remaining need fixed. Ordinary capacity weakly falls and sale cost weakly

rises with L. Under ordinary-first ordering, both changes weakly raise $[c^S(L) - c^F](\widetilde{q} - K^O(L))^+$. Under facility-first ordering, access value is constant while $K^O \geq \widetilde{q}$. When $K^O < \widetilde{q}$, its change with capacity has sign $c^O - c^S(L) < 0$, while its change with sale cost has sign $\widetilde{q} - K^O(L) > 0$. The two branches coincide at $K^O(L) = \widetilde{q}$, so access value is pointwise nondecreasing through the kink.

Access value is also nondecreasing in remaining need: its slope is zero or $c^S - c^F > 0$ under ordinary-first ordering and is $c^O - c^F > 0$ or $c^S - c^F > 0$ under facility-first ordering. Nonfacility capacity $K^{-F}(L)$ is weakly decreasing, whereas $\widetilde{q}_i(L)$ is weakly increasing. Once the need exceeds that capacity, nonfacility funding remains infeasible at every larger loss; access value is then infinite and $I_i^e = 1$. The first-use indicator is therefore nondecreasing across both regions.

Away from kinks, (32) gives source-use derivatives $I_i^e \mathbf{1}\{\widetilde{q}_i > K^O\}$ for the facility and $\mathbf{1}\{\widetilde{q}_i < K^O\}$ for ordinary borrowing. Equation (33) gives I_i^e and $(1 - I_i^e)\mathbf{1}\{\widetilde{q}_i < K^O\}$. In the necessary-use region, $\widetilde{q}_i > K^O(L) + V - L > K^O(L)$, so these derivative pairs equal $(1, 0)$ under either cost ordering. Since need weakly rises and ordinary capacity weakly falls, the facility derivative is nondecreasing within type and the ordinary derivative is nonincreasing. Averaging over the fixed distribution of types proves the result. □

For the model-implied costs $c^S(L) = L/(V - L)$ and $c^F = \phi - 1$, the maintained ordering requires both

$$\frac{L}{V} > 1 - \frac{1}{\phi} \qquad \text{and} \qquad \frac{L}{V} > \frac{c^O}{1 + c^O},$$

or $L/V > \max\{1 - 1/\phi, c^O/(1 + c^O)\}$. Holding remaining need fixed, the direct capacity-and-sale-cost effect is zero wherever ordinary capacity covers that need. Total access value can still rise because the loss-sensitive need rises.

A.3.1 Participation and mean borrowing

Entry changes mean borrowing even when each bank's allocation is locally linear within its participation status. Maintain the substitution proposition's restrictions and fix reserves and all primitives other than the first-use cost and remaining need. Hold L fixed while varying $\widetilde{q}$ in a neighborhood where $0 < \widetilde{q} < V$, nonfacility funding is feasible, and $\widetilde{q} \neq K^O(L)$. Let F_ε be the conditional first-use-cost distribution given the fixed primitives, with a continuous density f_ε at the finite access saving $\Delta \equiv \Delta^F(\widetilde{q}, L \mid \bar{\rho})$; the distribution is held fixed as need varies.

For source $j \in \{b, n\}$, let j_1 and j_0 be its variable-cost-minimizing uses with and without the facility option. Participation probability is $P_e = F_\varepsilon(\Delta)$, so

$$\mathbb{E}_\varepsilon[j] = P_e j_1 + (1 - P_e) j_0.$$

The expectation averages over first-use costs within the fixed type. Its average within-status response is

$$\beta_\varepsilon^j \equiv P_e \frac{\partial j_1}{\partial \widetilde{q}} + (1 - P_e) \frac{\partial j_0}{\partial \widetilde{q}}.$$

Differentiating the mean gives the within-status response plus the allocation change at entry:

$$\frac{\partial \mathbb{E}_\varepsilon[j]}{\partial \widetilde{q}} = \beta_\varepsilon^j + (j_1 - j_0) f_\varepsilon(\Delta) \frac{\partial \Delta}{\partial \widetilde{q}}. \tag{34}$$

Access value is nondecreasing in need by the proof above. Since $b_0 = 0 \leq b_1$, entry contributes a nonnegative term to the response of mean facility borrowing. For ordinary borrowing, (32) gives

$n_1 = n_0$ when ordinary borrowing is cheaper and (33) gives $n_1 = 0 \leq n_0$ when the facility is cheaper, so entry contributes a nonpositive term to the response of mean ordinary borrowing.

These are comparisons at a given loss. The entry term need not increase with L, so the proposition's monotonicity does not extend to the derivative of mean borrowing or to a regression interaction that includes entry; (16) concerns participation probability, not the draw-weighted entry term. Averaging over other bank characteristics requires conditions permitting differentiation under the expectation, and the smooth formula excludes the boundary at which nonfacility funding becomes infeasible.

A.4 Secured recovery under narrow collateral

Recovery is analyzed for a fixed contract and may involve overpledging. For a positive draw b_i^{br}, gross pledged face ζ_i satisfies

$$b_i^{\mathrm{br}} \leq a_i \zeta_i, \qquad y_i + \zeta_i \leq V_i.$$

Net collectible value after enforcement costs is $z_i \equiv \mathcal{R}_i(\zeta_i) \in [0, \zeta_i]$. We maintain net-principal coverage $z_i \geq b_i^{\mathrm{br}}$; it does not follow from $a_i \leq 1$. Under an enforceable first-priority interest, secured recovery is

$$\min\{\phi_i b_i^{\mathrm{br}}, z_i\} = s_i b_i^{\mathrm{br}}, \qquad s_i \equiv \min\left\{\phi_i, \frac{z_i}{b_i^{\mathrm{br}}}\right\}. \tag{35}$$

Under the maintained net-principal coverage $z_i \geq b_i^{\mathrm{br}}$, (35) implies that total secured recovery is at least the principal amount. The unsecured deficiency is $(\phi_i b_i^{\mathrm{br}} - z_i)^+ = (\phi_i - s_i) b_i^{\mathrm{br}}$ and is zero if and only if $z_i \geq \phi_i b_i^{\mathrm{br}}$. Under full collection and minimal pledge, $z_i = \zeta_i = b_i^{\mathrm{br}}/a_i$, so $s_i = \min\{\phi_i, 1/a_i\}$. The collateral's total collectible value is at least the principal amount when $a_i \leq 1$ and covers the entire promised facility claim exactly when $a_i \leq 1/\phi_i$.

If an additional impairment $\chi_i \in (0,1)$ scales collectible value to $(1-\chi_i)z_i$, total collectible value is at least the principal amount when $(1-\chi_i)z_i \geq b_i^{\mathrm{br}}$ and covers the full promised claim when $(1-\chi_i)z_i \geq \phi_i b_i^{\mathrm{br}}$. Under full collection and minimal pledge, these conditions become $a_i \leq 1-\chi_i$ and $a_i \leq (1-\chi_i)/\phi_i$. Recovery on any unsecured deficiency depends on the residual estate, which the model does not specify.

For the BTFP, advance sizing used par with 100 percent margin and required pledged par to cover advances; the facility also retained recourse (Board of Governors of the Federal Reserve System, 2024). Operating Circular No. 10 governs the security interest and application of proceeds. Its §12.4 applies proceeds to specified fees and expenses, then interest, then principal, so recovery equal to the advance amount does not mean that principal is paid before interest.[40] These institutional facts motivate the maintained priority and collection conditions, but gross par coverage alone does not establish net recovery.

Remark A.2 (Narrow collateral and lender exposure). Suppose the bank can make new risky loans ν_i paying $R_i^\nu > 1$ with probability $1-\pi_i$ and zero otherwise, and those loans are ineligible collateral. Conditional on a facility draw, recovery in (35) is capped by the pledged safe payoff and does not depend on ν_i or on how the cash is spent. Any unsecured deficiency remains outside the recovery block.

Now let $\nu_i \geq 0$ measure units of new lending, each with face F_i, and admit a fraction $\theta_i \in [0,1]$ as collateral, with $R_i^\nu \leq F_i$ and $F_i > (1-\pi_i)R_i^\nu$. Conditional on drawing on the pledged loans, and under independence between that event and loan default, their aggregate date-2 collateral

[40] Operating Circular No. 10, §12.4.

face-to-expected-payoff gap is

$$\nu_i \theta_i [F_i - (1 - \pi_i) R_i^{\nu}].$$

Positive correlation between drawing and default widens it. The gap is not date-1 capacity and need not equal ultimate lender loss, which also depends on the advance, promised claim, margins, priority, recourse, and residual-estate recovery. The model does not determine origination. At $\theta_i = 0$, narrow collateral creates no capacity from new risky lending and eliminates this collateral-specific exposure.

