Monetary Tightening and U.S. Bank Fragility in 2023: Mark-to-Market Losses and Uninsured Depositor Runs?[1]

March 13, 2023

Erica Jiang, Gregor Matvos, Tomasz Piskorski, and Amit Seru

Abstract

We analyze U.S. banks' asset exposure to a recent rise in the interest rates with implications for financial stability. The U.S. banking system's market value of assets is $2 trillion lower than suggested by their book value of assets accounting for loan portfolios held to maturity. Marked-to-market bank assets have declined by an average of 10% across all the banks, with the bottom 5th percentile experiencing a decline of 20%. We illustrate that uninsured leverage (i.e., Uninsured Debt/Assets) is the key to understanding whether these losses would lead to some banks in the U.S. becoming insolvent-- unlike insured depositors, uninsured depositors stand to lose a part of their deposits if the bank fails, potentially giving them incentives to run. A case study of the recently failed Silicon Valley Bank (SVB) is illustrative. 10 percent of banks have larger unrecognized losses than those at SVB. Nor was SVB the worst capitalized bank, with 10 percent of banks having lower capitalization than SVB. On the other hand, SVB had a disproportional share of uninsured funding: only 1 percent of banks had higher uninsured leverage. Combined, losses and uninsured leverage provide incentives for an SVB uninsured depositor run. We compute similar incentives for the sample of all U.S. banks. Even if only half of uninsured depositors decide to withdraw, almost 190 banks are at a potential risk of impairment to insured depositors, with potentially $300 billion of insured deposits at risk. If uninsured deposit withdrawals cause even small fire sales, substantially more banks are at risk. Overall, these calculations suggest that recent declines in bank asset values very significantly increased the fragility of the US banking system to uninsured depositor runs.

[1] Jiang is at University of Southern California (erica.jiang@marshall.usc.edu), Matvos is at Northwestern University and NBER (gregor.matvos@kellogg.northwestern.edu), Piskorski is at Columbia and NBER (tp2252@gsb.columbia.edu), and Seru is at Stanford GSB, the Hoover Institution, SIEPR and NBER (aseru@stanford.edu).

When central banks tighten monetary policy, it can have significant negative impacts on the value of long-term assets, including government bonds and mortgages. This can create losses for banks, which engage in maturity transformation: they finance long maturity assets with short-term liabilities—deposits. As interest rates rise, the value of a bank's assets can decline, potentially leading to bank failure through two broad, but related channels. First, if a bank's liabilities exceed the value of its assets, it may become insolvent. This is particularly likely for banks which need to increase deposit rates as interest rates rise. Second, uninsured depositors may become concerned about potential losses and withdraw their funds, causing a run on the bank.

Uninsured depositors represent a significant source of funding for commercial banks, which can make runs a significant risk for these institutions.[2] In fact, during the 1980s and 1990s, nearly one-third of savings and loan institutions failed due to losses incurred from long-term fixed-rate mortgages that declined in value when interest rates surged. This resulted in a substantial reduction in the net worth of the S&L industry. More recently, the largest bank failure since the great recession occurred on March 10, 2023, when Silicon Valley Bank (SVB) was taken into FDIC receivership. 92.5% of its deposits were uninsured, leading to significant withdrawals that ultimately resulted in the bank's collapse within two days. In this note we provide a simple analysis of all U.S. banks' asset exposure to a recent rise in the interest rates with implications for financial stability.

The Federal Reserve Bank responded to high inflation by increasing interest rates, which resulted in a substantial decline in the market value of long-duration assets. From March 07, 2022, to March 6, 2023, the federal funds rate rose sharply from 0.08% to 4.57% (Figure 1(a)), and this increase was accompanied by quantitative tightening. As a result, long-dated assets similar to those held on bank balance sheets experienced significant value declines during the same period. For instance, the exchange-traded fund that tracks the market value of residential mortgages (SPDR Portfolio Mortgage-Backed Bond ETF—SPMB) declined by approximately 11% (Figure 1b) from 2022:Q1 to 2023:Q1. Similarly, the market value of commercial mortgages indicated by the iShares CMBS ETF declined by 10% during this time. Long maturity treasury bonds were particularly affected by monetary policy tightening, with 10-20 year and 20+ year Treasury bonds losing about 25% and 30% of their market value, respectively, as suggested by iShare Treasury ETF. Overall, as is evident, the FED's monetary policy tightening caused significant value declines in long duration assets.

To assess the financial stability of U.S. banks, we use bank call report data capturing asset and liability composition of all US banks (over 4800 institutions) combined with market-level prices of long-duration assets.[3] Our analysis proceeds in multiple stages. Firstly, we examine losses on banks' assets including their loan portfolios held to maturity, which have not been marked-to-market, as well as securities linked to real estate (such as mortgage-backed securities (MBS), commercial mortgage-backed securities (CMBS)), US Treasuries, and other asset-backed securities (ABS)). These assets compromise more than half of bank assets (80% of $20 trillion dollars). Adjusting these assets to their market values, our findings indicate that bank assets decline on average by 10%, with the bottom 5th percentile experiencing a decline of approximately 20%. The market value of U.S. banking system assets is $2 trillion lower than suggested by their book value. Interestingly, SVB does not stand out as much in the distribution of marked-to-market losses, with about 10% of banks experiencing worse marked-to-market losses on their portfolio.

Next, we analyze how this decline in assets impacts the solvency and run incentives of banks. We begin by assessing banks' funding structures before the recent monetary tightening. While SVB was reasonably well-

[2] See Egan et al. (2017).

[3] For assessments of U.S. banks' exposure to credit and interest rate risk in periods preceding the 2022-2023 monetary tightening episode see, among others, Begenau et al. (2015), Kelly et al. (2016), Drechsler et al. (2017, 2021), Egan et al. (2017), Atkeson et al. (2018), Begenau and Stafford (2019), and Xiao (2020).

capitalized from a capital perspective, with 10% of banks having less capital than SVB, its use of uninsured deposits stood out. It ranked in the 1st percentile of the distribution in uninsured leverage, suggesting that over 78% of its assets were funded by uninsured deposits.[4] In other words, SVB's bank liabilities were more prone to runs than those of other banks.

Finally, we analyze several scenarios that combine the analysis of declines in marked-to-market asset values, along with banks' capitalization and uninsured leverage. This analysis informs us about the impact on the solvency and run incentives of banks.

Banks' Hidden Losses: "Marking to Market"

To understand the impact of interest rate increases on banks' asset values, we begin by examining bank balance sheets, following Jiang et al. (2020). Since a substantial portion of bank portfolios, specifically loans held to maturity, are not marked to market, we rely on exchange-traded funds (ETFs) across various asset classes to conduct our analysis. For the typical bank, real estate loans account for approximately 42% of their assets (Table A1). Moreover, securities linked to real estate (such as mortgage-backed securities (MBS), commercial mortgage-backed securities (CMBS), treasuries, and other asset-backed securities (ABS) constitute approximately 22% of the average bank's assets. As these assets represent more than half of the total assets for a typical bank, we concentrate on marking them to market, which may result in underestimating the effect on the remaining portion of the bank balance sheet, which we leave unchanged.

We mark bank assets to market in three steps.

1) We obtain the asset maturity and repricing data for all FDIC-insured banks in their regulatory filings (Call Report Form 031 and 041) in 2022:Q1. Banks are required to report the values of residential MBS and non-residential MBS securities (Schedule RC-B). They are also required to report the values of loans that are secured by first liens on 1- 4 family residential properties and all loans and leases excluding loans that are secured by first liens on 1-4 family residential properties (Schedule RC-C) by maturity and repricing breakdowns.[5]

2) We use traded indexes in real estate and treasuries to impute the market value of real estate loans held on bank balance sheet. Longer duration fixed income assets were affected more by interest rate increases, so we want to adjust the market values of loans based on their maturity. Because of limited maturity information across RMBS maturities, we use one RMBS exchange traded fund, and then adjust across maturities using treasury prices. As a baseline, we use changes in the market price of U.S. Treasury bonds and RMBS from 2022:Q1 to 2023:Q1. To adjust for maturity, we use iShare U.S. Treasury Bond ETFs and S&P Treasury Bond Indices across various maturities that match the maturity and repricing breakdowns in the call reports. For each of these ETFs and indices, we calculate the price declines since 2022:Q1, plotted in Figure 1.

