Deposit Franchise Runs*

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Abstract

We model a new type of bank run, a deposit franchise run. Banks pay below-market rates on deposits, which makes the deposit franchise a valuable asset. For a bank to keep this value, deposits must stay in the bank; if they leave, their value is lost to the bank. This makes the deposit franchise a runnable asset. Unlike Diamond-Dybvig runs, deposit franchise runs can occur even if the bank's loans are fully liquid. Since the deposit franchise value increases with interest rates, a run is more harmful, and hence more likely, when rates are high. To avoid runs, banks can shorten the duration of their assets, but this can make them insolvent if interest rates fall. Avoiding both runs and insolvency requires additional capital in proportion to the value of the uninsured portion of the deposit franchise. We use our model to estimate deposit franchise values and show how to identify vulnerable banks in the context of the 2023 Regional Bank Crisis.

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1 Introduction

In the year leading up to March 2023, the Federal Reserve raised short-term interest rates by nearly 5%. Long-term rates rose by 2.5%. The sharp increase had a big impact on the value of bank assets. Banks held \$17 trillion of long-term loans and securities with an average duration of about four years. The implied loss on these assets was thus $4 \times 0.025 \times \$17 = \$1.7$ trillion. Bank equity stood at \$2.2 trillion, hence these losses had the potential to wipe out most of the capital of the banking sector.

Strikingly, bank investors were unconcerned. The value of bank stocks, shown in Figure 1, held up well and tracked the overall stock market throughout 2022 and early 2023. Bank profits, as captured by their net interest margins, also held up and even rose slightly despite the large maturity mismatch. Evidently, banks had another source of profits supporting their value.

That source of profits was deposits. Deposits are special, as reflected in their rates, which are low and insensitive to market rates. This "low beta" makes deposits much more profitable for banks when interest rates rise. Historically, deposit betas have been about 0.4. As a result, when the Fed raised rates banks went from earning 0% to a $(1 - 0.4) \times 0.05 = 3\%$ spread on deposits. Deposits stood at \$17 trillion, so deposit profits rose by \$510 billion per year. At this rate, it would take banks just over three years to recoup their asset losses with higher deposit profits.

The offsetting impact of interest rates on bank assets and deposits is not a coincidence. Prior work shows that banks use long-term assets to hedge their deposit franchise (Drechsler et al., 2021). This explains the stability of bank stocks in the face of interest rate hikes seen in Figure 1. Yet the figure also shows that something broke in March 2023 when Silicon Valley Bank (SVB) failed. Bank stocks dropped by 20% and stayed down. The deposit franchise hedge turned out to be fragile. Why was it fragile?

In this paper, we argue that the deposit franchise is a runnable asset, and that this creates fragility when interest rates rise. When rates rise, the value of a bank's assets falls while the value of its deposit franchise rises. For the deposit franchise to remain valuable, however, deposits must stay in the bank. If they run, the bank loses the future profits it would have earned on them, and the deposit franchise is destroyed. The bank's asset losses, on the other hand, remain. The loss of the deposit franchise can therefore make the bank insolvent. This justifies the run in the first place. Unlike in traditional bank run models (Diamond and Dybvig, 1983), a run equilibrium arises even if loans are fully liquid. The run is on the deposit franchise itself. We call it a deposit franchise run.

We provide a model of deposit franchise runs and analyze the conditions under which they occur. A representative bank issues deposits and invests in loans and securities with