A.5 Auxiliary funding margins

A.5.1 Retained draws and on-demand access

Starting from a selected stress allocation $(\rho_i, n_i, b_i^0, \sigma_i)$, the securities remaining after sales can support the additional facility cash

$$\overline{K}_i^F \equiv I_i^{\text{op}} a_i \left(V_i - \frac{\sigma_i}{p_i} \right) - b_i^0 \geq 0.$$

A retained draw $k_i^{\text{buf}} \in [0, \overline{K}_i^F]$ gives total borrowing $b_i^{\text{tot}} = b_i^0 + k_i^{\text{buf}}$ and net reserve change $\Delta x_i = k_i^{\text{buf}} - \rho_i$:

$$\rho_i + n_i + b_i^{\text{tot}} + \sigma_i = q_i + k_i^{\text{buf}}, \qquad n_i + b_i^{\text{tot}} + \sigma_i = q_i + \Delta x_i. \tag{36}$$

This is a second-stage choice, outside the date-1 funding problem.

Remark A.3 (On-demand access removes the early-draw motive). Suppose every unused dollar remains available later with certainty and without delay on identical or weakly better all-in terms, including pricing, eligibility, capacity, maturity or refinancing, and fixed charges. If holding borrowed cash has strictly positive net cost in every state, an early draw supplies liquidity the bank does not yet need. A later state-contingent draw supplies the same liquidity and avoids that cost, so zero early buffering is uniquely optimal.

Actual BTFP access and pricing did not satisfy that benchmark. Eligibility was assessed at each new extension, while an outstanding advance was not accelerated solely because eligibility later changed. Each advance was also priced at the rate prevailing on its draw date and fixed for its life (Board of Governors of the Federal Reserve System, 2024). Access risk and expected rate changes can therefore motivate an early draw, but this framework does not identify either motive. Borrowing beyond observed deposit outflows need not be precautionary because q_i also includes o_i; reserve retention in (36) is the relevant accounting distinction.

A.5.2 Access risk and retained draws

Borrowing required primary-credit eligibility at the time credit was extended. A bank could therefore lose unused access in a state in which it was valuable while keeping an existing advance (Board of Governors of the Federal Reserve System, 2024). We leave the supervisory state outside the model because it is unobserved and because pricing and other access margins also changed. Retained draws are consequently evidence consistent with precautionary liquidity demand, not an identified measure of it.

Relation to price-stabilizing intervention. A purchase and par lending act on the same forced-liquidation margin through different instruments. A purchase supports the market price for

all holders. Par lending leaves p_i unchanged and raises the cash obtainable against the eligible pool only for banks with operational access. Under the recovery conditions in Appendix A.4, the maintained safe-payoff, collection, priority, and net-principal-coverage conditions make total secured recovery at least the principal amount; full coverage of the promised claim requires $z_i \geq \phi_i b_i^{\mathrm{br}}$. The model does not rank the instruments because it takes prices as given and has no welfare criterion.

A.5.3 Matched-horizon carry

In a separate post-stress state, gross carry surplus from spare BTFP capacity is

$$G_i(v_{i\omega}, K_{i\omega}^c) = \max_{0 \leq b^c \leq K_{i\omega}^c} \{v_{i\omega} b^c - \Gamma_i(b^c)\}, \qquad 0 \leq K_{i\omega}^c \leq \overline{K}_i^F. \tag{37}$$

Here ω indexes a post-stress carry state and $v_{i\omega}$ is expected reserve remuneration net of facility interest and other linear costs over the same horizon. The balance-sheet cost Γ_i is increasing, differentiable, and strictly convex, with $\Gamma_i(0) = 0$. Initiating carry costs $f_{i\omega}^A \geq 0$. Let $I_i^0 = 1$ if the original first-access cost ε_i has already been paid and zero otherwise; in particular, $I_i^0 = 1$ whenever $b_i^0 > 0$.

Proposition A.4 (Matched-horizon carry)**.** *The gross optimizer is unique and weakly increasing in $v_{i\omega}$ and $K_{i\omega}^c$. For positive capacity it is zero when $v_{i\omega} \leq \Gamma_i'(0)$, interior with $\Gamma_i'(b_{i\omega}^{c*}) = v_{i\omega}$ when $\Gamma_i'(0) < v_{i\omega} < \Gamma_i'(K_{i\omega}^c)$, and at capacity when $v_{i\omega} \geq \Gamma_i'(K_{i\omega}^c)$. The bank initiates carry if and only if*

$$G_i(v_{i\omega}, K_{i\omega}^c) > f_{i\omega}^A + (1 - I_i^0)\varepsilon_i, \tag{38}$$

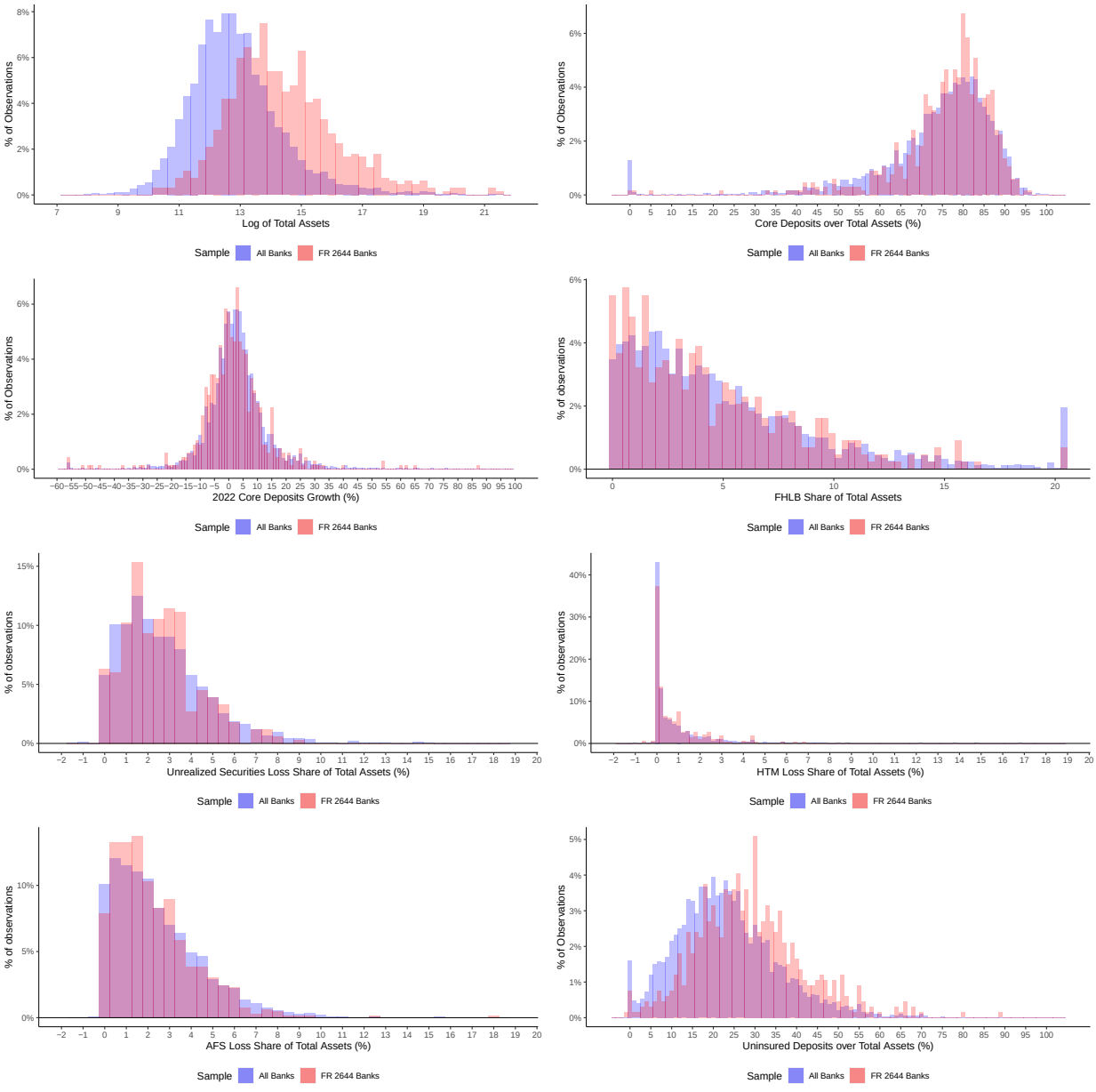
with no carry at equality. Conditional on initiating carry, the selected draw is positive.

