Collateral Mobility and the Lender of Last Resort

Antonis Kotidis*
Board of Governors of the Federal Reserve System

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Abstract

Using confidential Federal Reserve Discount Window data from March 2023, I study collateral mobility in lender-of-last-resort lending. Banks with prior experience were more likely to post loan collateral and did so two days faster than inexperienced peers, while showing little effect for securities collateral. When loan collateral was pledged to FHLBs, redeployment to the Fed slowed by an additional three to four days, even among sophisticated banks, because of absent subordination agreements and different collateral reporting practices. In fast runs, what matters is not only where collateral sleeps, but how fast it can move when it needs to wake up.

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1. Introduction

Classical lender-of-last-resort (LOLR) theory assumes that collateral can be turned into central-bank funding when banks need it. This paper asks whether that conversion is fast enough in modern bank runs (Cipriani, Eisenbach and Kovner, 2024). That question is central to financial stability policy. Sometimes banks may not want to borrow from the LOLR because borrowing can be interpreted as a sign of weakness - the classic stigma problem (Armantier, Ghysels, Sarkar and Shrader, 2015; Anbil, 2018). Other times, the constraint is on the central bank: central banks should lend to illiquid but solvent banks and not to insolvent institutions (Bagehot, 1873; Rochet and Vives, 2004). I study a third margin: even when the bank is willing to borrow and the central bank is ready to lend, can the bank get the collateral to the central bank fast enough?

Figure I motivates this timing margin. During the March 2023 banking turmoil, securities collateral reached the Federal Reserve Discount Window (DW) before deposit outflows intensified. Loan collateral also supported borrowing, but only after outflows had begun. This pattern may reflect differences in banks' depositor bases or asset composition. It may also reflect operational frictions that delay the conversion of collateral into borrowing, such as legal documents, prior experience with the DW and interoperability frictions among liquidity providers - the Federal Reserve and Federal Home Loan Banks (FHLBs).

The macroeconomic relevance of this timing margin is not hypothetical. Rose (2024) documents that during the 1985 Ohio and Maryland thrift crises, the Federal Reserve received urgent DW loan requests from institutions that were not prepared to borrow quickly. The Cleveland Fed took extraordinary steps to accelerate lending, including deploying staff to deliver borrowing documents and establishing field warehouses to take possession of pledged collateral. Even so, the process of reviewing and pledging collateral was time-consuming and temporary suspensions of banking activity followed. This episode shows why crisis liquidity depends on the ability to mobilize collateral quickly.

Using confidential data from the March 2023 banking turmoil, I show that bank-level operational readiness and system-level interoperability determine how quickly collateral can move. For identification, I exploit three sources of variation: (i) cross-sectional differences in whether banks had signed Operating Circular 10 (OC-10) - the legal agreement governing DW access - before the crisis; (ii) variation in prior DW borrowing experience; and (iii) institutional differences across FHLB districts and the Federal Reserve in subordination agreement coverage

and collateral reporting practices.

I document three main findings. First, bank-level operational readiness strongly predicts collateral pledging during the crisis. Institutions with signed OC-10 agreements were substantially more likely to pledge collateral at the DW, with the effects especially pronounced among banks familiar with the pledging process through prior borrowing experience. This relationship is strongest for loan collateral, which requires more complex documentation than securities but offers greater liquidity value once the sunk cost of operational readiness has been paid.[1] Economically, these fully operationally ready banks - those with OC-10 in place and prior borrowing experience - were nearly five times more likely to mobilize loan collateral and more than twice as likely to mobilize securities collateral relative to the unconditional baseline probabilities. The effects are also largest among banks with elevated funding vulnerability measured by uninsured deposit ratios.

Second, among fully operationally ready institutions, prior DW borrowing experience translated into significantly faster collateral mobilization. Banks that had borrowed from the DW within five years of March 2023 (and, as such, were familiar with the pledging process) posted loan collateral nearly two days faster than their operationally ready but inexperienced peers. This speed advantage is economically meaningful: when deposit outflows accelerate over days, a two-day delay in securing liquidity access can prove decisive. The speed benefit for securities collateral was more modest, consistent with lower administrative complexity.

Third, I show that system-level interoperability frictions impeded collateral redeployment from FHLBs to the DW, even among operationally sophisticated banks. The first friction involves subordination agreements - legal instruments that allow the Federal Reserve to establish senior liens on collateral already pledged to FHLBs. Banks in districts with pre-arranged subordination agreements posted loan collateral approximately 1.2 days faster than otherwise similar institutions.[2] The second friction stems from heterogeneity in collateral reporting practices.

[1] Loans may generate more usable funding at the DW than in alternative liquidity markets because some loan categories are difficult or not possible to pledge elsewhere.

[2] A subordination agreement is primarily used to perfect a lender's security interest in loan collateral. However, in practice, it is sometimes used to perfect a lender's security interest in securities collateral when Fedwire Securities Services is closed. For example, on March 10, 2023, at Signature Bank's request, FHLB New York subordinated its interest in a total of approximately $7.1 billion in excess pledged securities collateral to the FRBNY via a subordination agreement to allow the bank to access DW funding. The subordination agreement was necessary because Signature Bank missed the cutoff time to directly transfer securities held by a custodian bank to the FRBNY (GAO, 2024).

Institutions in need of funding (proxied by high uninsured deposit ratios) operating in FHLB districts that accepted summary-based reporting required roughly two additional days to satisfy the Federal Reserve's loan-level listing requirements. Taken together, these two frictions delayed collateral mobilization between FHLBs and the Federal Reserve by three to four days, even among operationally sophisticated institutions.

These results recast LOLR liquidity as a problem of collateral mobility. Classical theory emphasizes whether a bank is solvent and whether collateral is eligible. In fast runs, collateral must also reach the central bank quickly enough to be turned into funding. The evidence shows that this timing constraint arises both inside banks, through prior experience with the DW, and across liquidity providers, through subordination agreements and collateral reporting practices. In this sense, collateral mobility is a distinct constraint on LOLR effectiveness.