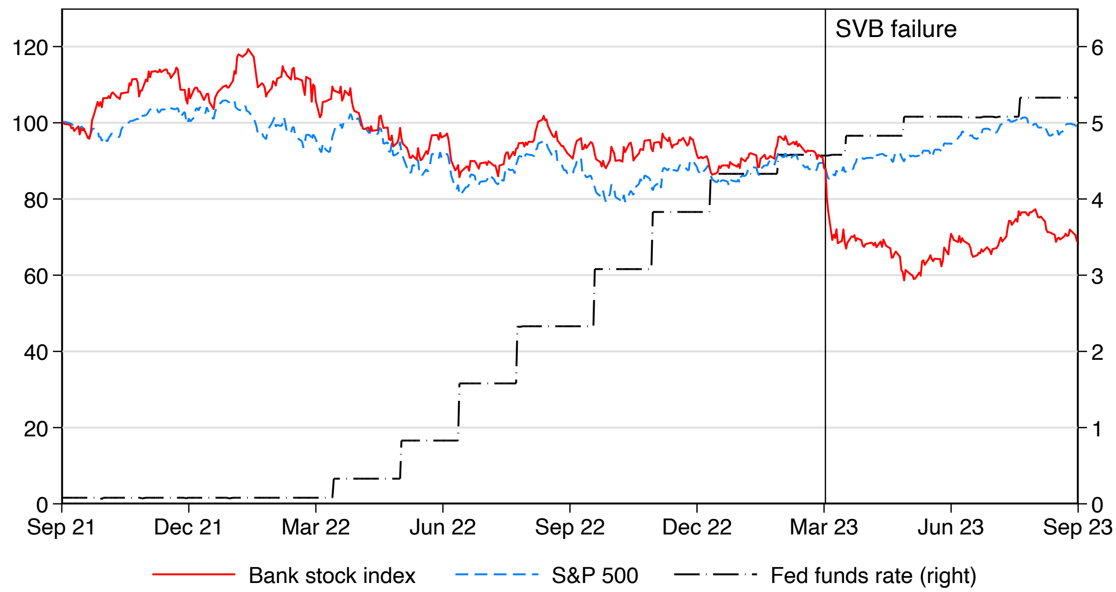

Figure 1: The figure plots the NASDAQ Bank Stock Index (BANK) in red, the S&P500 index in blue dash, and Fed funds rate in black dash-dot (right scale). The bank index and S&P 500 are indexed to 100 in September, 2021. The vertical line marks the failure of Silicon Valley Bank.

a given duration. These assets are fully liquid; there are no fire sales or liquidation costs. The bank has deposit market power, which allows it to pay a deposit rate that is low and insensitive to the market interest rate, i.e. its deposit beta is less than one. The bank thus earns a deposit spread that increases with the market rate. This makes its deposit franchise valuable. The deposit franchise does not come for free: the bank must pay an operating cost to maintain it. The deposit franchise therefore resembles an interest rate swap in which the bank pays fixed (the operating cost) and receives floating (the deposit spread). Like a swap, the deposit franchise has negative duration, at least partly hedging the positive duration of the bank's loans and securities.

Unlike a swap, the deposit franchise is an intangible asset. Depositors are not contractually obligated to pay the bank its deposit spread. They can withdraw at any time, leaving the bank with fewer profits. This lowers the value of the bank's deposit franchise, and by extension its total value. The lower bank value gives the remaining depositors an incentive to run. Specifically, we assume that a fraction of depositors are uninsured. Uninsured depositors take the bank's solvency into account in deciding to stay or run. If they stay, the deposit franchise is valuable and the bank is solvent, which justifies their decision to stay. But if they run, the uninsured portion of the deposit franchise is destroyed. If the loss exceeds the value of the bank's equity, the bank becomes insolvent. This justifies the decision to run. A run equilibrium thus emerges without loan illiquidity.

The runnable asset is the uninsured portion of the deposit franchise.

A unique feature of deposit franchise runs is their sensitivity to interest rates. When interest rates are low, deposit spreads are narrow and the value of the deposit franchise is low. This value would still be lost if a run took place, but that would not make the bank insolvent, and so a run does not take place. In contrast, when interest rates are high, deposit spreads are wide and the value of the deposit franchise is high. Losing the deposit franchise in this case does more harm to the bank's solvency, and this makes a run more likely. This implies that deposit franchise runs, if left unaddressed, create a tradeoff between monetary tightening and financial stability.

To deter a deposit franchise run, the bank must be able to survive one. This means that it must be able to pay off its depositors if they decide to run. Since a run destroys the uninsured deposit franchise, the bank's assets excluding the uninsured deposit franchise must be worth more than its deposits. In particular, the value of its loans and securities must be high enough. This imposes a tighter constraint on the bank than the one it needs to remain solvent absent a run. The wedge between the bank's solvency and "no-run" constraints widens when interest rates rise because its uninsured deposit franchise becomes large relative to the value of its loans and securities.

One way the bank can satisfy its no-run constraint is by setting a short asset duration. This keeps the value of its loans and securities high when interest rates rise, eliminating the run equilibrium. However, setting a short asset duration violates the bank's solvency constraint if interest rates fall instead of rising. Falling rates shrink deposit spreads and depress the value of the deposit franchise. If the bank's loans and securities have a short duration, they will not appreciate enough to offset this. If rates fall sufficiently, the bank becomes unable to cover its operating costs and becomes insolvent, a "zombie bank". Banks thus face a risk management dilemma: if they set a long asset duration they risk runs at high interest rates, but if they set a short asset duration they risk insolvency at low rates.

Escaping the dilemma requires sufficient capital. Higher capital keeps the value of the bank high enough to pay off depositors if interest rates rise. The bank can then set a long asset duration that avoids insolvency if interest rates fall. Our model gives a simple formula for the amount of capital needed: it is given by the highest possible value of the uninsured deposit franchise, $u\left(1-\beta^{U}\right)$, where u is the share of uninsured deposits and β^{U} is their deposit beta. Banks with a lot of uninsured deposits (high u) or highly profitable ones (low β^{U}) need more capital. The formula highlights another unique feature of deposit franchise runs: unlike other types of runs, they are not caused by uninsured deposits per se but by *low-beta* uninsured deposits. Low-beta uninsured deposits thus pose a particular risk to financial stability.[1]

We use our model to estimate banks' deposit franchise values from regulatory data. We first estimate bank-level deposit betas, separately for insured and uninsured deposits, as our model requires. We then estimate deposit operating costs, also separately for insured and uninsured deposits, using a hedonic approach similar to Hanson et al. (2015). We input these estimates into our model to calculate bank-level deposit franchise values as a function of interest rates. We find that deposit franchise values rose sharply, from about 0% of assets in 2021 (prior to the rate hikes) to 11% on the eve of SVB's failure. This increase is about the same as total bank capital.