Proof. The gross objective is strictly concave on a compact interval. Its derivative $v_{i\omega} - \Gamma_i'(b)$ is strictly decreasing, giving the three regions and weak comparative statics. Comparing maximized gross surplus with both unpaid fixed costs gives (38). □

A positive spot IORB–BTFP spread is only a proxy for $v_{i\omega}$. Holding the spread, spare capacity, Γ_i, and the remaining primitives fixed, prior facility use weakly lowers the carry-participation threshold.

A.6 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.7 Independence of Vulnerability Measures

Figure A2 shows the cross-sectional relationship between unrealized securities losses and uninsured deposit shares as of 2022Q4. The two vulnerability measures are essentially uncorrelated ($\rho = -0.018$, $p = 0.64$), indicating independent variation in the two dimensions of fragility. This orthogonality validates the interpretation of the interaction term in Table 2: the amplification effect captures genuine complementarity between distinct vulnerabilities rather than selection into a common risk factor.

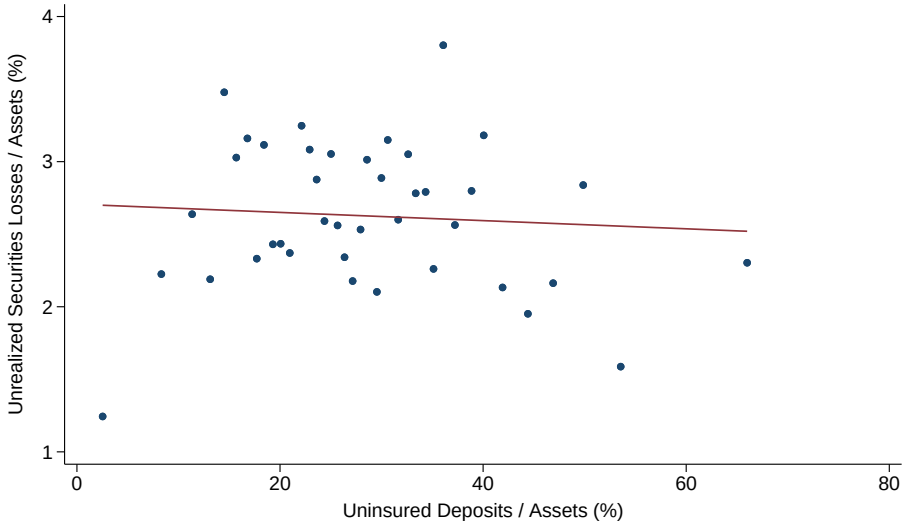


Figure A2: Cross-Sectional Independence of Vulnerability Measures

Note: Binned scatter plot showing unrealized securities losses and uninsured deposits (both as percentage of total assets, measured as of 2022Q4). Each point represents the average within 40 equal-sized bins of the uninsured deposit distribution. Sample: N=668 banks in the main cross-sectional analysis.

A.8 Deposit pricing

The deposit pricing analysis in Section 4.5 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. Figures A3 and A4 show the differential rate responses for 12-month and 24-month CDs.

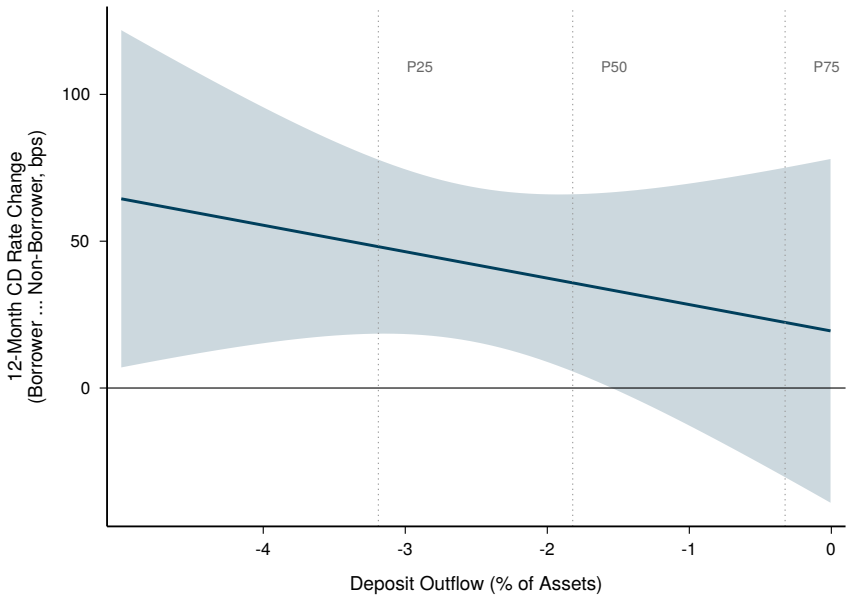


Figure A3: 12-Month CD Rate Differential Response to Deposit Outflows

Note: Figure shows the differential rate response (borrower minus non-borrower) for 12-month CDs over 26 weeks following SVB failure (March 10 – September 2023), evaluated over the outflow range (negative deposit growth). Shaded area represents 90% confidence intervals. Vertical dotted lines mark the 25th, 50th, and 75th percentiles of the deposit outflow distribution. Evaluated at mean values of all other controls using full control specification. Based on regression in Table A15, 12-month CD columns.

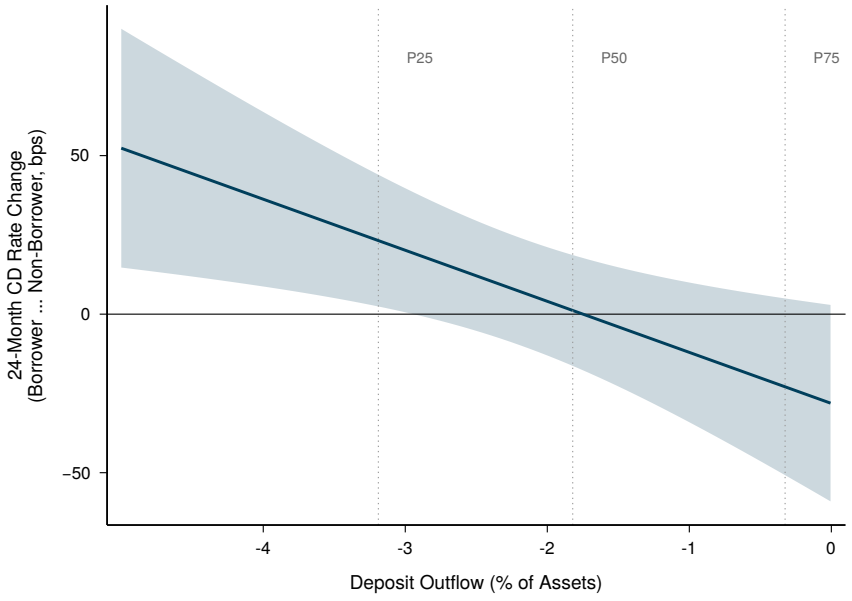
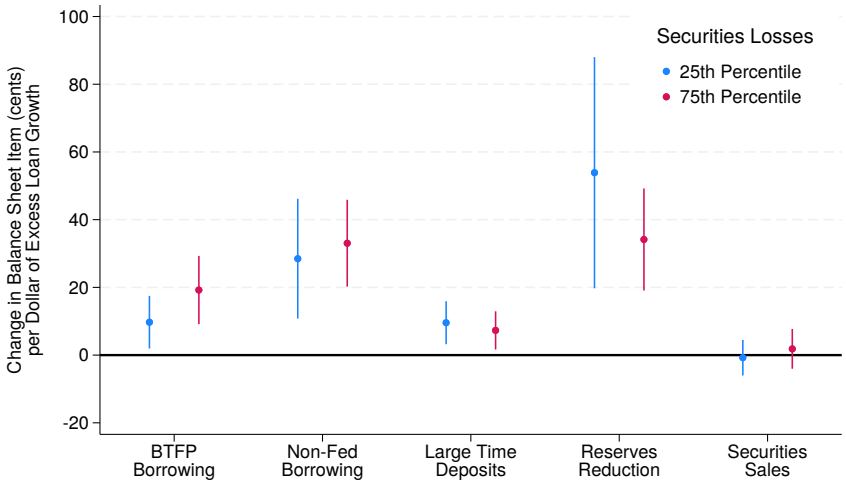


Figure A4: 24-Month CD Rate Differential Response to Deposit Outflows

Note: Figure shows the differential rate response (borrower minus non-borrower) for 24-month CDs over 26 weeks following SVB failure (March 10 – September 2023), evaluated over the outflow range (negative deposit growth). Shaded area represents 90% confidence intervals. Vertical dotted lines mark the 25th, 50th, and 75th percentiles of the deposit outflow distribution. Evaluated at mean values of all other controls using full control specification. Based on regression in Table A15, 24-month CD columns.