Contribution to the literature: The paper makes three contributions. First, the paper contributes to the literature on LOLR by identifying collateral mobility as a distinct constraint on crisis liquidity. Classical LOLR theory emphasizes whether central banks should lend to illiquid but solvent banks against good collateral. Empirical work has focused largely on whether banks are willing to borrow, especially because DW borrowing may carry stigma (e.g., Armantier, Ghysels, Sarkar and Shrader, 2015; Anbil, 2018; Anbil, Carlson, and Styczynski, 2023; Gorton, Ross, and Ross, 2024; Carlson and Styczynski, 2025). This paper asks: even when the bank is willing to borrow and the central bank is prepared to lend, can collateral become central-bank funding quickly enough? To the best of my knowledge, this is the first paper to measure this margin directly using bank-level crisis data. The results show that collateral mobility is not an institutional detail, but a condition for LOLR effectiveness in fast runs. Although this margin has been widely recognized in official discussions of DW readiness (FRB, 2023; Barr, 2023; BIS BCBS, 2023; Coelho, Drehmann, Walters and Murphy, 2024; GAO, 2024), it has not been incorporated into the empirical literature on central-bank liquidity provision.

Second, the paper contributes to theories of liquidity provision and pledgeability. Classic models of banking fragility emphasize that pledgeable assets allow banks to raise funding against otherwise illiquid claims (e.g., Diamond and Dybvig, 1983; Holmström and Tirole, 1997, 1998; Kiyotaki and Moore, 1997; Diamond and Rajan, 2001; Diamond, Hu, and Rajan, 2020). I show that pledgeability has a timing dimension. Securities collateral can be mobilized relatively quickly, while loan collateral requires more preparation and is more sensitive to prior experience. In March

2023, prior borrowing experience accelerated loan-collateral posting by about two business days, but had little effect on securities collateral. This distinction matters because, in a fast run, collateral that arrives too late may not provide sufficient liquidity.

Third, the paper contributes to the literature on creditor coordination by showing that coordination frictions also arise across public liquidity providers. Existing work has focused largely on private creditors in corporate distress, debt restructuring and information sharing among lenders (Gertner and Scharfstein, 1991; Bolton and Scharfstein, 1996; Brunner and Krahnen, 2008; Hertzberg, Liberti, and Paravisini, 2011). I show that an analogous problem arises when collateral already pledged to an FHLB must be redeployed to the Federal Reserve. In that setting, crisis liquidity depends not only on the borrower's solvency or the central bank's willingness to lend, but also on intercreditor arrangements that determine how quickly legal claims can move.

The remainder of the paper proceeds as follows. Section 2 provides institutional background on DW collateral mobility, emphasizing the operational differences between securities and loan collateral and the role of FHLB-Fed interoperability. Building on this institutional background, Section 3 presents a simple framework where collateral takes time to mobilize. Section 4 describes the data sources and sample construction. Section 5 presents the empirical results. Section 6 concludes.

2. Operational Requirements for Pledging Collateral at the Discount Window

2.1. Operating Circular 10

Banks accessing the DW must pledge eligible collateral to secure their borrowings. This practice reflects the central bank's adherence to statutory requirements under Section 10B of the Federal Reserve Act. The collateralization process begins when depository institutions establish a lending relationship with their Reserve Bank by completing the Operating Circular 10 agreement package.

Operating Circulars (OC) are documents issued by Reserve Banks that set out the terms under which they provide services to depository institutions. There are ten circulars in total, each corresponding to a specific service area. For example, OC-1 contains the terms for opening, maintaining, and terminating a master account with a Reserve Bank. To use the DW, banks must agree to the terms of OC-10 by signing the *Letter of Agreement* - the key legal document that governs the lending relationship between the Reserve Bank and depository institution. Along with

the Letter of Agreement, depository institutions must submit three additional documents: the *Authorizing Resolutions for Borrowers*, the *Official Authorization List*, and the *OC-10 Certificate*. The resolution grants authority to certain officers within the depository institution to pledge collateral and carry debt on its behalf, while the authorization list confirms the names, titles, and signatures of the authorized officers listed in the resolution. These documents together ensure that anyone pledging collateral or requesting advances has proper authorization, thereby reducing legal risk to the Reserve Bank. The OC-10 certificate provides legal information such as the institution's address and legal name.

2.2. Perfecting Security Interests

Once the Reserve Bank approves the OC-10 package, it proceeds with perfecting its security interest in the pledged collateral. The perfection mechanism is more complicated for loans than securities, because the law that governs commercial transactions in the United States - the Uniform Commercial Code (UCC) - treats securities and loans differently.

Securities are considered "investment property" because they trade in financial markets. A lender can perfect its security interest in securities *via control (i.e., via possession)*, which gives the lender effective rights to realize upon the collateral. In contrast, loans are not traded in financial markets and lack readily observable market values. That is, loans are harder to identify (i.e., loans are not associated with individual CUSIPs), value or transfer. This means they do not constitute "investment property", and a lender cannot perfect its security interest via control. Instead, a lender perfects its security interest *via filing (i.e., via claim)*. This niche but important distinction introduces more operational work when depository institutions choose to pledge loans at the DW especially when these loans are already pledged with another creditor.

Securities Collateral: Consider a depository institution that holds Treasury securities pledged to an FHLB as collateral securing outstanding advances. The Treasury securities appear as pledged assets on the institution's balance sheet, but it is the FHLB that maintains *control* of them. That is, the depository institution cannot give transfer instructions to deliver them to the DW; only the FHLB can release them.

Assume for simplicity that the FHLB requires full repayment of the advance to release the securities collateral. The depository institution initiates a Fedwire Funds payment from its master

account at the Fed to the FHLB and provides instructions for collateral release. For each CUSIP pledged, the FHLB releases its security interest and executes Fedwire Securities transfers to the depository institution's custodian (such as Bank of New York Mellon) or its Fedwire Securities Account at the Fed.

With the securities now free of FHLB *control*, the bank can direct its custodian to pledge the collateral to its Reserve Bank. Alternatively, if the securities are in the bank's own Fedwire Securities Account, it can transfer them directly to the Fed's Restricted Securities Account. The Reserve Bank then establishes *control* by taking direct possession of securities delivered to its Restricted Securities Account - meaning the Fed now has exclusive transfer authority over the collateral. Importantly, the securities remain on the pledging bank's balance sheet as assets with disclosure that they are encumbered.