3) We compute the mark-to-market value losses as

$$Loss = \sum_t RMBS\ multiplier \times (RMBS_t + Mortgage_t) \times \Delta TreasuryPrice_t + Treasury\ and\ Other\ Securities\ and\ Loans_t \times \Delta TreasuryPrice_t,$$

where t indicates the maturity and repricing breakdowns: less than 1 year, 1-3 years, 3-5 years, 5-10 years, 10-15 years, and 15 years or more. $\Delta TreasuryPrice_t$ is the market price change of Treasury bonds with maturity t from 2022:Q1 to 2023:Q1 that we obtained in the second step.

[4] See Jiang et al. 2020 for a longer analysis of uninsured leverage in the U.S. banking and shadow banking system.
[5] The breakdowns are "less than three months," "three months to one year," "one to three years," "three to five years," "five to fifteen years," and "more than fifteen years."

RMBS and residential mortgages have additional risk due to prepayment risk. We account for this by constructing an $RMBS\ multiplier$ that uses average market price changes of RMBS and Treasury bonds across various maturities over this period:

$$RMBS\ multiplier = \frac{\Delta iShare\ MBS\ ETF}{\Delta \text{S\&P}\ Treasury\ Bond\ Index}.$$

We then define the mark-to-market asset value in 2023:Q1 as total assets in 2022:Q1 minus the mark-to-market value loss defined above. In some ways, our estimates are conservative, since we only marked down the value of real estate loans and other assets and securities and loans discussed above, rather than all assets on the bank balance sheets. On the other hand, we do not account for possible interest rate hedges that banks could have entered, potentially offsetting decline in value due to interest rate change.

Marking the value of real estate loans, government bonds, and other securities results in significant declines in bank assets. We present the distribution of asset declines due to unrealized losses in Figure 2A. The average banks' unrealized losses are around 10% after marking to market. The 5% of banks with worst unrealized losses experience asset declines of about 20%. We note that these losses amount to a stunning 96% of the pre-tightening aggregate bank capitalization.

The unacknowledged losses do differ slightly across the size distribution. They are smallest for GSIBs at 8.8% and largest for large non-GSIB banks at 10%. Note that there are also likely substantial differences in the uses of interest rate hedges across the size distribution of banks (esp. GSIBs). We are unable to account for this due to data limitations. There are substantial differences in the types of loans from which the losses arise. For GSIBs, RMBS is the largest part of the losses, and for small banks, it is other loans. In total the U.S. banking system's market value of assets is $2 trillion lower than suggested by their book value of assets as of 2023:Q1.

Perhaps somewhat puzzling at first, the recently failed SVB does not stand out as much in the distribution of marked to market losses. About 11 percent of banks suffered worse marked to market losses on their portfolio (Figure 2). In other words, if SVB failed because of losses alone, more than 500 other banks should also have failed.

The Role of Uninsured Leverage: Run Incentives, and the Case of SVB

We next turn to assessing banks' funding structures before the monetary tightening. We show that SVB was not especially thinly capitalized relative to other banks. Instead, we show that it stood out on the dimension of uninsured leverage, making it much more run prone than other banks. Table A1 presents the funding structure of the U.S. banking industry prior to the monetary tightening. The median bank funds 9 % of their assets with equity, 65% with insured deposits, and 26% with uninsured debt comprising uninsured deposits and other debt funding. There was very little difference in the capitalization across banks prior to monetary policy tightening. The 10^{th} percentile best capitalized bank had a ratio of equity to assets (E/A) of 14%, while the 10^{th} percentile worst capitalized bank had 8% percent capital. Again, SVB is not an outlier—it is at the 10^{th} percentile of capitalization of U.S. banks.

SVB did stand out from other banks in its distribution of uninsured leverage, the ratio of uninsured debt to assets (see Jiang et al. 2020 for a more comprehensive analysis of uninsured leverage of U.S. banking and shadow banking sector). Banks differ significantly in the share of funding they obtain from uninsured sources. The 5^{th} percentile bank uses 6 percent of uninsured debt. For this bank, 94% of funding is not run prone comprising equity and deposits.

On the other hand, the 95th percentile bank uses 52 percent of uninsured debt. For this bank, even if only half of uninsured depositors panic, this leads to a withdrawal of one quarter of total marked to market value of the bank. If any fire sale discounts result from these withdrawals, this can impose substantial losses on the remaining creditors, increasing their incentives to run. SVB was in the 1st percentile of distribution in insured leverage. Over 78 percent of its assets was funded by uninsured deposits. This fact suggests that uninsured deposits played a critical role in the failure of SVB.

Run Incentives and Uninsured Leverage: Simple Example

Unlike insured depositors, uninsured depositors stand to lose a part of their deposits if the bank fails, potentially giving them incentives to run. Here we want to better understand why a bank, which is potentially poorly capitalized but uses insured deposits for funding may not fail, but a similar bank with uninsured deposits will. We present a simple numerical example, which illustrates the intuition.

Consider a bank, whose long duration assets are risk free perpetuities (T-bonds with infinite maturity), paying an annual coupon of 3% before monetary tightening, and short duration asset is cash paying 0. Specifically, the bank holds $10BN in cash and $90BN in treasuries. To make things simple, we assume that the bank earns no rents on the liability side *prior to FED tightening*: the bank has $80 BN of deposits at the deposit cost of 3%[6] and $10BN of long-term debt at the legacy fixed rate of 3%. The current risk-free rate is 3%. In other words, for simplicity, the market and face value of bank liabilities are the same. Then, the market value of equity is $10 BN.

Fed's Tightening: Suppose the FED unexpectedly increases the risk-free rate rises by 100 basis points due to inflation. The value of the banks long term assets asset declines by 25% to $\$67.5BN = \frac{\$90BN*3\%}{4\%}$ and the value of total bank assets will be 77.5BN. This computation corresponds to the more involved "mark to market" analysis of assets in Figure 2.

Despite a large swing in the value of assets, it is not yet clear whether this bank is insolvent (the value of assets exceeds that of deposits), and whether depositors should consider running. This critically depends on the composition of depositors, i.e., how many are insured versus uninsured, and on the interest rates paid on deposits. We can generate a range of possibilities by considering different behavior by uninsured depositors. We study whether insured depositors would be impaired under these scenarios. The idea is that impaired insured depositors is the lower bar for FDIC intervention. In other words, we provide uninsured depositors with the smallest incentives to run.

Baseline Scenario: Sleepy Depositors Consider the case where all the depositors are sleepy. Specifically, they do not require a change in deposit rates offered to them – in spite of the higher rates being offered (say if they invested in Treasury securities), nor do they consider withdrawing money from a bank if potentially impaired.[7] This scenario could correspond to the case of the bank financed with predominantly insured (and sleepy) deposits. In that case, the marked to market cost of liabilities is $\$67.5BN = \frac{\$90BN*3\%}{4\%}$. The bank would be still solvent and have positive equity value equal to $10BN. Intuitively, the bank still has a positive cash flow and if debt stays in place at the same rate (and deposits are sleepy), the market value of debt on liability side also declines with an increase in the interest rate.

---

[6] The cost of deposits includes the deposit rate and acquisition costs. The deposits are cheaper than the risk free-rate due to some special value depositors attach to the money lie debt (see for e.g., Jiang et al. 2020).

[7] See Dreschler et al. (2017) and Egan et al. (2017) who argue that the deposit franchise may allow banks to pay deposit rates that are low and Dreschler et al. (2021) who argue that in addition, these deposit rates are insensitive to market interest rates.

But what if uninsured (and maybe insured) depositors want a higher deposit rate when the interest rates rise or want their money back? Consider the range of scenarios below:

Scenario 1: Suppose 50% of depositors are uninsured and half of them run. In this case the bank needs to pay uninsured depositors $20BN. The remaining marked-to market value of bank assets will be 57.5BN which is more than the remaining face value of insured deposits equal to $40BN. In this case a scaled down bank can, in principle, continue its operations. The bank is solvent, and the uninsured investors have no incentives to run—they can be paid in full.