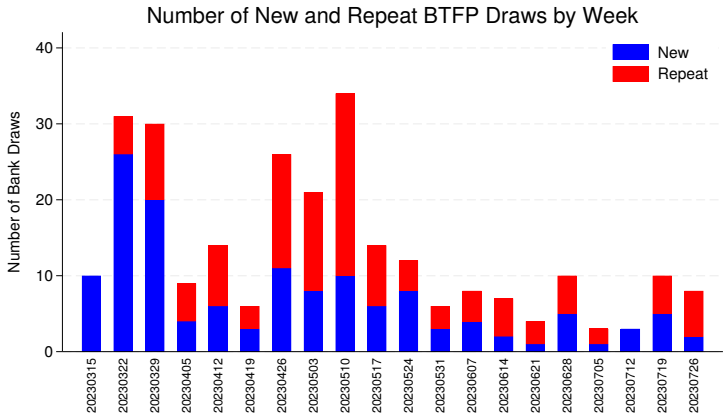
A.9 Additional figures and tables

Figure A5: How Banks Fund Excess Loan Growth



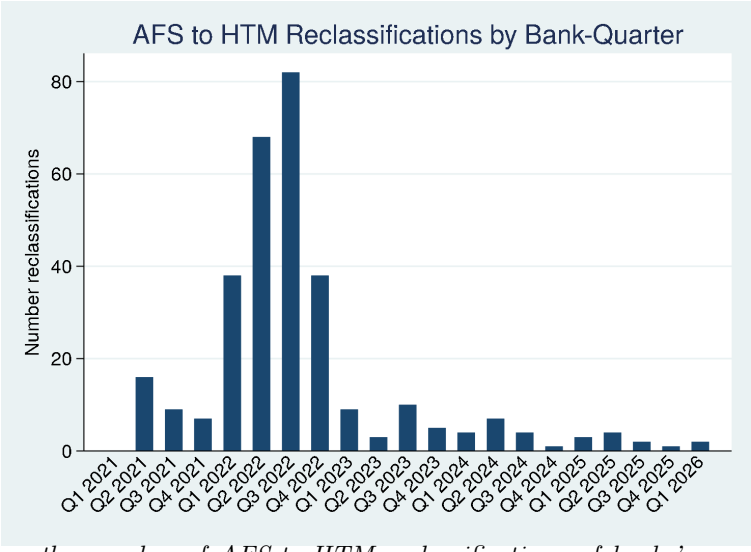
Notes: The chart presents estimates of how much various funding sources are used (in cents) to meet a $1 increase in funding needs (as measured by excess loan growth). Blue dots (lines) present point estimates (95% confidence intervals) for overall usage. Red dots and lines present equivalent estimates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

Figure A6: How Banks Draw on BTFP



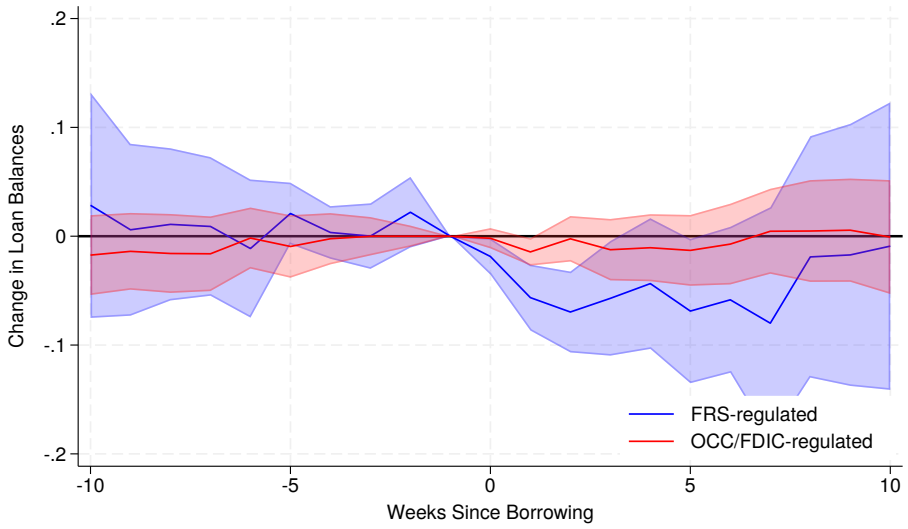
Note: The chart shows the number of draws on BTFP by banks each week. It distinguishes between new darws (in blue) and repeat draws (in red) by any given bank over the sample period.

Figure A7: AFS to HTM Reclassifications of Security Holdings



Note: The chart shows the number of AFS-to-HTM reclassifications of banks' security holdings by bank-quarter, inferred like in Granja et al. (2024) based on Call Report data.

Figure A8: 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%.

Table A1: 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*	-0.006
	(0.013)	(0.022)	(0.014)	(0.022)	(0.014)	(0.035)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.012*				-0.012*
		(0.006)				(0.006)
$\times \frac{\text{HTM loss}}{\text{Assets}}$				-0.031**		
				(0.011)		
$\times \frac{\text{AFS loss}}{\text{Assets}}$				-0.009		
				(0.006)		
$\times \frac{\text{CRE loans}}{\text{Assets}}$						0.000
						(0.001)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.022	0.362*			0.019	0.362*
	(0.081)	(0.156)			(0.081)	(0.155)
$\frac{\text{HTM loss}}{\text{Assets}}$			0.014	1.014**		
			(0.141)	(0.298)		
$\frac{\text{AFS loss}}{\text{Assets}}$			0.024	0.283*		
			(0.080)	(0.158)		
$\frac{\text{CRE loans}}{\text{Assets}}$					-0.011	-0.014
					(0.010)	(0.023)
$\frac{\Delta\text{Loans}}{\text{Assets}}$	0.259**	0.258**	0.259**	0.249*	0.260**	0.259**
	(0.099)	(0.099)	(0.099)	(0.099)	(0.099)	(0.099)
$\frac{\text{Liquid assets}}{\text{Assets}}$	-0.023	-0.023*	-0.023	-0.023	-0.029*	-0.030*
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)
Dep. growth 2022	0.042**	0.042**	0.042**	0.041**	0.041**	0.041**
	(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	0.053
	(0.037)	(0.038)	(0.037)	(0.039)	(0.038)	(0.039)
Avg. funding cost	0.542	0.587*	0.542	0.582*	0.495	0.534
	(0.349)	(0.348)	(0.348)	(0.350)	(0.352)	(0.367)
$\frac{\text{Tier 1 Capital}}{\text{Assets}}$	0.086	0.079	0.086	0.082	0.093	0.085
	(0.056)	(0.056)	(0.056)	(0.057)	(0.059)	(0.059)
Community bank	0.627	0.537	0.621	0.506	0.806	0.729
	(0.908)	(0.895)	(0.911)	(0.906)	(0.937)	(0.916)
Regional bank	1.368	1.310	1.366	1.298	1.454	1.402
	(0.950)	(0.943)	(0.952)	(0.951)	(0.959)	(0.952)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.137	0.146	0.137	0.151	0.138	0.148
Observations	668	668	668	668	668	668

*Notes: Same specification as Table 2 with the full set of controls reported. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A2: Core Deposit Outflows: Controlling for Loan Delinquencies