Loan Collateral: Unlike securities, a lender cannot perfect its security interest in pledged loan collateral via control. Instead, a lender perfects its security interest via *filing* by submitting a UCC financing statement to the Office of the Secretary of State where the bank is located. When the Reserve Bank files a UCC, it essentially searches for competing UCC filings on the borrower's collateral. If there is no competing filing, the Reserve Bank creates public notice, so that other lenders know the Reserve Bank has established priority on the borrower's collateral in the event of default.

Matters become more complicated when the borrower's assets are already under blanket lien with another creditor. Consider, for example, a depository institution that holds residential mortgages pledged to an FHLB as collateral securing outstanding advances. While FHLBs offer members a specific pledge lien agreement, the most commonly used agreement is a blanket lien under which the FHLB's security interest attaches to *all* of a member's assets. If the FHLB has a blanket lien on the depository institution's entire residential mortgage portfolio, the depository institution cannot request the release of individual mortgages from the FHLB's lien - unlike Treasury securities where individual CUSIPs can be released.

This is where filing-based perfection comes in. To transfer the security interest, the Reserve Bank and FHLB must enter a subordination agreement. A subordination agreement is a document that establishes which lender gets paid first in the event the depository institution defaults.[3]

[3] For example, when a depository institution defaults, the proceeds from liquidating collateral flow first to the

Importantly, not all FHLB and Reserve Bank pairs have subordination agreements in place for all institutions within their districts (i.e., arrangements may not cover FHLB members that do not pledge loans to an FRB), which can delay the transfer of security interest in loan collateral under tight timelines. Back to our example, when a subordination agreement exists, the FHLB can subordinate its first-lien priority interest on a portion of the institution's mortgage portfolio. For instance, the FHLB might subordinate $200 million of collateral out of $1 billion total collateral covering a $200 million FHLB advance. Importantly, during this process, the collateral *never* moves; rather, it stays with the bank via a borrower-in-custody (BIC) arrangement.[4] What moves is the security interest in the pledged loan collateral.

2.3. Preparing Loan Collateral Schedules

Once the Reserve Bank has perfected its security interest in loan collateral, the depository institution must prepare a comprehensive loan-level collateral schedule providing detailed information for each mortgage, including borrower identity, property location and interest rates. Depending on the depository institution's size, requirements vary regarding the level of detail in the reporting document. Nonetheless, the process is the same across all Reserve Banks and requires institutions to specifically list individual loans and their characteristics. This method of collateral reporting is called *listing*.

In contrast, FHLBs exhibit substantial variation in collateral reporting practices (Figure II). Some FHLBs accept primarily portfolio-level aggregate data (summary), while others require primarily loan-level schedules (listing). Instead of listing individual loans, institutions using the summary method provide a description of the residential mortgage portfolio, including the number of loans pledged and geographic coverage, among other characteristics.

Due to this divergence in collateral reporting practices, institutions that normally rely on FHLBs for funding may not be accustomed to submitting loan data in the format required by Reserve Banks, which can introduce significant time delays in the redeployment of collateral.

Federal Reserve for full satisfaction of DW loans and then to the FHLB for its subordinated claims.

[4] A BIC agreement allows the bank to maintain loan collateral in house and provide periodic reports on the characteristics of the loans in the BIC. Since both FHLBs and Reserve Banks accept loan collateral primarily through borrower-in-custody agreements, this is not an important friction. The BIC application determines what collateral the bank wishes to pledge (electronic or tangible loans), whether the collateral is acceptable (bank internal rating need approval by the Reserve Bank), where the bank keeps the collateral (e.g., online for electronic loans or in fire-proof cabinets for tangible loans) and how the bank plans to pledge collateral (in-scope versus out of scope requirements).

2.4. Processing Times

The preceding discussion establishes that collateral transfer timelines are shaped by two key factors: individual bank preparedness and the interoperability frictions governing liquidity provision among creditors. Critically, processing times also depend on the type of collateral being transferred. For securities collateral, the complete cycle from FHLB advance repayment to receiving a DW loan generally requires one business day. For loan collateral, the timeline may extend considerably depending on whether a subordination agreement exists between the relevant FHLB and Reserve Bank, whether the institution maintains the required loan-level schedules in the proper format, and how quickly the Reserve Bank can complete its collateral valuation process.

These processing times are not merely administrative details; they can be decisive during periods of liquidity stress. Figure I plots standardized net deposit flows for depository institutions that posted collateral to the DW in March 2023. The vertical axis reports standardized deposit flows, expressed as z-scores relative to each institution's pre-crisis distribution of daily net flows, where positive values indicate net deposit outflows and negative values indicate net inflows. For each bank, flows are standardized using the pre-crisis distribution of daily net flows. The horizontal axis is re-centered so that day 0 denotes the first day on which the bank posted collateral to the DW. The figure shows that banks typically posted securities collateral one business day before large net outflows materialized. This timing highlights a central operational point: during stress, banks need collateral that can be mobilized quickly. A one-day processing time for securities collateral may provide sufficient runway when outflows are anticipated. By contrast, loan collateral often requires several days to process because of subordination agreements, loan schedule preparation, and collateral valuation. In rapid deposit runs, that timeline may be too slow.

3. A Simple Framework

Building on the institutional background, this section presents a simple framework. Central banks typically measure collateral capacity through lendable value. For collateral type *j*, let:

$$LV_j = \left(1 - h_j\right) \times MV_j$$

where MV_j is the market value of the collateral and h_j is the haircut. This equation says how much

funding the bank can obtain once the collateral is eligible and accepted at the central bank. However, it does not say how long it takes for that collateral to turn into funding. Let t_j be the number of days required for the bank to post collateral type *j* at the DW. Let *H* be the time before the bank's liquidity constraint becomes binding. Collateral type *j* provides effective crisis liquidity only if it can be posted before that point. Effective lendable value therefore becomes:

$$LV_j = \left(1 - h_j\right) \times MV_j \times \mathbf{1}\{t_j \leq H\}$$

If $t_j \leq H$, the collateral arrives in time and supports borrowing. If $t_j > H$, the collateral may still be eligible, but it does not help the bank meet funding pressures. Under the standard formula:

$$\frac{\partial \mathrm{LV_j}}{\partial \mathrm{h_j}} = -\mathrm{MV_j}$$

In other words, if the haircut increases by one percentage point, lendable value falls by one percentage point of the collateral's market value. With timing, however, we have:

$$\frac{\partial LV_j}{\partial h_j} = -MV_j \times \mathbf{1}\{\tau_j \leq H\}$$