*Scenario 2: Suppose 50% of depositors are uninsured and they all run***.** The bank needs to pay uninsured depositors $40BN. The remaining marked-to market value of bank assets will be $37.5BN. This is less than the face value of remaining insured deposits that equal to $40M and the FDIC will have to close the bank. Notice that we did not assume any fire sale cost of bank asset liquidation, yet, even insured depositors are impaired. Under this scenario, the bank is insolvent because of a run, because a run reprices bank liabilities to be marked to market.

Scenario 3: All depositors run or leave for higher yielding alternatives The bank is insolvent under this scenario. After selling its assets the bank will have $77.5M (= $67.5M from liquidation proceeds + $10M of its cash buffer). This is not enough to cover the face value of deposits equal to $80M. If all bank depositors are uninsured, they will have an incentive to run on a bank since the marked-to-market value of bank assets is less than the face value of uninsured deposits.

Marked to Market Losses, Solvency, and Run Risk

We next more systematically consider whether marking asset losses to market renders a share of U.S. banks insolvent, or exposes them to run risk. There are several issues that arise when considering whether banks are insolvent and run prone, even after marking assets to market. First, it is difficult to evaluate the market value of deposit liabilities. One the one hand deposits are on demand, and thus could be evaluated at their face value at prevailing rates. On the other hand, there may be a spread between deposit rates to fed funds rates due to banks' market power, allowing banks to earn rents (Egan et al 2017, Dreschler et al. 2021). Under this scenario one may want to consider on demand liabilities more akin to long duration assets, which also lose value when rates rise (Dreschler et al. 2021). Second, it is unclear how run prone uninsured deposits are. Egan et al. (2017) estimate that uninsured deposits are somewhat elastic to default, but this elasticity can result in multiple equilibria, and such complex counterfactuals are beyond the scope of this note. Instead, we consider several alternative scenarios, which consider a range of behaviors of uninsured depositors, and regulators, which play a central role in bank failures.

Are Assets of U.S. Banks Sufficient to Cover Uninsured Deposits?

The first benchmarking exercise considers the run incentives of uninsured depositors from the perspective of assets after marking assets to market. Specifically, we consider whether the assets in the U.S. banking system are large enough to cover all uninsured deposits. Intuitively, this situation would arise if all uninsured deposits were to run, and the FDIC *did not close the bank prior to the run ending*. Figure 3A plots the histogram of uninsured deposit to asset ratio and marked-to-market asset ratio. Figure 3B plots uninsured deposit to asset ratio against bank size. As we observe, while the decline in asset values increased the ratio of uninsured deposits to assets, virtually all banks (barring two) have enough assets to cover their uninsured deposit obligations. In other words, if the FDIC does not step in to protect the deposit insurance fund, or if the liquidation of the assets does not cause substantial fire sales, there is little reason for uninsured depositors to run.

Notably, SVB, is one of the worst banks in this regard. Its marked-to-market assets are barely enough to cover its uninsured deposits. Even a small fire sale discount would result in uninsured depositors in losing money in a run, making a run rational. This fact can help explain why the uninsured depositors run may have occurred for this bank.

Uninsured Deposits and Scenarios on Running

We next consider a several scenarios related to uninsured depositor behavior to assess the fragility of banks to uninsured depositors runs. We study whether insured depositors would be impaired under these scenarios. The idea is that impaired insured depositors is the lower bar for FDIC intervention.

For that purpose, Figure 4 plots the distribution of insured deposit coverage ratio. We defined it as:

$$\text{Insured Deposit Coverage ratio} = \frac{\text{Mark} - \text{to} - \text{market Assets} - \text{Uninsured Deposits} - \text{Insured Deposits}}{\text{Insured Deposits}}$$

We simulate two scenarios. In scenario 1 (Figure 4aand 4b), we assume half of all uninsured depositors run. In scenario 2 (Figure 4c and 4d), we assume all uninsured depositors run. We compare the scenarios pre and post FED monetary tightening.

Prior to FED interest rate increases, U.S. banks were solvent under both scenarios, and uninsured depositors had no incentives to run. In other words, even if all uninsured deposits would have been withdrawn, the remaining assets would have been sufficient to cover insured deposits. Of course, this assumes that deposit withdrawals do not result in fire sales, which would further depress assets. But absent fire sales, the U.S. banks would have been able to withstand all deposit withdrawals.

As we discuss above, the recent FED tightening has resulted in substantial losses in the value of banks' long duration assets. Out calculations imply that banks are much more fragile to uninsured depositors runs after the tightening. Suppose that all uninsured depositors were to withdraw funds from U.S. banks. Figure 4(a), shows that 1619 U.S. banks would have negative insured deposit coverage, suggesting insured deposits would be impaired (Table 1). While the median bank is small, with assets of $0.3BN, the aggregate losses would be large, and would involve $2.6T of aggregate deposits, and a shortfall for the deposit insurance fund of $300BN. This would provide the FDIC with enormous incentives to intervene during a run, such as in the case of SVB, and thus in fact provide incentives for uninsured depositors to run.

The scenario under which all uninsured depositors run is likely too extreme, although not impossible once the news of a run spreads. Therefore, in Scenario 2 we consider whether banks are able to withstand half of their uninsured depositors withdrawing funds. Again, this scenario assumes that banks can liquidate their assets at market prices, rather than facing a fire sale discount. Even under this scenario, we find that there are 186 banks with a negative insured deposit coverage ratio. In other words, for these banks comprising about $300BN of insured deposits, even insured deposits would be impaired. The losses to the deposit insurance fund would total approximately $10BN. If the FDIC shut these banks following a run, there would be no funds left for the remaining uninsured depositors. In other words, the decision to run would have been a rational one. So, our calculations suggest these banks are certainly at a potential risk of a run, absent other government intervention or recapitalization.

Interestingly, while SVB is very close to the boundary of a negative insured deposit coverage ratio, our calculations suggest is should have been able to survive a run without impairing insured depositors. However, even a 0.4% fire sale discount would have resulted impaired insured deposits if all uninsured depositors ran.

Last, we plot the 10 largest banks at risk of a run, which we define as a negative insured deposit coverage ratio if all uninsured depositors run. Because of the caveats in our analysis as well as the potential of exacerbating their situation, we anonymize their names, but we also plot SVB as comparison. We plot how their mark-to-market asset losses (Y axis) against their uninsured deposits as a share of marked to market assets. Some of these banks have low uninsured deposits, but large losses, but the majority of these banks have over 50% of their assets funding with uninsured deposits. SVB stands out towards the top right corner, with both large losses, as well as large uninsured deposits funding.

Extreme Insolvency: No Deposit Franchise

Finally, we also consider an extreme case under which we compute the solvency of banks by assessing whether the marked to market value of assets is sufficient to cover all non-equity liabilities. In other words, if all depositors and debtholders withdrew their funding today, could banks repay their debts. This is akin to assuming that there is no value to banks' deposit franchise. We assume that when assets are liquidated, there is no additional discount due to liquidation, so assets can be sold at their current market value. This scenario is extreme, because insured depositors have no incentives to withdraw funds as a function of default risk. On the other hand, it is a useful benchmark to better understand the de facto capitalization of the U.S. banking sector. Implicitly, this calculation assumes that increasing interest rates do not decrease the value of bank liabilities, i.e., the fed funds rate instantaneously pass-through to deposit rates.

We present these results in Appendix A that plots the histograms (density) of the equity to asset ratio as of 2022:Q1 and the mark-to-market equity to asset ratio as of 2023:Q1 (Panel A) and these values by bank size (Panel B). The reference lines in Panel A indicates Silicon Valley Bank's equity to asset ratio as of 2022Q1 and its mark-to-market equity to asset ratio. As we observe, prior to the recent asset declines all US banks had positive bank capitalization. However, after the recent decrease in value of bank assets, 2,315 banks accounting for $11 trillion of aggregate assets have negative capitalization. This calculation (summarized in Table 1) underscores that recent declines in bank asset values significantly decreased bank capitalization and bank insolvency risk.