	$\frac{\Delta \text{Deposits}}{\text{Assets}}$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\frac{\text{Uninsured deposits}}{\text{Assets}}$	-0.032**	-0.004	-0.035***	-0.006	-0.034**	-0.009	-0.034**	0.002	-0.033**	-0.011
	(0.013)	(0.024)	(0.013)	(0.023)	(0.013)	(0.024)	(0.013)	(0.023)	(0.014)	(0.024)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.012*		-0.011*		-0.012*		-0.012**		-0.011*
		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)
$\times \frac{\text{Core loan delinq}}{\text{Assets}}$		-0.003								
		(0.005)								
$\times \frac{\text{C\&I loan delinq}}{\text{Assets}}$				-0.029***						
				(0.010)						
$\times \frac{\text{CRE loan delinq}}{\text{Assets}}$						0.003				
						(0.036)				
$\times \frac{\text{RRE loan delinq}}{\text{Assets}}$								-0.053**		
								(0.023)		
$\times \frac{\text{Consumer loan delinq}}{\text{Assets}}$										0.088***
										(0.029)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.026	0.372**	0.026	0.358**	0.022	0.363**	0.023	0.381**	0.022	0.343**
	(0.081)	(0.160)	(0.081)	(0.157)	(0.081)	(0.156)	(0.081)	(0.155)	(0.081)	(0.161)
$\frac{\text{Core loan delinq}}{\text{Assets}}$	0.183***	0.289								
	(0.064)	(0.233)								
$\frac{\text{C\&I loan delinq}}{\text{Assets}}$			0.234***	1.701***						
			(0.076)	(0.548)						
$\frac{\text{CRE loan delinq}}{\text{Assets}}$					0.011	-0.111				
					(0.265)	(0.735)				
$\frac{\text{RRE loan delinq}}{\text{Assets}}$							0.206	1.422**		
							(0.291)	(0.589)		
$\frac{\text{Consumer loan delinq}}{\text{Assets}}$									0.069	-0.336
									(0.338)	(0.365)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.142	0.151	0.142	0.156	0.137	0.146	0.137	0.154	0.137	0.155
Observations	668	668	668	668	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 with the same specification and controls as Table 2, to which we add delinquencies (30-89 days and past 90 days) and non-accruals as a percent of total assets for core, C&I, CRE, RRE, and consumer loans, both in levels and interactions. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

Table A3: 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)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.013	0.019	0.008	-0.008	-0.022*	-0.014
	(0.013)	(0.018)	(0.014)	(0.023)	(0.012)	(0.017)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.003		0.007		-0.004
		(0.005)		(0.007)		(0.005)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.081	0.154	0.007	-0.191	0.142*	0.253
	(0.072)	(0.153)	(0.085)	(0.170)	(0.080)	(0.154)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.090	0.090	0.098	0.101	0.070	0.071
Observations	661	661	668	668	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)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.014	0.012	0.006	0.003	0.014	0.014
	(0.012)	(0.018)	(0.011)	(0.016)	(0.009)	(0.015)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		0.001		0.001		0.000
		(0.005)		(0.004)		(0.004)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.073	0.046	0.057	0.016	0.039	0.038
	(0.080)	(0.146)	(0.075)	(0.122)	(0.066)	(0.106)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.132	0.132	0.074	0.074	0.067	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 2. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A4: 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)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	-0.014	-0.009	-0.030*	-0.021
	(0.015)	(0.014)	(0.017)	(0.016)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	-0.011**			
	(0.005)			
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. losses $<$ 90th percentile)		-0.012**		
		(0.005)		
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. losses $\geq$ 90th percentile)		-0.012***		
		(0.004)		
$\times \frac{\text{Loss HTM}}{\text{Assets}}$			-0.027**	
			(0.012)	
$\times \frac{\text{HTM losses}}{\text{Assets}} \times$ (HTM loss $<$ 90th percentile)				-0.042***
				(0.016)
$\times \frac{\text{HTM losses}}{\text{Assets}} \times$ (HTM loss $\geq$ 90th percentile)				-0.029***
				(0.010)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.377**	0.362**		
	(0.169)	(0.143)		
$\frac{\text{HTM loss}}{\text{Assets}}$			0.897**	0.946***
			(0.358)	(0.297)
Bank controls	Yes	Yes	Yes	Yes
R^2	0.171	0.146	0.171	0.148
Observations	539	668	539	668
P-value for coeff. equality test		.9		.19

*Notes: Same specification as Table 2 allowing for non-linear effects of total securities losses and HTM losses. In columns 2 and 4, the specification opens up the coefficient for uninsured deposits interacted with securities losses by the magnitude of banks' total and HTM losses, distinguishing by banks with losses above and below the 90th percentile of the sample distribution. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A5: 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	0.002	-0.162***	-0.073	-0.012	-0.401***	-0.498***	-0.437***
	(0.007)	(0.008)	(0.011)	(0.053)	(0.057)	(0.089)	(0.067)	(0.104)	(0.149)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.006**	-0.007**		-0.036*	-0.036**		0.039	0.039
		(0.003)	(0.003)		(0.018)	(0.018)		(0.024)	(0.024)
$\times \frac{\text{CRE loans}}{\text{Assets}}$			-0.001			-0.002			-0.002
			(0.000)			(0.003)			(0.004)
$\frac{\Delta\text{Deposits}^+}{\text{Assets}}$	-0.002	0.001	0.004	0.067	0.045	0.038	-0.213**	-0.196	-0.090
	(0.009)	(0.008)	(0.007)	(0.106)	(0.079)	(0.059)	(0.087)	(0.148)	(0.195)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		-0.002	-0.002		0.009	0.009		-0.006	-0.011
		(0.003)	(0.003)		(0.027)	(0.029)		(0.054)	(0.050)
$\times \frac{\text{CRE loans}}{\text{Assets}}$			-0.000			0.000			-0.004
			(0.000)			(0.002)			(0.005)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.034***	0.016	0.015	0.210***	0.104	0.101	0.093	0.207**	0.209**
	(0.007)	(0.011)	(0.011)	(0.050)	(0.070)	(0.070)	(0.063)	(0.099)	(0.101)
$\frac{\text{CRE loans}}{\text{Assets}}$			-0.000			0.001			0.005
			(0.001)			(0.006)			(0.014)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.002*	0.002*	0.002	0.014**	0.014**	0.012*	-0.001	0.000	-0.002
	(0.001)	(0.001)	(0.001)	(0.006)	(0.006)	(0.007)	(0.009)	(0.009)	(0.010)
$\frac{\Delta\text{Loans}}{\text{Assets}}$	0.011	0.010	0.010	0.066	0.063	0.062	0.261*	0.266*	0.266*
	(0.009)	(0.009)	(0.009)	(0.051)	(0.052)	(0.053)	(0.149)	(0.149)	(0.149)
$\frac{\text{Liquid assets}}{\text{Assets}}$	-0.002**	-0.001*	-0.001	-0.006	-0.005	-0.000	-0.044***	-0.045***	-0.040***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.005)	(0.008)	(0.008)	(0.010)
Dep. growth 2022	-0.001	-0.002	-0.001	-0.019**	-0.020**	-0.019**	0.007	0.009	0.010
	(0.001)	(0.001)	(0.001)	(0.009)	(0.008)	(0.009)	(0.012)	(0.012)	(0.012)
$\frac{\text{FHLB advances}}{\text{Assets}}$	0.006*	0.006*	0.007**	0.039	0.041	0.043*	-0.015	-0.018	-0.015
	(0.003)	(0.003)	(0.003)	(0.025)	(0.025)	(0.026)	(0.031)	(0.031)	(0.032)
Avg. funding cost	0.009	0.004	0.008	0.297	0.283	0.318	-0.328	-0.311	-0.284
	(0.022)	(0.022)	(0.023)	(0.193)	(0.201)	(0.200)	(0.233)	(0.235)	(0.237)
$\frac{\text{Tier 1 capital}}{\text{Assets}}$	0.002	0.002	0.001	-0.001	-0.003	-0.007	-0.001	0.001	-0.007
	(0.005)	(0.005)	(0.006)	(0.015)	(0.015)	(0.017)	(0.030)	(0.032)	(0.031)
Community bank	0.094**	0.078**	0.063	0.556*	0.471	0.352	-2.123***	-2.030***	-2.203***
	(0.043)	(0.039)	(0.040)	(0.326)	(0.311)	(0.334)	(0.662)	(0.646)	(0.654)
Regional bank	0.083*	0.068	0.054	0.583	0.508	0.423	-1.052	-0.970	-1.097
	(0.048)	(0.045)	(0.042)	(0.367)	(0.346)	(0.331)	(0.719)	(0.705)	(0.701)
Constant	-0.174**	-0.107	-0.093	-1.491**	-1.138*	-1.143*	3.051***	2.664***	2.578***
	(0.078)	(0.079)	(0.082)	(0.583)	(0.624)	(0.660)	(0.831)	(0.852)	(0.893)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.084	0.092	0.096	0.102	0.108	0.111	0.170	0.173	0.177
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 A6: Wholesale Borrowing: Controlling for Loan Delinquencies