In this case, haircuts matter only for collateral that can be moved in time. Building on the institutional background, the empirical analysis studies two sources of this delay. First, prior DW experience can reduce the bank-level time required to post collateral. Second, interoperability between the Federal Reserve and FHLBs can affect the time required to redeploy collateral that is already encumbered with FHLBs. Both experience and interoperability matter because they reduce t_j. More formally, the effective lendable value differs across collateral types *j* because mobilization times differ. For securities, we have:

$$t_S = t_{S^o} - \beta_S \times EXPERIENCE$$

while for loans, we have:

$$t_L = t_{L^o} - \beta_L \times EXPERIENCE + \gamma \times FHLB$$

The institutional background suggests $t_{L^o} > t_{s^o}$, $\beta_L > \beta_s$, and $\gamma > 0$. In other words, loans take longer to move than securities, prior experience should matter more for loans, and (loan) collateral already pledged to FHLBs should face additional delay when subordination agreements or reporting practices do not align. This structure maps directly to the empirical tests, which is the focus of the remainder of the paper.

4. Data

The analysis relies on confidential Federal Reserve data on collateral pledged at the DW by depository institutions between March 6 and March 31, 2023. I construct two key variables from these data: (1) indicator variables for whether a depository institution pledged loan or securities collateral during the sample period, and (2) timing variables measuring business days elapsed between March 8, 2023 - the crisis onset marked by Silvergate's voluntary liquidation announcement - and each institution's collateral posting date. These variables are combined with confidential Federal Reserve data on institutions' OC-10 borrowing documents, historical DW usage over the preceding five years (2018-2022), and subordination agreements between Reserve Banks and FHLBs, as well as publicly available data on FHLB collateral reporting practices.

Appendix Table I presents summary statistics for the full sample of 9,370 institutions. Approximately 4 percent of institutions pledged loan or securities collateral during the sample period. Among the 354 institutions posting loan collateral and 363 posting securities collateral, the average time to pledge was approximately seven days. Half of all sample institutions maintained current borrowing documentation, while one-quarter had accessed the DW within the previous five years.

In terms of the collateral posted at the DW during the sample period, Appendix Table II reports that total collateral pledged by sample banks increased by $340 billion, rising from $2,453 billion to $2,793 billion. This growth was driven primarily by loan collateral, which increased by $259 billion (from $1,841 billion to $2,100 billion), with securities collateral contributing an additional $81 billion (from $612 billion to $693 billion).

5. Empirical analysis

The empirical analysis asks whether collateral mobility constrained DW access during March 2023. I proceed in three steps. First, I examine whether prior DW experience predicts collateral posting, distinguishing between loan and securities collateral. Second, I test whether prior experience affects the speed of collateral pledging. Third, I study whether collateral already pledged to FHLBs moved more slowly to the Federal Reserve because of subordination and collateral reporting frictions. If the mechanism is collateral mobility, effects should be strongest for loan than securities collateral throughout, where legal and reporting frictions are greater.

5.1. Discount Window Process Familiarity and Collateral Pledging

Table I presents regression estimates examining the importance of borrowing documents on file and prior DW experience for pledging loan and securities collateral in March 2023. Our dependent variables are dummies that take the value of one if a depository institution increased the pledged loan or securities collateral to the DW between March 6, 2023, and March 31, 2023, zero otherwise. The independent variables are also dummies that take the value of one if a depository institution had OC-10 borrowing documents in place as of March 6, 2023 (a proxy for operational readiness), and whether it had borrowed from the DW anytime during 5 years prior to March 2023 (a proxy for process familiarity). The specifications control for FRB district fixed effects and bank characteristics including the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. For the loan collateral regressions, I also control for the average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023, while for the securities collateral regressions, I separately control for the average share of loan collateral to total collateral pledged between March 06, 2023, and March 31, 2023.

The results indicate that institutions with signed OC-10 borrowing documents were significantly more likely to increase loan collateral at the DW. In the baseline specification (column 1), having borrowing documents is associated with a 5.6 percentage point higher probability of having pledged loan collateral. This relationship strengthens considerably for institutions that combine document preparation with actual borrowing experience: the interaction term between having documents and prior borrowing activity shows an additional 21 percentage

point increase in the probability of loan collateral pledging. This large positive interaction effect indicates that operational readiness combined with institutional familiarity substantially increases loan collateral pledging.

The pattern for securities collateral is qualitatively similar but with important differences in magnitude. Column 3 shows that depository institutions with borrowing documents in place are 3.2 percentage points more likely to pledge securities collateral. In the fully specified model (column 4), the main effect of borrowing documents remains positive but becomes statistically insignificant, while the interaction term indicates an additional 15.2 percentage points increase in the probability of securities collateral pledging. Notably, this interaction effect is smaller than the corresponding effect for loan collateral, suggesting that the complementarity between operational readiness and experience is stronger for the more complex loan pledging process.[5]

5.2. Identification Challenges

The baseline results in Table I face potential omitted variables bias because banks that establish DW operational capacity may differ systematically from other banks along unobservable dimensions that also affect collateral pledging decisions. Specifically, banks with borrowing documents and prior DW experience may have distinct liquidity needs that independently drive both their DW preparedness and their propensity to pledge collateral. While the model includes FRB district fixed effects and bank-level controls, these may not fully capture the selection mechanism determining which banks establish DW operational capacity.

Table II addresses this concern through heterogeneity analysis, exploiting cross-sectional variation in funding vulnerability (measured by the uninsured deposits-to-total assets ratio). The key insight is that if the relationship were primarily driven by omitted bank characteristics correlated with both DW familiarity and collateral pledging, we would expect similar coefficients across vulnerability groups. Instead, the effects are significantly stronger for high-vulnerability banks. In particular, among institutions with elevated funding needs, having borrowing documents corresponds to a 3.4 percentage point higher probability of loan collateral pledging (column 1), compared to 1.6 percentage points for institutions with low funding needs (column 2). The

[5] The overall economic effect from having signed OC-10 and prior DW borrowing experience - derived from the linear combination of the three coefficients - is 19.4 and 8.6 percentage points increase in the probability of loan and securities collateral pledging, respectively.

interaction between documentation and past borrowing experience shows an even more pronounced divergence: high vulnerability banks with both documents and prior borrowing experience show an additional 21.7 percentage point increase in loan collateral pledging, versus 14.3 percentage points for their less vulnerable counterparts. For securities collateral, the baseline effect of documentation corresponds to 3.6 percentage points for more and 1.5 percentage points for less vulnerable institutions - effects that are similar to the baseline effects of documentation for loan collateral. The interaction terms remain positive and significant in both subsamples but are economically smaller than the estimates for loan collateral.