Conclusion

We provide a simple analysis of U.S. banks' asset exposure to a recent rise in the interest rates with implications for financial stability. The U.S. banking system's market value of assets is $2 trillion lower than suggested by their book value of assets. We show that these losses, combined with a large share of uninsured deposits at some U.S. banks can impair their stability. Even if only half of uninsured depositors decide to withdraw, almost 190 banks are at a potential risk of impairment to even insured depositors, with potentially $300 billion of insured deposits at risk. If uninsured deposit withdrawals cause even small fire sales, substantially more banks are at risk. Overall, these calculations suggest that recent declines in bank asset values significantly increased the fragility of the US banking system to uninsured depositors runs.

There are several medium-run regulatory responses one can consider to an uninsured deposit crisis. One is to expand even more complex banking regulation on how banks account for mark to market losses. However, such rules and regulation, implemented by myriad of regulators with overlapping jurisdictions might not address the core issue at hand consistently (Agarwal et al. 2014).[8] Alternatively, banks could face stricter capital requirement, which would bring their capital ratios closer to less regulated lenders, as documented in Jiang et al (2020). Discussions of this nature remind us of the heated debate that occurred after the 2007 financial crisis, which many might argue did not result in sufficient progress on bank capital requirements (see Admati et al. 2013, 2014 and 2018).

[8] In addition, such regulations might have implications for non-bank institutions (shadow banks) that provide several services like banks and have gained market share that reflects in part the regulatory actions on banks (see Buchak et al. 2022). These institutions are predominantly financed with short-term uninsured debt, but they are also significantly better capitalized than banks on average (Jiang et al. 2020). See also Greenwood et al. (2017), Corbae and D'Erasmo (2021), and Begenau and Landgvoit (2022) for recent studies of impact of regulatory policies on banks.

References:

Admati, A, P. DeMarzo, M. Hellwig, and P. Pfleiderer, 2013, Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity Is Not Socially Expensive, Working Paper.

Admati, A. and M. Hellwig, 2014, “Bankers New Clothes: What’s wrong with Banking and what to do about it?”

Admati, A, P. DeMarzo, M. Hellwig, and P. Pfleiderer, 2018, The Leverage Rachet Effect, *Journal of Finance* 73, 145-198.

Agarwal, S., Lucca, D., Seru, A., and Trebbi, F., 2014, Inconsistent Regulators: Evidence from Banking, *Quarterly Journal of Economics* 129, 889-938.

Atkeson, A. G. A. d'Avernas, A. L. Eisfeldt, and P.-O. Weill, 2018, Government Guarantees and the Valuation of American Banks, *NBER Macroeconomics Annual*.

Begenau, J., M. Piazessi, and M. Schneider, 2015, Banks’ Risk Exposures, working paper.

Begenau, J., and E. Stafford, 2019, Do Banks Have an Edge, working paper.

Begenau, J, and T. Landgvoit, 2022, Financial Regulation in a Quantitative Model of the Modern Banking System, *Review of Economic Studies* 89, 1748–1784.

Buchak, G., G. Matvos. T. Piskorski, and A. Seru, 2022, Beyond the Balance Sheet Model of Banking: Implications for Bank Regulation and Monetary Policy, forthcoming in the *Journal of Political Economy*.

Corbae, D., and P. D’Erasmo, 2021, Capital Buffers in a Quantitative Model of Banking Industry Dynamics, *Econometrica* 89, 2975–3023.

Drechsler, I., A. Savov, and P. Schnabl, 2017, The Deposits Channel of Monetary Policy, *Quarterly Journal of Economics* 132, 1819-1876.

Drechsler, I., A. Savov, and P. Schnabl, 2021, Banking on Deposits: Maturity Transformation without Interest Rate Risk, *Journal of Finance* 76, 1091-1143.

Egan, M., Matvos, G., Hortacsu, A., 2017. Deposit Competition and Financial Fragility: Evidence from the US Banking Sector, *American Economic Review* 107, 169-216

Greenwood, R., J. C. Stein, S. G. Hanson, and A. Sunderam, 2017, Strengthening and Streamlining Bank Capital Regulation, *Brookings Papers on Economic Activity*, 479–565.

Jiang, E., G. Matvos, T. Piskorski, and A. Seru, Banking without Deposits: Evidence from Shadow Bank Call Reports, NBER working paper.

Kelly, B., H. Lustig, and S. Van Nieuwerburgh, 2016, Too-Systemic-to-Fail: What Option Markets Imply about Sector-Wide Government Guarantees, *American Economic Review*, 106, 1278-1319.

Xiao, Kairong, 2020. Monetary Transmission through Shadow Banks, *The Review of Financial Studies* 33, 2379-2420.

Table 1: Insolvent Banks Under Different Scenarios

This table describes insolvent banks based on mark-to-market asset values under each of our scenarios. In column 1, we assume all assets are liquidated and report the statistics of banks that have negative mark-to-market equity to asset ratios. In columns 2-4, we report the statistics of all insolvent banks, where insolvency is defined as not being able to pay all insured deposits. In scenario 1, we assume all uninsured depositors run. In scenario 2, we assume 50% uninsured depositors run. In scenario 3, we assume that there is a fire sale discount such that Silicon Valley Bank starts not being able to pay all insured deposits, i.e., the remaining mark-to-market asset value after paying all runnable uninsured deposits is equal to the insured deposit value. Note that SVB is not classified as insolvent in Scenario 1. Its insured deposit coverage ratio, defined as (mark-to-market asset – uninsured deposit – insured deposit)/insured deposit, is 5.6%. Aggregate asset shows the sum of total assets of banks in each category: banks with negative mark-to-market equity/asset ratio in column 1, and banks with negative insured deposit coverage ratios in columns 2-4, where insured deposit coverage ratio is calculated as (mark-to-market asset – uninsured deposit – insured deposit)/insured deposit. Aggregate equity shows the sum of equity of banks in each category. Aggregate insured deposit is the sum of total insured deposits of banks in each category. Total shortfall is the sum of total uncovered insured deposits. The rest of the values are median values of all banks in each category. Numbers in parentheses are standard deviations. Systemically important banks (GSIB banks) are classified according to bank regulators' definition. Sources: Bank Call Reports in 2022Q1 and various ETF and indices price data as described in the main text.

	(1) All Assets Liquidate	(2) 100% Uninsured Depositor Run	(3) 50% Uninsured Depositor Run	(4) 0.4% Fire Sale Discount
Aggregate Asset	11T	4.9T	0.3T	5.3T
Aggregate Equity	1.0T	0.4T	0.02T	0.4T
Aggregate Insured Deposit	5.2T	2.6T	0.3T	2.7T
GSIB Banks	2.2T	1.1T	20B	1.1T
Total Shortfall	1.5T	0.3T	0.01T	0.3T
GSIB Banks	0.6T	0.11T	0.8B	0.1T
Total Asset	0.4B	0.3B	0.2B	0.3B
	(68B)	(46B)	(9B)	(45B)
Liability/Asset	91.7	91.9	92.0	91.9
	(2.3)	(2.3)	(3.0)	(2.3)
Domestic Deposit/Asset	89.6	90.7	90.8	90.7
	(4.9)	(3.1)	(3.7)	(3.0)
Insured Deposit/Asset	66.4	67.8	79.7	67.6
	(11.6)	(11.4)	(5.8)	(11.6)
Uninsured Deposit/Asset	22.1	22.4	10.2	22.5
	(11.7)	(11.8)	(7.2)	(12.0)
Equity/Asset	8.3	8.1	8.0	8.1
	(2.3)	(2.3)	(3.0)	(2.3)
Observations	2315	1619	186	1724

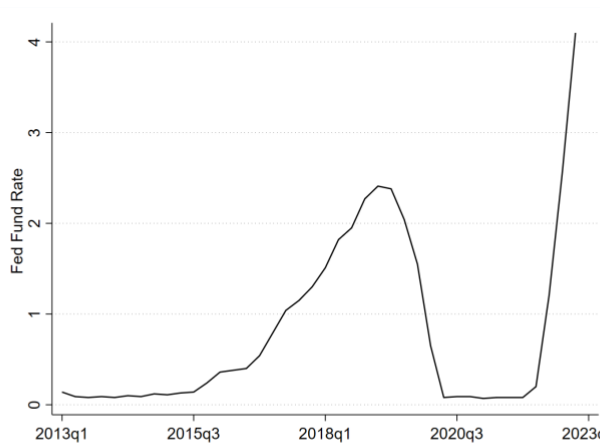
Table 2: Mark-to-Market Statistics by Size