	0/1 BTFP Borrowings					ΔBTFP Borrowings / Assets					ΔNon-Fed Borrowings / Assets				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
ΔDeposits⁻ / Assets	-0.013	-0.012	-0.014	-0.010	-0.013	-0.095	-0.086	-0.072	-0.093	-0.078	-0.358***	-0.444***	-0.496***	-0.395***	-0.498***
	(0.009)	(0.008)	(0.009)	(0.010)	(0.008)	(0.069)	(0.063)	(0.060)	(0.069)	(0.058)	(0.106)	(0.104)	(0.108)	(0.105)	(0.105)
× Securities losses / Assets	-0.006**	-0.006**	-0.006**	-0.006**	-0.006**	-0.034*	-0.035*	-0.036**	-0.035*	-0.035*	0.025	0.033	0.040	0.030	0.037
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.018)	(0.018)	(0.018)	(0.019)	(0.018)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)
× Core loan delinq / Assets	0.001					0.039					-0.227*				
	(0.010)					(0.046)					(0.136)				
× C&I loan delinq / Assets		0.001					0.171					-0.473*			
		(0.034)					(0.163)					(0.274)			
× CRE loan delinq / Assets			0.012					-0.014					-0.044		
			(0.021)					(0.151)					(0.242)		
× RRE loan delinq / Assets				-0.008					0.098					-0.428	
				(0.031)					(0.127)					(0.268)	
× Consumer loan delinq / Assets					0.010					0.051					0.092
					(0.008)					(0.040)					(0.061)
Securities losses / Assets	0.017	0.016	0.016	0.016	0.017	0.110	0.105	0.097	0.107	0.107	0.156	0.190*	0.210**	0.177*	0.202**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.070)	(0.070)	(0.071)	(0.071)	(0.070)	(0.097)	(0.099)	(0.100)	(0.099)	(0.099)
Core loan delinq / Assets	-0.001					0.031					-0.690***				
	(0.018)					(0.084)					(0.206)				
C&I loan delinq / Assets		-0.013					0.068					-0.932***			
		(0.016)					(0.135)					(0.186)			
CRE loan delinq / Assets			0.009					-0.228					0.206		
			(0.066)					(0.443)					(0.567)		
RRE loan delinq / Assets				-0.002					0.454					-0.625	
				(0.114)					(0.570)					(0.781)	
Consumer loan delinq / Assets					0.034					0.177					-0.462*
					(0.032)					(0.160)					(0.269)
Uninsured Deposits / Assets	0.002*	0.002*	0.002	0.002*	0.002*	0.013**	0.013**	0.013**	0.014**	0.015**	0.000	0.004	0.001	0.001	-0.004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.093	0.092	0.095	0.093	0.093	0.110	0.109	0.121	0.110	0.109	0.196	0.198	0.174	0.183	0.180
Observations	668	668	668	668	668	668	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 with the same specification and controls as Table 3, to which we add delinquencies (30-89 days and past 90 days) and non-accruals as a percent of total assets for core, C&I, CRE, RRE, and consumer loans, both in levels and interactions. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

Table A7: Pecking Order of Funding Sources

	$\frac{\Delta BTFP\ borr.}{Assets}$	$\frac{\Delta DW\ borr.}{Assets}$	$\frac{\Delta Non-Fed\ borr.}{Assets}$	$\frac{\Delta Large\ time\ dep.}{Assets}$	$\frac{-\Delta Reserves}{Assets}$	$\frac{-\Delta Securities}{Assets}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{\Delta \text{Deposits}^-}{\text{Assets}}$	-0.073	-0.000	-0.498***	-0.036	-0.726**	-0.005
	(0.057)	(0.006)	(0.104)	(0.042)	(0.297)	(0.040)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	-0.036*	-0.000	0.039	-0.009	0.081	-0.007
	(0.018)	(0.002)	(0.024)	(0.011)	(0.067)	(0.013)
$\frac{\text{Securities loss}}{\text{Assets}}$	0.104	-0.003	0.207**	-0.005	0.036	-0.052
	(0.070)	(0.010)	(0.099)	(0.048)	(0.239)	(0.051)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.014**	0.001	0.000	-0.000	-0.000	0.002
	(0.006)	(0.001)	(0.009)	(0.004)	(0.016)	(0.003)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.108	0.006	0.173	0.061	0.220	0.037
Observations	668	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 specification and controls as Table 3. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A8: Funding of Excess Loan Growth

	$\frac{\Delta BTFP\ Borr.}{Assets}$	$\frac{\Delta DW\ Borr.}{Assets}$	$\frac{\Delta Non-Fed\ Borr.}{Assets}$	$\frac{\Delta Large\ time\ dep.}{Assets}$	$\frac{-\Delta Reserves}{Assets}$	$\frac{-\Delta Securities}{Assets}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{\Delta(\text{Loans-Deposits})^+}{\text{Assets}}$	0.051	-0.001	0.246*	0.113***	0.632***	-0.024
	(0.045)	(0.005)	(0.125)	(0.042)	(0.236)	(0.031)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	0.039***	0.001	0.019	-0.009	-0.081	0.011
	(0.015)	(0.002)	(0.026)	(0.012)	(0.057)	(0.011)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.066	-0.006	-0.019	0.075	0.094	-0.076
	(0.062)	(0.012)	(0.099)	(0.056)	(0.238)	(0.053)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.014**	0.000	0.005	-0.002	0.003	0.003
	(0.006)	(0.001)	(0.010)	(0.005)	(0.016)	(0.003)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.114	0.006	0.179	0.071	0.216	0.038
Observations	668	668	668	668	668	668

*Notes: Same specification and controls as in Table A7, while core deposit outflows and inflows are replaced, in a spline regression approach, with positive and negative in excess loan growth, respectively, as the dependent variable. 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. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A9: Wholesale Borrowing and Reserves by Bank Size

	0/1 BTFP Borrowings		$\frac{\Delta\text{BTFP Borrowings}}{\text{Assets}}$		$\frac{\Delta\text{Non-Fed Borrowings}}{\text{Assets}}$		$\frac{-\Delta\text{Reserves}}{\text{Assets}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\frac{\Delta\text{Deposits}^-}{\text{Assets}}$	-0.012+	-0.008	-0.073	-0.036	-0.498***	-0.495***	-0.726**	-0.754**
	(0.008)	(0.008)	(0.057)	(0.054)	(0.104)	(0.104)	(0.297)	(0.296)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	-0.006**		-0.036*		0.039+		0.081	
	(0.003)		(0.018)		(0.024)		(0.067)	
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Regional)		-0.020***		-0.170**		0.028		0.181*
		(0.006)		(0.067)		(0.076)		(0.095)
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Not regional)		-0.006**		-0.031*		0.039+		0.078
		(0.003)		(0.016)		(0.024)		(0.066)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.016+	0.016+	0.104+	0.099+	0.207**	0.206**	0.036	0.039
	(0.011)	(0.011)	(0.070)	(0.068)	(0.099)	(0.100)	(0.239)	(0.240)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.002*	0.001+	0.014**	0.011*	0.000	-0.000	-0.000	0.002
	(0.001)	(0.001)	(0.006)	(0.006)	(0.009)	(0.009)	(0.016)	(0.016)
Bank controls and interactions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.092	0.102	0.108	0.137	0.173	0.173	0.220	0.224
Observations	668	668	668	668	668	668	668	668
P-value for coeff. equality test		.01		.03		.87		.15

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), as well as reserve reductions over the interval March 8—May 3, 2023 on contemporaneous deposit outflows ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), securities losses, and the same controls like in Table 3. 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. In columns 2, 4, 6, and 8, the specification opens up the coefficient for negative deposit growth interacted with securities losses by banks' size, with regional defined as banks with total assets between $10 and $ 250 billion in assets) measured as of 2022:Q4. $^+$,,**,*** indicate significance at 20%, 10%, 5%, and 1%, respectively.*