This differential response aligns with theoretical predictions that liquidity backstop access should matter most for banks with fragile funding structures, while any remaining omitted variable bias would require unobservables to produce precisely this heterogeneity by jointly determining operational capacity and collateral pledging separately across vulnerability groups, which seems less likely.

However, a separate reverse causality concern remains: banks may endogenously choose their funding vulnerability conditional on having established DW operational capacity, taking on more uninsured deposits and perhaps invest in more illiquid (loan) collateral precisely because they have backstop access. Although I cannot definitively rule out this endogenous selection, an important pattern in Table II helps mitigate this concern. If this moral hazard channel were the primary driver - where having borrowing documents leads banks to endogenously increase funding vulnerability, which in turn drives loan holdings and collateral pledging - we would expect to observe strong heterogeneity in the baseline "has borrowing documents" coefficient across collateral types within vulnerability groups. However, the baseline document effects are similar across collateral types within vulnerability groups (0.034 vs. 0.036 for high UD/TA banks; 0.016 vs. 0.015 for low UD/TA banks). The substantial differential effect emerges primarily through the interaction term with past borrowing experience. Critically, past borrowing experience is less susceptible to reverse causality - it is implausible that banks borrowed from the DW years earlier in anticipation of increasing their funding vulnerability by end-2022. If moral hazard were driving the results, we would expect the opposite pattern: strong heterogeneity in the documents baseline effect and weaker interaction effects.

Taken together, the results support the view that administrative complexity is an important margin of LOLR access. Banks with borrowing documentation in place are more likely to mobilize

collateral, particularly when documentation is paired with prior DW experience. This relationship is much stronger for loan collateral than for securities collateral, consistent with the greater legal and operational requirements associated with pledging loans. To be sure, we do not interpret these estimates as causal: banks with documentation and prior experience may differ along other unobserved dimensions of preparedness. Nevertheless, the pattern is difficult to reconcile with a view in which collateral eligibility alone determines access to crisis liquidity. Instead, the results suggest that operational readiness affects whether collateral can actually be pledged when it is needed.

5.3. Speed of Collateral Pledging

To quantify the practical importance of DW familiarity during the March 2023 turmoil, Table III examines the speed at which operationally ready institutions - those with borrowing documents already in place as of March 8 - posted additional collateral after March 8. We treat March 8, when Silvergate Bank announced its voluntary liquidation, as the beginning of the banking turmoil. The dependent variables measure the number of business days between March 8 and when institutions increased their loan collateral (columns 1-2) or securities collateral (columns 3-4) at the DW, with values ranging from 0 to 17 business days (that is, the last business day is March 31).

The results show that among institutions already equipped with borrowing documentation, prior DW experience conferred substantial speed advantages. Banks with prior borrowing experience posted loan collateral nearly two days faster than their operationally ready but inexperienced counterparts (column 1). This 1.9-day reduction is both economically and statistically significant in the context of a rapidly unfolding crisis where funding pressures intensified within days. When examining heterogeneity by funding vulnerability (column 2), the effect of prior experience for less vulnerable banks attenuates somewhat to 1.1 days, while the effect for more vulnerable banks is somewhat larger to 1.2 days (the linear combination of the three coefficients), also statistically insignificant. These results indicate that prior familiarity with DW process yields similar speed advantages across all depository institutions regardless of their level of vulnerability.

The pattern for securities collateral differs meaningfully. Prior borrowing experience generates a modest 0.4-day reduction in pledging time (column 3) but is statistically insignificant. It also generates a smaller magnitude for less and more vulnerable banks (0.6 and 0.5 days) which is also

statistically insignificant. This smaller magnitude relative to loan collateral pledging aligns with the earlier finding that securities collateral pledging involves less administrative complexity. It also reinforces the interpretation that borrowing familiarity matters most where administrative processes are most complex. The nearly two-day advantage for loan collateral pledging underscores that prior testing and experience with the loan collateral process translates directly into faster crisis response.

5.4. Interoperability between the Fed and FHLBs

Subordination Agreements: The preceding analysis established that operational readiness and prior experience facilitate faster collateral pledging during crisis periods. However, for institutions already borrowing from the FHLB system, an additional friction may impede rapid redeployment of loan collateral to the DW: the legal priority of existing loan pledges. When a bank has already pledged loans to secure FHLB advances, shifting that collateral to the DW typically requires a subordination agreement - a legal instrument through which the FHLB explicitly subordinates its claim on specific collateral to allow the Federal Reserve to establish a senior lien.

Table IV explores the importance of subordination agreements between Reserve Banks and FHLBs for the speed of pledging loan collateral.[6] I begin with restricting the sample to institutions that were both operationally ready and actively engaged with the FHLB system, defined as being FHLB members *and* having outstanding advances (hence, collateral pledged) at FHLBs as of year-end 2022. I also restrict the sample to depository institutions with prior DW borrowing experience to isolate, to the extent possible, the importance of subordination agreements from other confounding factors.

The results indicate that subordination agreements helped reduce the time required to post additional loan collateral to the DW. Institutions in districts with agreements in place posted collateral 1.2 days faster than comparable institutions in districts without such arrangements (column 1). This finding is not driven by process differences across FHLBs or Reserve Banks because the specification controls for FHLB district and FRB district fixed effects, effectively exploiting the overlapping boundaries of FHLB and FRB districts (see Figure III). Column 2 explores whether this relationship varies with funding vulnerability. The point estimate suggests

[6] Subordination agreements typically occur at the FRB-FHLB-depository institution level; however, I only observe agreements at the FRB-FHLB level.

that vulnerable institutions in districts with subordination agreements may have moved even more rapidly; the interaction coefficient of -1.3 days would imply a total effect exceeding two days for vulnerable banks. However, this interaction is not statistically significant, preventing strong conclusions about differential effects by vulnerability.