This table presents the descriptive statistics of our key metrics after we find the mark-to-market asset values for each FDIC-insured depository institutions in the U.S. Aggregate loss is the total dollar losses calculated by summing over all dollar losses at each bank based on their 2022Q1 balance sheets. All other numbers outside parentheses are sample median values. Numbers in parentheses are standard deviations. Dollar losses are defined in the main text. We decompose all losses into losses from RMBS, Treasury and other securities, loans secured by residential 1 to 4 family properties (residential mortgage), and other loans. These values are expressed in terms of the percentage of total losses in the table. Loss/Asset is the percentage loss of the asset book values as of 2022Q1 after marking to market the main asset categories as described in the main text. Uninsured Deposit/MM Asset is the uninsured deposit amount as reported in 2022Q1 bank call reports divided by the mark-to-market asset value. Insured Deposit Coverage ratio is defined as (mark-to-market asset value - uninsured deposit -insured deposit)/insured deposit. Note that our analyses are done at charter bank level instead of bank holding company level. *Sources*: Bank Call Reports in 2022Q1 and various ETF and indices price data as described in the main text.

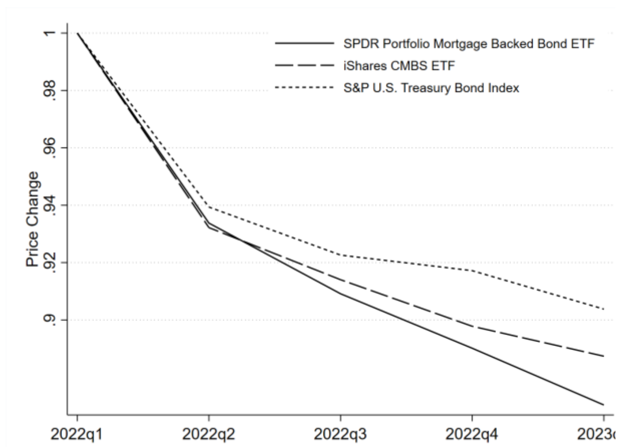
	(1) Total	(2) Small (<1.384B)	(3) Large (1.384B, 250B)	(4) GSIB (>250B)
Aggregate Loss	2.2T	144B	1.3T	0.73T
Individual Dollar Loss	28.6M	22.3	308.0	837.0
	(6.7B)	(38.2)	(8.9B)	(69.7B)
Share RMBS	13.2	11.4	22.6	17.4
	(19.2)	(18.5)	(20.6)	(32.8)
Share Treasury and Other	15.5	17.0	10.4	8.1
	(35.1)	(37.5)	(14.8)	(33.0)
Share Residential Mortgage	19.9	19.8	20.4	20.5
	(33.4)	(35.4)	(19.5)	(35.9)
Share Other Loan	32.8	32.7	33.8	1.0
	(32.7)	(34.3)	(21.6)	(38.9)
Loss/Asset	9.2	9.1	10.0	4.6
	(4.7)	(4.8)	(4.4)	(6.1)
Uninsured Deposit/MM Asset	24.2	22.7	35.7	19.0
	(14.1)	(12.6)	(15.8)	(26.6)
Insured Deposit Coverage Ratio	4.2	3.9	5.9	15.4
	(32.7)	(30.4)	(36.4)	(115.7)
Observations	4844	4072	743	29

Figure 1: Asset Prices

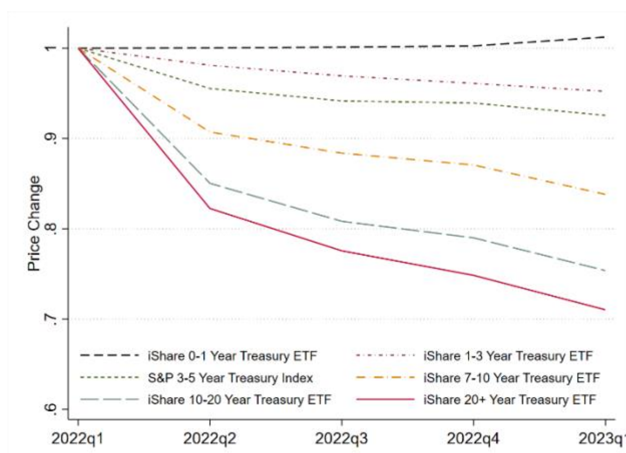
Panel (a) plots the time series of the fed fund rates. Panel (b) plots the changes in the market price of residential mortgage-backed securities (RMBS), commercial mortgage-backed securities (CMBS), and treasuries. RMBS market price is from SPDR Portfolio Mortgage-Backed Bond ETF (SPMB). CMBS market price is from iShares CMBS ETF (CMBS). Treasury market price index is from the S&P U.S. Treasury Bond Index. We calculate the price change since 2022Q1. Panel (c) plots the changes in the market price of treasuries with different maturities. The maturity structure is chosen to match the asset maturity breakdowns in call reports. We use iShares ETFs and S&P Treasury indices. *Data Sources: Various ETF and indices price data as described in the main text.*



(a) Fed Fund Rate



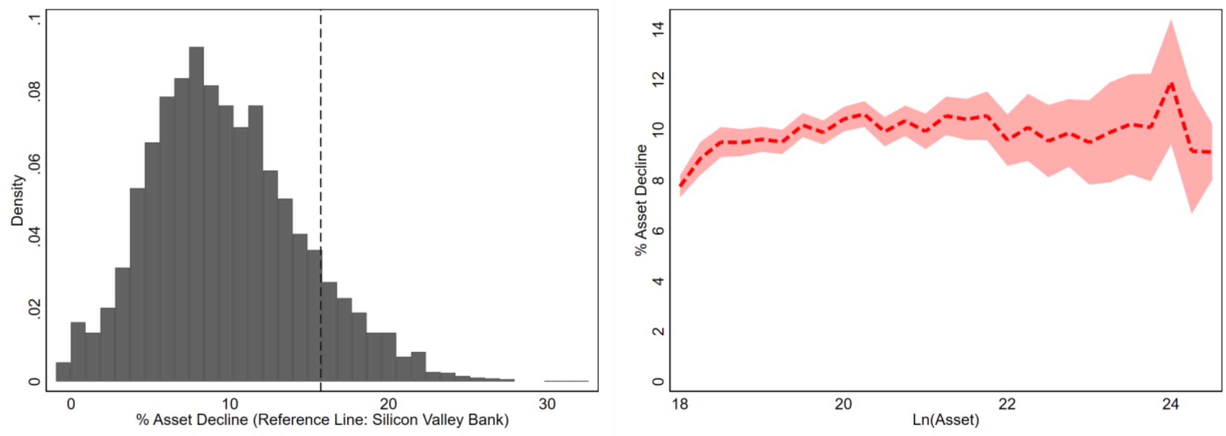
(b) RMBS, CMBS, Treasury



(c) Treasury by Maturity

Figure 2: Distribution of Change in Asset Value ("Marking to Market")