Table A10: 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)
$\frac{\Delta\text{Deposits}^-}{\text{Assets}}$	-0.012	-0.006	-0.073	-0.034	-0.498***	-0.451***
	(0.008)	(0.009)	(0.057)	(0.060)	(0.104)	(0.110)
$\times \frac{\text{Securities losses}}{\text{Assets}}$	-0.006**		-0.036*		0.039	
	(0.003)		(0.018)		(0.024)	
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. losses $<$ 90th percentile)		-0.010**		-0.061*		0.008
		(0.004)		(0.032)		(0.037)
$\times \frac{\text{Securities losses}}{\text{Assets}} \times$ (Sec. losses $\geq$ 90th percentile)		-0.005*		-0.029*		0.046**
		(0.003)		(0.016)		(0.022)
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), as well as reserve reductions over the interval March 8—May 3, 2023 on contemporaneous deposit outflows ($\Delta Deposits_{i,t,t'}/Assets_{i,t}$), securities losses, and the same controls like in Table 3. 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. In columns 2, 4, and 6, the specification opens up the coefficient for negative deposit growth interacted with securities losses by the magnitude of banks' security losses, distinguishing by banks with losses above and below the 90th percentile of the sample distribution. $^+$,,**,*** indicate significance at 20%, 10%, 5%, and 1%, respectively.*

Table A11: 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	0.001	-0.003	-0.028	0.029	-0.270***	-0.253***	-0.039
	(0.009)	(0.012)	(0.016)	(0.032)	(0.052)	(0.076)	(0.048)	(0.085)	(0.117)
$\times \frac{\text{Securities losses}}{\text{Assets}}$		0.001	0.001		0.010	0.008		-0.009	-0.016
		(0.005)	(0.005)		(0.022)	(0.023)		(0.026)	(0.027)
$\times \frac{\text{CRE loans}}{\text{Assets}}$			-0.000			-0.002			-0.008**
			(0.001)			(0.002)			(0.003)
$\frac{\text{Securities losses}}{\text{Assets}}$	0.036***	0.037***	0.037***	0.090***	0.095**	0.092**	-0.041	-0.076	-0.090
	(0.008)	(0.011)	(0.011)	(0.034)	(0.042)	(0.042)	(0.043)	(0.064)	(0.067)
$\frac{\text{CRE loans}}{\text{Assets}}$			0.000			-0.001			-0.010
			(0.001)			(0.005)			(0.009)
$\frac{\text{Uninsured Deposits}}{\text{Assets}}$	0.001	0.001	0.001	0.001	0.001	0.001	-0.004	-0.004	-0.003
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)
$BTFP_t > 0$	0.288***	0.288***	0.290***	0.232	0.230	0.232	-0.063	-0.073	-0.063
	(0.045)	(0.046)	(0.046)	(0.164)	(0.163)	(0.163)	(0.160)	(0.159)	(0.158)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.164	0.164	0.166	0.033	0.035	0.036	0.122	0.125	0.132
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 with the same specification and controls as Table 3, to which we add an indicator for outstanding BTFP loans at the start of the interval. *, **, *** denote significance at 10%, 5%, and 1%.*

Table A12: Determinants of Deposit Outflows—Credit Unions

	$\frac{\Delta\text{Deposits}}{\text{Assets}}$					
	(1) 2023:Q1	(2) 2023:Q1	(3) 2023:Q2	(4) 2023:Q2	(5) 2023:H1	(6) 2023:H1
$\frac{\text{Uninsured Dep.}}{\text{Assets}}$	0.057***	0.062***	0.022	0.027	0.076***	0.084***
	(0.022)	(0.023)	(0.017)	(0.018)	(0.024)	(0.025)
$\times \frac{\text{Securities loss}}{\text{Assets}}$		-0.015		-0.016**		-0.029*
		(0.012)		(0.008)		(0.016)
$\frac{\text{Securities loss}}{\text{Assets}}$	0.015	0.043	0.015	0.043	0.027	0.081
	(0.043)	(0.053)	(0.028)	(0.031)	(0.050)	(0.064)
Constant	-1.948*	-1.975*	2.469	2.442	-0.117	-0.167
	(1.165)	(1.165)	(1.969)	(1.970)	(2.056)	(2.059)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.198	0.198	0.132	0.132	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 A13: 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 A14: 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%.*

Table A15: Non-Borrower CD Rate Response: Level and Interaction Effects

	6-month CD		12-month CD		24-month CD	
	Level	+Interaction	Level	+Interaction	Level	+Interaction
Non-Borrower	-13.017	15.971	-16.619*	4.757	-4.591	16.423*
	(10.909)	(13.787)	(9.842)	(16.891)	(6.865)	(9.651)
$\frac{\Delta\text{Deposits}^-}{\text{Assets}}$	-5.959	-15.761**	1.019	-6.144	-2.232	-9.171**
	(5.138)	(6.514)	(5.202)	(8.434)	(3.111)	(4.302)
× Non-Borrower		12.744**		9.218		9.044**
		(5.128)		(6.167)		(4.016)
× $\frac{\text{Securities loss}}{\text{Assets}}$	0.419	1.155	-1.836	-1.270	0.135	0.674
	(1.225)	(1.266)	(1.439)	(1.603)	(0.609)	(0.639)
$\frac{\Delta\text{Deposits}^+}{\text{Assets}}$	-0.460	-0.455	-2.130	-2.295	-1.755	-1.784
	(3.834)	(3.793)	(3.525)	(3.505)	(2.066)	(2.056)
× $\frac{\text{Securities loss}}{\text{Assets}}$	0.002	-0.537	1.023	0.635	1.483	1.075
	(1.414)	(1.431)	(1.116)	(1.140)	(1.003)	(0.986)
$\frac{\text{Securities loss}}{\text{Assets}}$	-6.712	-5.006	-10.236**	-8.871*	-2.850	-1.490
	(5.051)	(5.137)	(4.340)	(4.716)	(3.144)	(3.292)
Constant	-0.725	-19.235	11.411	-3.648	-13.788	-28.174
	(42.158)	(41.366)	(28.904)	(30.364)	(22.640)	(22.167)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.0425	0.0568	0.0505	0.0606	0.0274	0.0450
N	408	408	425	425	402	402

*Notes: The table shows results from cross-sectional regressions of 26-week forward CD rate changes (basis points) on non-borrower indicator and core deposit flows. Non-borrowers did not borrow from BTFP within 8 weeks of the SVB announcement (March 10, 2023). Level columns report unconditional non-borrower effect; +Interaction columns add Non-Borrower × Outflow interaction. Superscripts on core deposits mark deposit flow direction: negative superscript for outflows (negative deposit growth), positive superscript for inflows. Horizon is 26 weeks after March 12, 2023. Controls: mark-to-market securities losses, tier 1 capital ratio, liquid assets (cash, federal funds, reverse repo, securities), average funding cost (interest expense as percent of liabilities), 2022 deposit growth, FHLB advances, bank size (community under $10 billion, regional $10-250 billion), measured 2022:Q4. Core deposit growth winsorized at 1st and 99th percentiles. Continuous variables in percentage points. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.*

Online Appendix

A.10 A withdrawal-stage benchmark

The main text takes direct withdrawals as given. They are loss-sensitive withdrawals driven by outside options or private motives that we do not model. This appendix adds a conditional withdrawal stage for the remaining uninsured depositors. It fixes operational access and the bank's funding rule, then asks when every possible withdrawal profile can be funded and waiting depositors paid in full. The benchmark draws on the liquidity-insurance mechanism in Diamond and Dybvig (1983).[41] The exercise is conditional: it neither determines facility use nor supplies a no-facility equilibrium counterfactual.

We suppress the bank index and normalize deposits to one. Let L denote the bank's securities loss, as in (2). Direct withdrawals have mass λ, as in (3), and maximum withdrawals are $\lambda_{\max} = \bar{\lambda} + u < 1$. The atomless coordinating population has mass

$$m_c \equiv \lambda_{\max} - \lambda = u[1 - \kappa(L)] \geq 0.$$

Total withdrawals therefore lie in $[\lambda, \lambda_{\max}]$. The dominance result below applies only to this coordinating population and requires no additional shape restriction on the direct-withdrawal schedule κ beyond the maintained bounds. Its realized value enters λ and therefore the current-gap and endpoint conditions below.