Collateral Reporting Practices: Beyond the existence of subordination agreements, a second institutional friction to rapid collateral redeployment between FHLB and Reserve Banks stems from divergent collateral reporting practices. As I discussed in section 2, Reserve Banks uniformly require individual loan-level listing when accepting loan collateral, a granular approach that facilitates precise collateral valuation and monitoring. FHLBs, by contrast, exhibit substantial heterogeneity in their collateral reporting practices: some districts accept summary-based pledges that aggregate loan characteristics, while others mandate detailed loan-by-loan listings comparable to FRB requirements (see Figure II).

Table V investigates whether this institutional misalignment affects the speed at which depository institutions mobilized loan collateral during the March 2023 crisis. The analysis focuses on vulnerable depository institutions that are operationally ready and familiar with DW processes and actively engaged with the FHLB system. I compare those institutions affiliated with "Low FHLB Listing" districts - defined as FHLBs at or below the 25th percentile of listed collateral share - against those in "High FHLB Listing" districts at or above the 75th percentile of listed collateral share.

The results reveal that vulnerable institutions operating in Low FHLB Listing environments (or High FHLB Summary districts because the set of FHLBs are the same) posted loan collateral to the DW approximately 2.2 days slower than less vulnerable banks (column 1). Conversely, vulnerable banks in High FHLB Listing districts exhibited faster response times posting collateral about 1 day earlier than less vulnerable banks (column 2). The economic effects are similar when both measures are included in the same specification (column 3) but become more pronounced when I control for additional bank characteristics (column 4). In the fully specified model, vulnerable institutions in Low FHLB Listing districts post loan collateral approximately 2 days slower, while those in High FHLB Listing districts post roughly 2 days faster, relative to less vulnerable banks.

Overall, these findings highlight that interoperability among liquidity providers is key to

collateral mobilization during crises. The analysis shows that even operationally ready institutions face meaningful delays (up to three or four days) in repurposing FHLB-pledged assets when subordination agreements do not exist or there is a divergence in collateral reporting practices.

6. Conclusion

Classical LOLR theory assumes that collateral can be turned into central-bank funding when banks need it. This paper shows that, in fast runs, the speed of that conversion is itself a constraint. Using confidential Federal Reserve DW data from the March 2023 banking turmoil, I document that collateral mobility depended on both bank-level experience and system-level arrangements between liquidity providers.

The first result is that prior DW experience mattered most for loan collateral. Banks with prior borrowing experience were more likely to post loan collateral and posted it about two business days faster. The same experience had little effect on securities collateral. The second result is that collateral already pledged to FHLBs moved more slowly to the Federal Reserve. Even among operationally sophisticated banks, absent subordination agreements and differences in collateral reporting practices delayed loan-collateral redeployment by an additional three to four days. These delays are large relative to the speed of modern deposit runs. They show that collateral can be eligible and available on a bank's balance sheet, yet still fail to become central-bank funding quickly enough.

These findings recast LOLR effectiveness as a problem of collateral mobility. Stigma asks whether banks are willing to borrow, while collateral eligibility asks whether the central bank should lend. This paper studies a third margin: even when the bank is willing to borrow and the central bank is ready to lend, can collateral reach the central bank fast enough? I show that in fast runs, what matters is not only where collateral sleeps, but how fast it can move when it needs to wake up.

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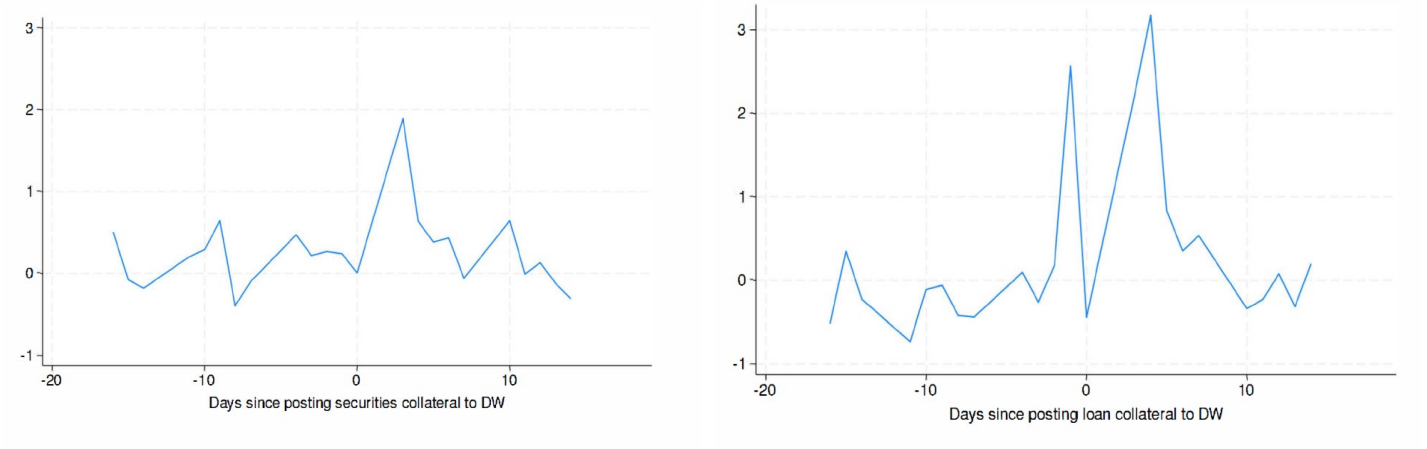
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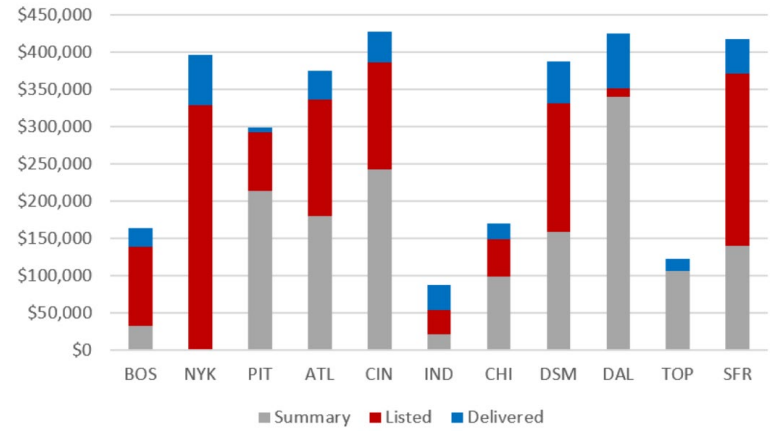
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Figure I: Deposit Trends before and after Posting Collateral