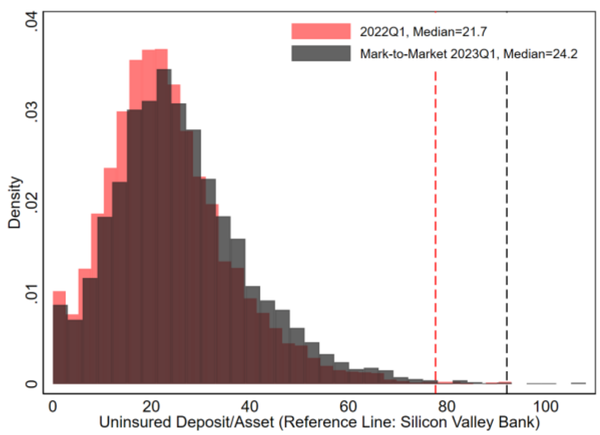
This figure plots the histograms (density) of the percentage of asset value decline when assets are mark-to-market according to market price growth from 2022Q1 to 2023Q1 (Panel a) and bank asset value decline by bank size (Panel b). We describe the steps to find the mark-to-market asset values in the main text. The reference line in Panel (a) indicates Silicon Valley Bank's asset value decline. Silicon Valley Bank's asset value declines by 15.7%, or $34 billion, after their assets are marked to market. The reference line is at 89th percentile. The 5th, 25th, median, 75th, and 95th percentiles in Panel (a) are 4%, 6%, 9%, 13%, and 19%, respectively. In Panel (b), the x-axis is asset value in log terms. The size distribution of the U.S. banking industry has a fat left-tail, meaning that there are many extremely small banks. The largest 50 banks' asset sizes range from $58.9 billion to $3.5 trillion, while the bottom 10 percentiles have asset values less than $68 million. Log assets of 18, 20, 22, and 24 are about $66 million, $485 million, $3.6 billion, and $26 billion. The decline at the right-end starts around log asset value of 24, which is about $26B. *Data Sources*: *Various ETF and indices price data as described in the main text.*



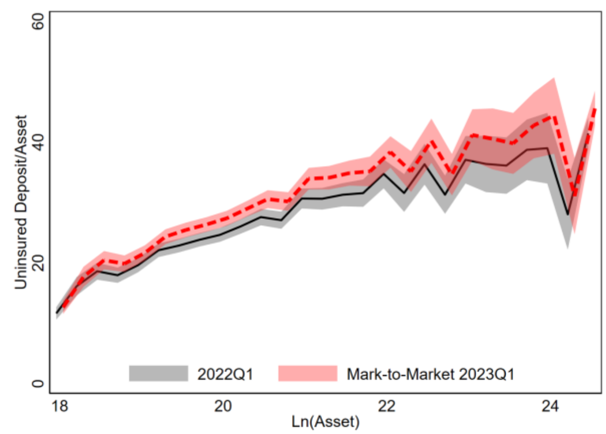
(a) Histogram (b) Asset Decline by Size

Figure 3: Distribution of Uninsured Deposit to Asset Ratio

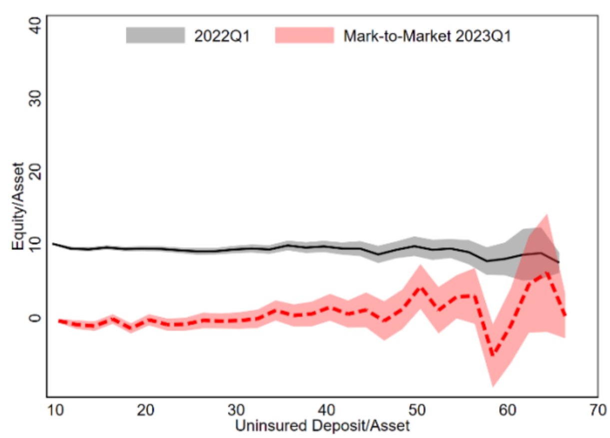
This figure plots the histograms (density) of uninsured deposit to asset ratios calculated based on 2022Q1 balance sheets and mark-to-market values using various ETFs and indices according to the method described in the main text (Panel a) and uninsured deposit ratio against bank size (Panel b). The reference lines in Panel (a) indicate Silicon Valley Bank's values. Silicon Valley Bank's uninsured deposit ratio is 78% based on its 2022Q1 balance sheet, which is about $169 billion. Its uninsured deposit to mark-to-market asset ratio is 92%. Both reference lines are at the 100th percentile. The 5th, 25th, median, 75th, and 95th percentiles of the mark-to-market distribution in Panel (a) are 6%, 17%, 24%, 33%, and 52%, respectively. In Panel (b), the decline at the right-end starts around log asset value of 24, which is about $26B. *Data Sources*: *Various ETF and indices price data as described in the main text.*



(a) Histogram



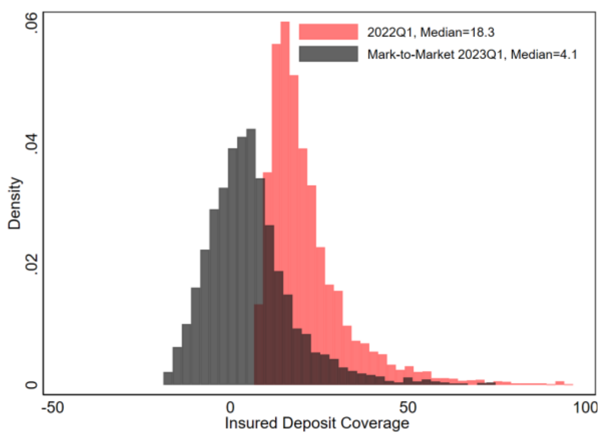
(b) Uninsured Deposit/Asset by Size



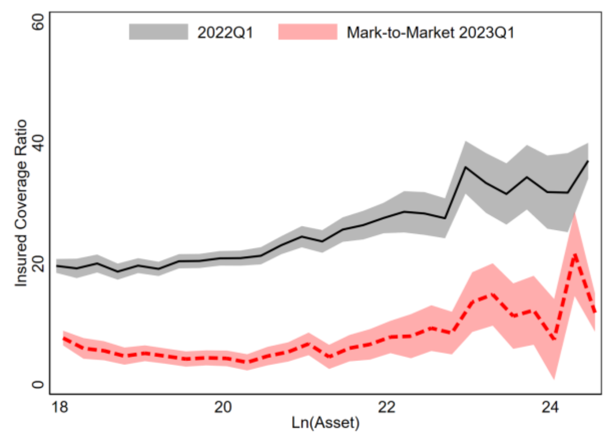
(c) Equity to Asset by Uninsured Deposit Ratio

Figure 4: Distribution of Insured Deposit Coverage Ratio under Different "Run" Scenarios

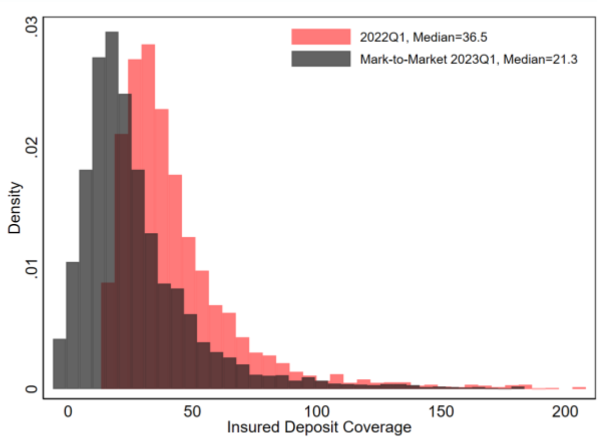
This figure plots the histograms (density) of insured deposit coverage ratio calculated based on 2022Q1 balance sheets and mark-to-market values using various ETFs and indices according to the method described in the main text (Panel a and c) and insured deposit coverage ratio against bank size (Panel b and d). Insured deposit coverage ratio is defined as (mark-to-market asset – uninsured deposit – insured deposit)/insured deposit. A negative value means that the remaining mark-to-market asset value after paying uninsured depositors who withdraw their deposits is not enough to cover all insured deposits. We simulate two scenarios. In scenario 1 (panel a and b), we assume all uninsured depositors run and withdraw their uninsured deposits from banks. In scenario 2 (panel c and d), we assume 50% of uninsured depositors withdraw their uninsured deposits from banks. Silicon Valley bank has a positive insured deposit coverage ratio. Its insured deposit coverage ratio is 5.6% in scenario 1, meaning that the remaining mark-to-market asset value is able to cover all insured deposits, and the remaining asset value is 5.6% of insured deposits after paying uninsured and insured deposits. However, SVB is close to not able to cover all its insured deposits. In Figure A2, we calculate that if the asset fire sale discount more than 0.4%, i.e., the value SVB is able to get by liquidating all its assets is not 100% of the market value, but less than 99.6%, SVB will not be able to cover all of its insured deposits. To make these figures, we remove the outliers by truncating the sample at 98th and 1st percentiles. The 5th, 25th, median, 75th, and 95th percentiles of the mark-to-market distribution in Panel (a) are -12%, -2.5%, 4%, 11%, and 34%, respectively and in Panel (b) are 1.3%, 12.5%, 21%, 36%, and 59%, respectively. Negative values mean that the insured deposits cannot be fully covered by liquidated assets after paying runnable uninsured deposits. For example, -12% means that 12% of total insured deposits will not be able to recover without government intervention. *Data Sources*: *Various ETF and indices price data as described in the main text.*