Payoffs are measured at $t = 2$, and cash carried from $t = 1$ has gross return one. A withdrawal at $t = 1$ pays $d > 0$, while waiting promises $d_2 = dr^d$ with $r^d > 1$. The bank has reserves x and a safe pool with face $V = 1 - x$ payable at $t = 2$, with market price $p \in (0, 1)$, so $L = V(1 - p)$. It also has $Z \geq 0$ in other terminal resources, net of all claims except deposits and the facility claim introduced below. These resources arrive only at $t = 2$, so they can service claims but cannot fund withdrawals at $t = 1$. Receivership administrative, enforcement, and collection expenses are normalized to zero. Set other current demand to zero and maintain $x < \lambda d$, so the current gap is

$$g(\Lambda) = \Lambda d - x > 0. \tag{39}$$

Operational access is active and commonly known. This appendix specializes the shared-collateral problem in Lemma A.1 to the BTFP schedule $\alpha_B(p) \equiv 1$, full eligibility of the safe pool V, and exact pledge. The pledged safe payoff is fully collected. The facility term reaches $t = 2$, or refinancing through that date is assured, and promised cumulative repayment is $\phi \geq 1$. Maintain

$$1 < r^d \leq \phi \leq \frac{1}{p}. \tag{40}$$

For every fundable withdrawal profile, the selected bridge is

$$b(\Lambda) = g(\Lambda), \qquad y(\Lambda) = 0, \qquad \overline{g} = V. \tag{41}$$

The facility-use decision and its fixed cost are sunk before the withdrawal stage. Conditional on that decision, $\phi \leq 1/p$ makes the facility weakly cheaper than selling, so (41) is the access-enabled selection in part (b) of Lemma A.1. The benchmark neither re-evaluates facility use profile by profile nor imposes a first-use test at the realized profile.

[41] Drechsler *et al.* (2026, Internet Appendix, Section XI.B) obtain a related no-run result from a run-contingent long-term central-bank loan that is nonrunnable and effectively junior to current uninsured deposits. This benchmark instead works through current cash capacity.

Under this zero-expense normalization, any facility claim not recovered from the pledged safe payoff is an unsecured deficiency. The maintained depositor-preference convention for FDIC-insured banks puts this deficiency behind deposit liabilities.[42] Pledging assigns $b(\Lambda)$ of safe payoff to the facility. Conditional on current feasibility, a depositor who waits receives

$$U_W(\Lambda) = \min\left\{dr^d, \frac{V + Z - b(\Lambda)}{1 - \Lambda}\right\}. \tag{42}$$

Define the late-depositor and full-repayment residuals

$$\mathcal{D}(\Lambda) \equiv V + Z - b(\Lambda) - (1 - \Lambda)dr^d, \tag{43}$$

$$\mathcal{F}(\Lambda) \equiv V + Z - \phi b(\Lambda) - (1 - \Lambda)dr^d. \tag{44}$$

Since $\mathcal{D}(\Lambda) = \mathcal{F}(\Lambda) + (\phi - 1)b(\Lambda)$, depositor service does not guarantee full facility repayment.

Definition A.5 (Physical run-proofness)**.** Conditional on operational access and (41), the bank is physically run-proof if every $\Lambda \in [\lambda, \lambda_{\max}]$ is currently fundable and every waiter receives dr^d. Equivalently, $g(\Lambda) \leq V$ and $\mathcal{D}(\Lambda) \geq 0$ throughout the interval. This is a capacity and service property, not an equilibrium selection.

Lemma A.6 (Endpoint tests)**.** *Under the maintained horizon convention and (40):*

(a) The bank is physically run-proof if and only if

$$g(\lambda_{\max}) \leq V, \qquad \mathcal{D}(\lambda) \geq 0. \tag{45}$$

(b) All deposit and facility claims are repaid at every profile if and only if current capacity holds and

$$\mathcal{F}(\lambda_{\max}) \geq 0. \tag{46}$$

This stronger condition is sufficient for physical run-proofness.

Proof. Current capacity is tightest at $\lambda_{\max}$. On the fundable domain, (41) gives

$$\mathcal{D}(\Lambda) = V + Z - g(\Lambda) - (1 - \Lambda)dr^d, \qquad \mathcal{D}'(\Lambda) = d(r^d - 1) > 0,$$

and

$$\mathcal{F}(\Lambda) = V + Z - \phi g(\Lambda) - (1 - \Lambda)dr^d, \qquad \mathcal{F}'(\Lambda) = d(r^d - \phi) \leq 0.$$

Thus late-depositor service is tightest at λ, whereas full repayment is tightest at $\lambda_{\max}$. Finally, $\mathcal{D} = \mathcal{F} + (\phi - 1)b$ proves that full repayment at every profile implies late-depositor service at every profile. □

The bound $\phi \leq 1/p$ selects facility borrowing over a sale, $r^d \leq \phi$ makes the full-repayment residual nonincreasing, and $r^d > 1$ makes the late-depositor residual increasing and later gives

[42] Operating Circular No. 10 grants the Reserve Bank a security interest securing all obligations and governs enforcement and application of collateral proceeds (§§6.0, 12.0–12.4), https://www.frbservices.org/binaries/content/assets/crsocms/resources/rules-regulations/082823-operating-circular-10.pdf. Under 12 U.S.C. §1821(d)(11)(A), secured claims are excluded to the extent of their security; administrative expenses rank first, deposit liabilities second, and other general or senior liabilities third, https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title12-section1821&num=0&edition=prelim.

strict preference for waiting. Using $x + V = 1$, physical run-proofness reduces to

$$\lambda_{\max} d - x \leq V, \qquad 1 + Z \geq d[\lambda + (1 - \lambda) r^d].$$

For comparison, without facility borrowing, reserves and sales can fund every withdrawal profile if and only if

$$\lambda_{\max} d \leq x + pV = 1 - L.$$

Par access raises this current-capacity bound to $\lambda_{\max} d \leq x + V = 1$. At $d = 1$, it therefore raises the cash-capacity ceiling, expressed as a share of deposits, from $1 - L$ to one, a gain of $L = W$ as in (13). This comparison concerns current cash capacity; it does not characterize the withdrawal equilibrium without the facility.

At $d = 1$, the service condition requires $Z \geq (1 - \lambda)(r^d - 1)$: terminal net resources must cover the waiting premium beyond the normalized reserves-and-securities endowment. Full repayment at every profile additionally requires

$$V + Z - \phi(\lambda_{\max} d - x) - (1 - \lambda_{\max}) d r^d \geq 0.$$

Under (40), this stronger condition also implies late-depositor service.

Definition A.7 (Conditional withdrawal-stage equilibrium)**.** Fix operational access, (41), and the bank's publicly known capacity and service properties. Restrict attention to properties that define depositor payoffs at every induced aggregate withdrawal mass; physical run-proofness satisfies this domain condition. Let μ be nonatomic on the coordinating population $\mathcal{J}$, with $\mu(\mathcal{J}) = m_c$. A measurable action map $\mathfrak{w} : \mathcal{J} \to \{\text{wait}, \text{withdraw}\}$ induces

$$\Lambda(\mathfrak{w}) = \lambda + \mu\big(\{j : \mathfrak{w}(j) = \text{withdraw}\}\big).$$

A pure-strategy withdrawal-stage Nash equilibrium is an equivalence class of profiles, equal almost everywhere, in which almost every coordinating depositor weakly prefers the prescribed action at the induced aggregate withdrawal mass. Each depositor takes that mass as given.

Proposition A.8 (Conditional no-coordination equilibrium)**.** *If the bank is physically run-proof and $r^d > 1$, waiting is strictly dominant for almost every coordinating depositor. The pure-strategy equilibrium is unique up to equality almost everywhere, and realized withdrawals equal λ.*

Proof. Physical run-proofness makes every profile currently feasible and gives each waiter dr^d; withdrawing pays d at each such aggregate mass. Since $r^d > 1$, almost every coordinating depositor strictly prefers to wait at every aggregate profile. Hence the all-wait profile is an equilibrium, and strict dominance excludes every other equilibrium up to almost-everywhere equality. □

Strict dominance also rules out a mixed equilibrium assigning positive weight to withdrawal. At the boundary $r^d = 1$, outside the maintained domain in (40), the same capacity-and-service conditions still fund every profile and service every waiter, but waiting is only weakly preferred, so the strict selection disappears. Capacity alone does not rule out a run. In this benchmark, the capacity condition makes every withdrawal profile fundable, the service condition gives every waiter dr^d, and $r^d > 1$ makes waiting strictly dominant.

Remark A.9 (Scope of the run benchmark). The equilibrium object is the withdrawal stage after operational access and facility use, with direct withdrawals fixed at λ. Actual BTFP participation was not publicly disclosed in real time. If capacity fails, date-1 payoffs require a rationing or closure rule. If capacity holds but late service fails, (42) still defines the withdrawal game, but we

do not characterize its equilibria. The benchmark therefore supplies neither a no-facility equilibrium nor a welfare comparison. It also maintains the full-eligibility, exact-pledge BTFP specialization, full collection, a term reaching the payoff or assured refinancing, terminal net resources Z but no other unmodeled resources or claims, zero administrative and enforcement expenses, and the FDIC-insured-bank priority convention stated above.