Note: The figure plots standardized net deposit flows for depository institutions that posted new or additional collateral to the Discount Window in March 2023. The left panel shows institutions that posted securities collateral, while the right panel shows institutions that posted loan collateral. The y-axis reports standardized deposit flows, expressed as z-scores relative to each institution's pre-crisis distribution of daily net flows; positive values indicate net deposit outflows, while negative values indicate net deposit inflows. Net deposit flows are the delta of Fedwire Funds payments sent less Fedwire Funds payments received (ACH transfers are excluded). The securities-collateral sample includes 175 banks, matched to Fedwire data, that either had no Discount Window securities collateral before the crisis and posted securities collateral in March 2023, or had some pre-crisis securities collateral and increased their securities collateral at the Discount Window by at least 25%. The loan-collateral sample includes 78 banks, matched to Fedwire data, that either had no Discount Window loan collateral before the crisis and posted loan collateral in March 2023, or had some pre-crisis loan collateral and increased their loan collateral at the Discount Window by at least 25%. For each depository institution, deposit flows are standardized using the pre-crisis distribution of daily net flows from March 2022 through February 2023. The x-axis is re-centered at the institution level such that day 0 denotes the first day in March 2023 on which the institution posted the relevant collateral type to the Discount Window.

Figure II: FHLB Collateral by Reporting Status



Note: The figure presents the distribution of collateral (in thousands of dollars) for each FHLB by the collateral reporting status (i.e., summary reporting, listing, or delivery) as of end-2022. Source: Report on Collateral Pledged to Federal Home Loan Banks, December 15, 2022.

Figure III: Mapping between FRB and FHLB Districts

FRB	FHLB	FRB	FHLB
1		*2*	
Atlanta	Atlanta	Chicago	Chicago
	Dallas		Des Moines
	Cinncinnati		Indianapolis
Cleveland	Cinncinnati	Dallas	Dallas
	Pittsburgh	New York	Boston
Minneapolis	Chicago		New York
	Des Moines	Philadelphia	Des Moines
	Indianapolis		New York
Kansas City	Dallas		Pittsburgh
	Des Moines	St Louis	Chicago
	Topeka		Cinncinnati
Richmond	Atlanta		Dallas
	Pittsburgh		Des Moines
San Francisco	Des Moines		Indianapolis
	San Francisco	Boston	Boston

Note: The table presents a mapping between FRB and FHLB districts.

Table I: Discount Window Process Familiarity and Collateral Pledging

	Pr(Loan Collateral Pledged)		Pr(Securities Collateral Pledged)	
	1	*2*	*3*	*4*
Has Borrowing Documents	0.056***	0.013*	0.032***	0.008
	(0.014)	(0.007)	(0.006)	(0.005)
Has Borrowed in the Past 5 Years		-0.028**		-0.074***
		(0.013)		(0.024)
Has Borrowing Documents *		0.210***		0.152***
Has Borrowed in the Past 5 Years		(0.010)		(0.027)
FRB district FE	yes	yes	yes	yes
Bank Controls	yes	yes	yes	yes
Observations	9370	9370	9370	9370
R^2	0.126	0.203	0.084	0.100

Note: Pr(Loan Collateral Pledged) is an indicator variable that takes the value of one if a depository institution increased the pledged loan collateral to the Discount Window between March 06, 2023, and March 31, 2023, zero otherwise. Pr(Securities Collateral Pledged) is an indicator variable that takes the value of one if a depository institution increased the pledged securities collateral to the Discount Window between March 06, 2023, and March 31, 2023, zero otherwise. Has Borrowing Documents is an indicator variable that takes the value of one if a depository institution had signed OC-10 as of March 08, 2023, zero otherwise. Has Borrowed in the Past 5 Years is an indicator variable that takes the value of one if a depository institution had, as of March 08, 2023, borrowed from the Discount Window during the past 5 years, zero otherwise. Bank Controls inlcude the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. In columns 1 and 2, Bank Controls also include a depository institution's average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023. In columns 3 and 4, Bank Controls also include a depository institution's average share of loan collateral to total collateral pledged between March 06, 2023, and March 31, 2023. Standard errors are clustered at the FRB district level.

Table II: Heterogeneous Effects by Bank Funding Vulnerability

	Pr(Loan Collateral Pledged)		Pr(Securities Collateral Pledged)	
	High UD/TA	Low UD/TA	High UD/TA	Low UD/TA
	1	*2*	*3*	*4*
Has Borrowing Documents	0.034***	0.016**	0.036***	0.015***
	(0.007)	(0.006)	(0.011)	(0.005)
Has Borrowed in the Past 5 Years	-0.006	0.006	0.016	-0.037***
	(0.007)	(0.025)	(0.012)	(0.010)
Has Borrowing Documents *	0.217***	0.143***	0.080***	0.111***
Has Borrowed in the Past 5 Years	(0.015)	(0.008)	(0.021)	(0.017)
FRB district FE	yes	yes	yes	yes
Bank Controls	yes	yes	yes	yes
Observations	2306	7064	2306	7064
R^2	0.262	0.157	0.172	0.074

Note: Pr(Loan Collateral Pledged) is an indicator variable that takes the value of one if a depository institution increased the pledged loan collateral to the Discount Window between March 06, 2023, and March 31, 2023, zero otherwise. Pr(Securities Collateral Pledged) is an indicator variable that takes the value of one if a depository institution increased the pledged securities collateral to the Discount Window between March 06, 2023, and March 31, 2023, zero otherwise. Has Borrowing Documents is an indicator variable that takes the value of one if a depository institution had signed OC-10 as of March 08, 2023, zero otherwise. Has Borrowed in the Past 5 Years is an indicator variable that takes the value of one if a depository institution had, as of March 08, 2023, borrowed from the Discount Window during the past 5 years, zero otherwise. High (Low) UD/TA is an indicator variable that takes the value of one if a depository institution was at or above (below) the 75th percentile of the distribution of uninsured deposits to total assets as of the fourth quarter of 2022 (75th percentile corresponds to about 22% of uninsured deposits to total assets). Bank Controls inlcude the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. In columns 1 and 2, Bank Controls also include a depository institution's average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023. In columns 3 and 4, Bank Controls also include a depository institution's average share of loan collateral to total collateral pledged between March 06, 2023, and March 31, 2023. Standard errors are clustered at the FRB district level.