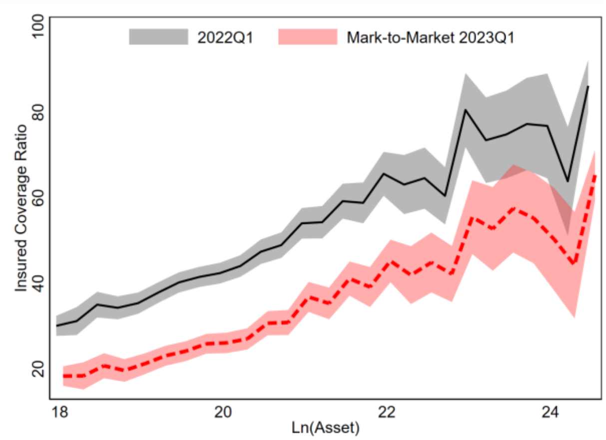
(a) Histogram



(b) Insured Deposit Coverage by Size



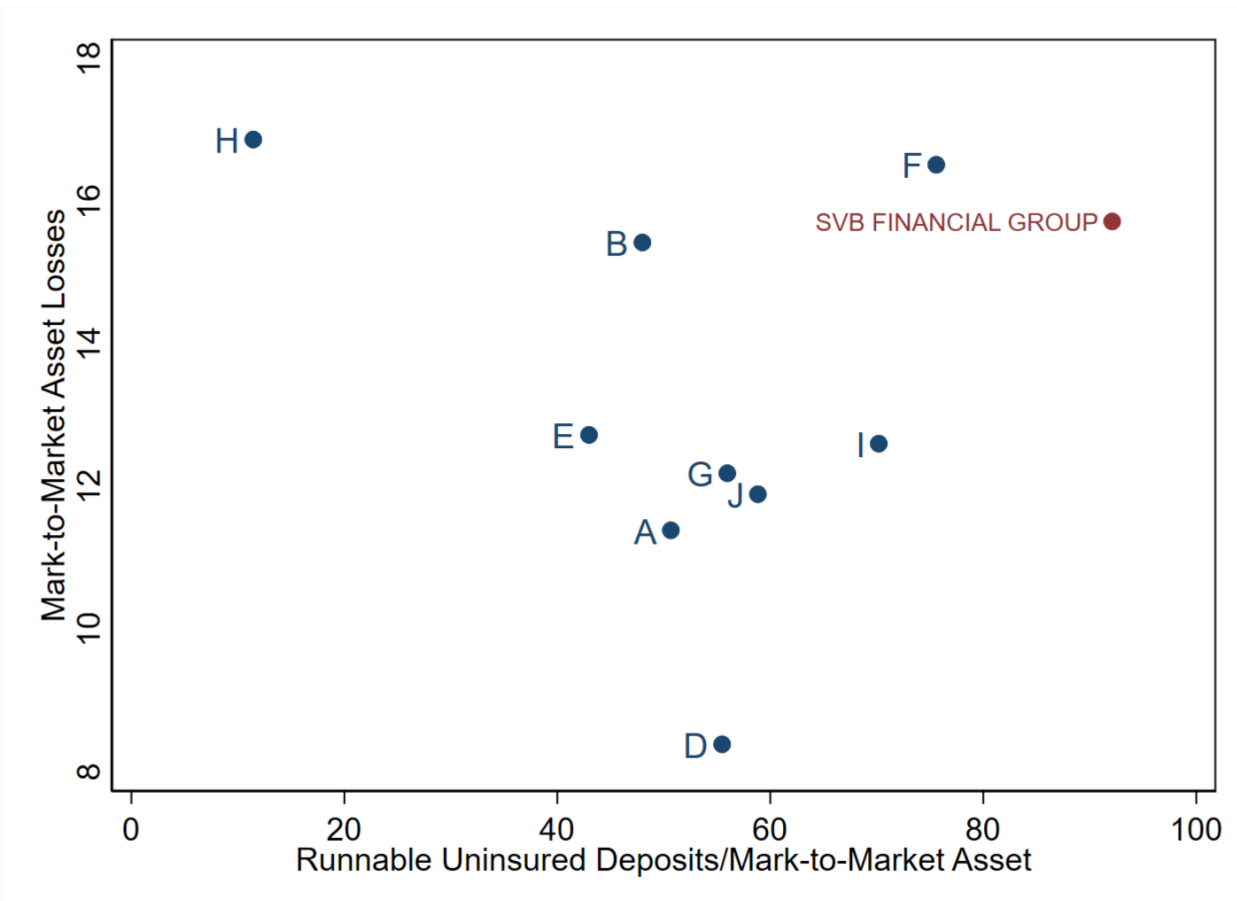
(c) Histogram



(d) Insured Deposit Coverage by Size

Figure 5: Insolvent Institutions if Uninsured Depositors Run

This figure presents the largest 10 insolvent banks in our simulated scenario 1. In this scenario, we assume all uninsured depositors run and withdraw their uninsured deposits from banks. We then calculate the insured deposit coverage ratio for each FDIC-insured bank in the U.S. Insured deposit coverage ratio is defined as (mark-to-market asset – uninsured deposit – insured deposit)/insured deposit. A negative value of this coverage ratio means that the remaining mark-to-market asset value after paying uninsured depositors who withdraw their deposits is not enough to cover all insured deposits. *We then find the sample of banks with negative insured deposit coverage ratio. We define these as insolvent because their market value of assets after paying runnable uninsured deposits will not be able to cover all insured deposits, without government intervention.* We plot the mark-to-market asset losses against the remaining mark-to-market asset value after paying runnable uninsured deposits for the 10 largest insolvent banks. Banks in the top right corner, where Silicon Valley Bank is, have the most severe asset losses and have the largest runnable uninsured depositor base. Among all these banks, 2 of them have asset values of more than $250 billion, 6 of them have asset values of more than $100 billion (and below $250 billion), and all of them have asset values above of $50 billion, the size threshold for stress testing till 2019. Banks are labeled according to their assets as of 2022:Q1 (i.e., A is the largest bank and J is the smallest bank by assets.)



APPENDIX

Table A1: Bank Balance Sheets

This table reports bank asset composition (Panel A) and liability and equity composition (Panel B) as of 2022Q1. In all panels, column 1 reports the statistics of the full sample of banks in the U.S. Column 2 reports the statistics of the subsample of small banks, where small banks are defined as the average total asset size in the two quarters being below $1.384 billion. Column 3 reports the statistics of the subsample of large banks, where large banks are defined as the average total asset size in the two quarters being above $1.384 billion and below $250 billion. Column 4 reports the statistics of the subsample of systemically important banks (GSIB banks). These definitions are based on the Community Reinvestment Act asset size thresholds in 2022 and the size threshold of regulatory stress tests. All numbers are based on sample median. Numbers in parentheses are standard deviations. *Data Sources: Bank Call Reports.*