Table III: Discount Window Process Familiarity and Speed of Collateral Pledging

	#Days to Post Loan Collateral since March 8		#Days to Post Securities Collateral since March 8	
	1	*2*	*3*	*4*
Has Borrowed in the Past 5 Years	-1.887**	-1.168	-0.409	-0.682*
	(0.690)	(0.869)	(0.470)	(0.373)
High UD/TA		1.530		-0.896
		(1.376)		(0.891)
Has Borrowed in the Past 5 Years * High UD/TA		-1.442		1.004
		(1.101)		(1.165)
FRB district FE	yes	yes	yes	yes
Bank Controls	yes	yes	yes	yes
Observations	354	354	363	363
R^2	0.217	0.219	0.115	0.117

Note: #Days to Post Loan Collateral since March 8 measures the number of business days it took depository institutions to post (additional) loan collateral to the Discount Window between March 8 and March 31. #Days to Post Securities Collateral since March 8 measures the number of business days it took depository institutions to post (additional) securities collateral to the Discount Window between March 8 and March 31. The variables take values between 0 (March 8, 2023) and 17 (March 31, 2023). March 8 was when Silvergate Bank announced liquidation. High UD/TA is an indicator variable that takes the value of one if a depository institution was at or above the 75th percentile of the distribution of uninsured deposits to total assets as of the fourth quarter of 2022. Bank Controls inlcude the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. In columns 1 and 2, Bank Controls also include a depository institution's average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023. In columns 3 and 4, Bank Controls also include a depository institution's average share of loan collateral to total collateral pledged between March 06, 2023, and March 31, 2023. Standard errors are clustered at the FRB district level.

Table IV: FRB-FHLB Subordination Agreements and Speed of Collateral Pledging

	#Days to Post Loan Collateral since March 8	
	1	*2*
Subordination Agreement	-1.211**	-1.202**
	(0.538)	(0.511)
High UD/TA		0.751
		(1.987)
Subordination Agreement * High UD/TA		-1.307
		(2.074)
FHLB district FE	yes	yes
FRB district FE	yes	yes
Bank Controls	yes	yes
Observations	214	214
R^2	0.237	0.239

Note: #Days to Post Loan Collateral since March 8 measures the number of business days it took depository institutions to post (additional) loan collateral to the Discount Window between March 8 and March 31. The variable takes values between 0 (March 8, 2023) and 17 (March 31, 2023). March 8 was when Silvergate Bank announced liquidation. High UD/TA is an indicator variable that takes the value of one if a depository institution was at or above the 75th percentile of the distribution of uninsured deposits to total assets as of the fourth quarter of 2022. Bank Controls inlcude the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. Bank Controls also include a depository institution's average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023. Standard errors are two-way clustered at the FHLB district and FRB district level.

Table V: FRB-FHLB Collateral Practices and Speed of Collateral Pledging

	#Days to Post Loan Collateral since March 8			
	1	*2*	*3*	*4*
High UD/TA	-0.429	0.907	0.076	-0.186
	(0.479)	(0.591)	(0.518)	(0.543)
Low FHLB Listing *	2.613**		2.108*	2.181*
High UD/TA	(1.048)		(1.068)	(1.063)
High FHLB Listing *		-1.889**	-1.058	-1.811
High UD/TA		(0.782)	(0.730)	(1.121)
FHLB district FE	yes	yes	yes	yes
Bank Controls	no	no	no	yes
Observations	192	192	192	192
R^2	0.102	0.098	0.103	0.162

Note: #Days to Post Loan Collateral since March 8 measures the number of business days it took depository institutions to post (additional) loan collateral to the Discount Window between March 8 and March 31. The variable takes values between 0 (March 8, 2023) and 17 (March 31, 2023). March 8 was when Silvergate Bank announced liquidation. High UD/TA is an indicator variable that takes the value of one if a depository institution was at or above the 75th percentile of the distribution of uninsured deposits to total assets as of the fourth quarter of 2022. Low FHLB Listing is an indicator variable that takes the value of one for FHLB districts that are below or equal to the 25th percentile of the share of listed collateral to total collateral pledged as of end-2022. High FHLB Listing is an indicator variable that takes the value of one for FHLB districts that are at or above the 75th percentile of the share of listed collateral to total collateral pledged as of end-2022. Bank Controls inlcude the log of a depository institution's total assets, share of deposits to total assets, share of FHLB advances to total assets, share of HTM securities losses to total assets and share of cash to total assets as of the fourth quarter of 2022. Bank Controls also include a depository institution's average share of securities collateral to total collateral pledged between March 06, 2023, and March 31, 2023. Standard errors are clustered at the FHLB district level.

Appendix Table I: Summary Statistics

Variables	*N*	*p25*	*mean*	*median*	*p75*	*sd*
Pr(Loan Collateral Pledged)	9370	0	0.04	0	0	0.20
Pr(Securities Collateral Pledged)	9370	0	0.04	0	0	0.19
Has Borrowing Documents	9370	0	0.5	1	1	0.5
Has Borrowed in the Past 5 Years	9370	0	0.25	0	1	0.43
#Days to Post Loan Collateral since March 8	354	3	6.91	7	11	4.88
#Days to Post Securities Collateral since March 8	363	4	7.87	7	11	4.55
Subordination Agreement	214	1	0.9	1	1	0.3
Share FHLB Listing	192	0.29	0.4	0.45	0.55	0.22

Note: The table presents summary statistics of the main variables used in the analysis.

Appendix Table II: Collateral Pledged at the Discount Window

	6-Mar-23	31-Mar-23
Total Collateral	2,453	2,793
Loan Collateral	1,841	2,100
Securities Collateral	612	693

Note: This table reports total, loan, and securities collateral pledged at the Discount Window by sample banks during March 6–31, 2023. All values are in billions of US dollars.