Panel A: Asset Composition – 2022Q1

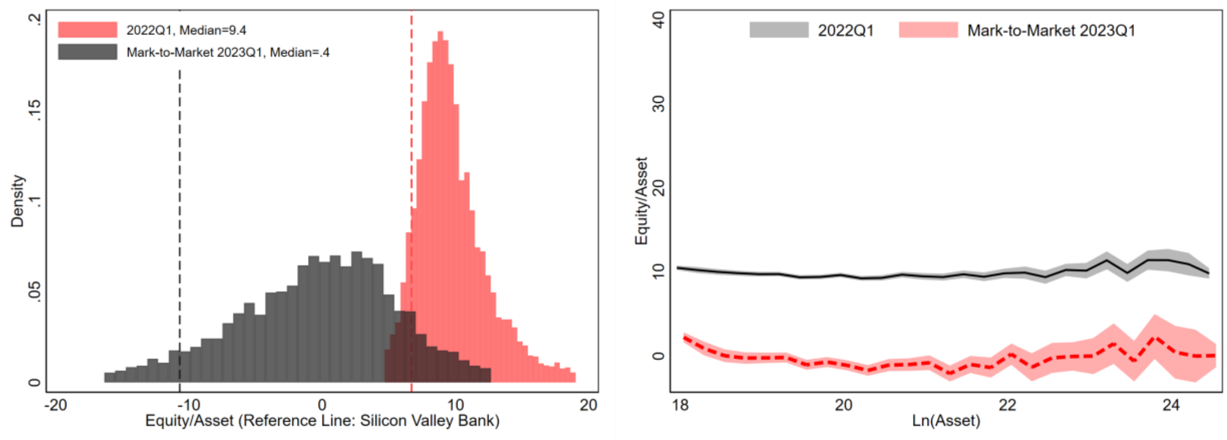
	(1) Total	(2) Small (<1.384B)	(3) Large (1.384B, 250B)	(4) GSIB (>250B)
Total Asset (Billion)	0.3	0.2	2.9	29.6
	(74.7)	(0.3)	(137.1)	(618.3)
Observations	4844	4072	743	29
(Percentage of Asset)				
Cash	10.5	11.0	8.0	26.0
	(12.7)	(12.7)	(9.2)	(32.3)
Security	21.7	22.4	19.5	17.6
	(17.0)	(17.4)	(14.2)	(19.9)
Treasury	0.4	0.4	0.6	1.9
	(6.2)	(6.4)	(4.6)	(10.1)
RMBS	0.7	0.3	5.3	0.0
	(6.5)	(5.7)	(8.4)	(10.0)
CMBS	0.0	0.0	0.8	0.0
	(2.5)	(2.4)	(3.1)	(1.6)
ABS	0.0	0.0	0.5	0.0
	(3.9)	(3.7)	(4.9)	(4.3)
Other Security	11.9	13.8	5.1	0.0
	(14.2)	(14.6)	(8.7)	(8.1)
Total Loan	56.9	55.6	64.0	34.4
	(17.6)	(17.5)	(15.8)	(26.1)
Real Estate Loan	42.4	41.7	45.9	7.0
	(18.0)	(17.7)	(18.1)	(18.3)
Residential Mortgage	13.0	13.3	11.6	3.4
	(13.4)	(13.6)	(12.3)	(17.6)
Commercial Mortgage	1.1	0.8	2.8	0.0
	(4.6)	(3.9)	(7.0)	(1.8)
Other Real Estate Loan	22.9	22.3	27.2	0.0
	(12.8)	(12.6)	(13.0)	(5.5)
Agricultural Loan	0.3	0.6	0.0	0.0
	(5.5)	(5.7)	(3.3)	(0.4)
Commercial & Industrial Loan	5.7	5.5	7.2	0.0
	(6.7)	(6.3)	(8.4)	(4.4)
Consumer Loan	1.3	1.4	0.8	0.0
	(6.3)	(4.9)	(10.9)	(14.8)
Loan to Non-Depository	0.0	0.0	0.0	0.0
	(1.6)	(1.2)	(2.8)	(4.0)
Fed Funds Sold	0.0	0.0	0.0	0.0
	(4.8)	(5.1)	(1.0)	(0.1)
Reverse Repo	0.0	0.0	0.0	0.0
	(1.0)	(0.9)	(1.3)	(3.0)

Panel B: Liability Composition – 2022Q1

	(1) Total	(2) Small (<1.384B)	(3) Large (1.384B, 250B)	(4) GSIB (>250B)
Total Liability	90.6	90.7	90.3	88.8
	(10.5)	(10.6)	(4.9)	(38.4)
Domestic Deposit	88.2	88.5	86.8	78.2
	(12.6)	(12.5)	(9.5)	(39.2)
Insured Deposit	64.9	66.5	53.1	26.6
	(15.4)	(14.3)	(14.7)	(30.4)
Uninsured Deposit	21.8	20.5	32.6	17.2
	(12.9)	(11.6)	(14.4)	(25.2)
Foreign Deposit	0.1	0.0	0.1	0.0
	(10.0)	(5.4)	(10.0)	(11.8)
Fed Fund Purchase	0.0	0.0	0.0	0.0
	(1.1)	(1.1)	(1.3)	(0.1)
Repo	0.0	0.0	0.0	0.0
	(1.5)	(1.4)	(1.6)	(1.0)
Other Liability	1.0	0.9	1.9	4.1
	(4.7)	(4.3)	(6.4)	(7.3)
Total Equity	9.4	9.3	9.7	11.2
	(10.5)	(10.6)	(4.9)	(38.4)
Common Stock	0.1	0.2	0.0	0.1
	(3.0)	(3.1)	(1.2)	(8.0)
Preferred Stock	0.0	0.0	0.0	0.0
	(0.3)	(0.3)	(0.2)	(0.5)
Retained Earning	6.5	6.8	5.4	5.3
	(7.9)	(8.2)	(4.1)	(23.2)

Figure A1: Distribution of Change in Equity Value

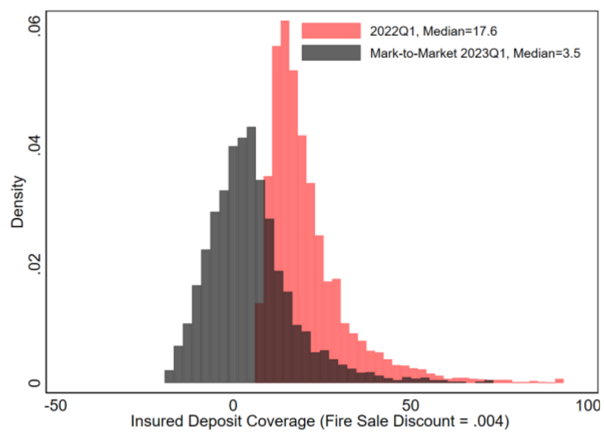
This figure plots the histograms (density) of equity to asset ratio calculated based on 2022Q1 balance sheets and mark-to-market values using various ETFs and indices according to the method described in the main text (Panel a) and equity to asset ratio against bank size (Panel b). The reference lines in Panel (a) indicate Silicon Valley Bank's values. Silicon Valley Bank's equity to asset ratio 6.7% based on its 2022Q1 balance sheet. Its equity to mark-to-market asset ratio is -10.7%. The red and the gray lines are at the 10th and 7th percentiles, respectively. In Panel (b), the decline at the right-end starts around log asset value of 24, which is about $26B. *Data Sources*: *Various ETF and indices price data as described in the main text.*



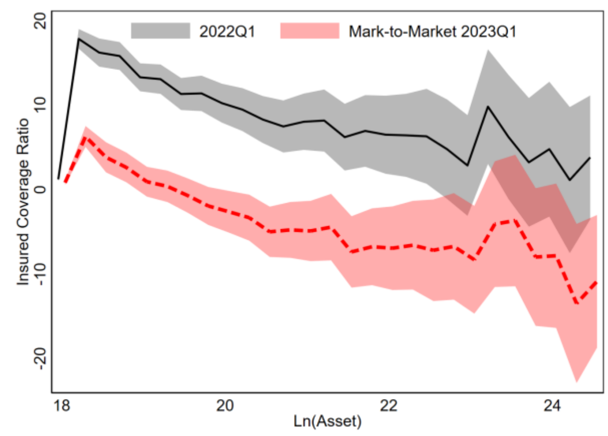
(a) Histogram (b) Equity to Asset by Size

Figure A2: Scenario Analysis - Distribution of Insured Deposit Coverage Ratio

This figure plots the distribution of insured deposit coverage ratio, defined as (mark-to-market asset – uninsured deposit – insured deposit)/insured deposit. We simulate a scenario where there is a fire sale discount such that Silicon Valley Bank starts not being able to pay all insured deposits, i.e., the remaining mark-to-market asset value after paying all runnable uninsured deposits is equal to the insured deposit value. The fire sale discount is assumed to be 0.4%.



(a) Histogram



(b) Insured Deposit Coverage by Size