To see if banks were exposed to deposit franchise runs, we also need to estimate the market value of their assets. We do so using detailed information on their repricing maturity and amortization schedule. We match each asset-by-maturity bin to a corresponding Bloomberg index to recover its market value. We find that asset values fell sharply, by about 8%, as a result of the interest rate hikes. Banks were thus roughly hedged to interest rates absent a run as the gain on their deposit franchise offset the loss on their assets. This explains why bank stocks performed relatively well during this period.

The warning sign in our estimation is that about half the value of the average bank's deposit franchise came from low-beta uninsured deposits. This is still manageable as the average bank had enough capital to cover a loss of that size. However, we find that uninsured deposit franchise values were highly concentrated among a few banks. Specifically, SVB, Signature, and First Republic stand out as big outliers. Each of these banks had both a high share of uninsured deposits and a low uninsured deposit beta. They also had relatively long asset duration. As a result, when interest rates rose, the value of their uninsured deposit franchise became large relative to their capital. This made them exposed to deposit franchise runs, which explains their failure. Our framework is thus able to identify which banks are vulnerable to deposit franchise runs—and which are not.

To validate our model and empirical results, we run an event study around the failure of SVB. The idea is that SVB's failure triggered concerns about other banks. Our model predicts that these concerns should be stronger for banks more at risk of a deposit franchise run. We therefore expect banks with a lot of low-beta uninsured deposits to have lower stock returns during a window around SVB's failure. Our results support this prediction: banks with more uninsured deposits experienced lower returns, but only if their uninsured deposits had a low beta. This finding distinguishes deposit franchise runs from

[1] Almost all of SVB's deposits were uninsured business checking and savings accounts with very low beta. Our model implies that this exposed SVB to a deposit franchise run. In contrast, Citigroup also had a large amount of uninsured deposits but they paid close to the market rate. Citigroup was therefore not exposed. Other banks were not exposed because they had mostly insured deposits. Thus, while SVB is an outlier, it helps to explain why other banks, which had similar mark-to-market losses, did not fail.

other mechanisms such as traditional bank runs.

We conclude by extending the model in three ways. The first recognizes that deposits may flow out for other reasons than runs such as rate-driven outflows as in the deposits channel of monetary policy (Drechsler et al., 2017). In our model, rate-driven outflows reduce the rate at which the deposit franchise appreciates with interest rates, making its duration less negative. We show that this is equivalent to having a higher deposit beta in our baseline model, and provide a formula for the required adjustment. The second extension accounts for credit risk. We show that credit losses can trigger a deposit franchise run, particularly when interest rates are high.

Finally, we consider the implications of our model for setting interest rates. If bank capital is sufficiently high to deter a deposit franchise run, then monetary policy is unconstrained. But if it is not sufficiently high, and if banks' asset duration is long, then interest rate hikes risk triggering runs. If asset duration is short, then interest rate cuts risk making banks insolvent. This reinforces the case for either shrinking the amount of low-beta uninsured deposits or requiring additional capital so that the threat of deposit franchise runs does not impose a constraint on monetary policy.

2 Related Literature

Our paper brings together the literatures on bank runs and bank interest rate risk management. In the canonical model of Diamond and Dybvig (1983), a key pre-condition for runs is that bank loans are illiquid. Illiquidity makes the value of the bank lower if depositors run than if they stay. If it is low enough, a run equilibrium exists (see also Allen and Gale, 1998, 2000; Rochet and Vives, 2004). Egan et al. (2017) use structural estimation to identify run equilibria. Goldstein and Pauzner (2005) recover a unique equilibrium using the theory of global games (Morris and Shin, 2000). Gorton and Winton (2003); Allen and Gale (2009); Royal Swedish Academy of Sciences (2022) provide insightful reviews. Our contribution is to identify a new source of bank runs, the deposit franchise. The value of the deposit franchise inherently depends on whether depositors run or stay. It therefore makes the bank vulnerable to runs whether its loans are liquid or not.[2]

The distinction is important because regulators have sought to prevent runs by requiring banks to hold high quality liquid assets such as Treasury bonds and agency mortgage-backed securities (see Diamond and Kashyap, 2016; Dewatripont and Tirole, 2018). This

[2]There is an interesting connection between deposit franchise runs and the international finance literature on reserve assets (e.g., Farhi and Maggiori, 2017; He et al., 2019). Triffin (1961) warned that persistent U.S. current account deficits would eventually trigger a collapse of the dollar, while Despres et al. (1966) argued that the dollar is implicitly backed by the present value of the liquidity premia on U.S. Treasuries. In this sense, one can think of U.S. debt as the world's uninsured deposit franchise.

type of requirement is ineffective against deposit franchise runs because they can occur even if assets are fully liquid. Hanson et al. (2024) argue that banks should be required to hold short-term liquid assets such as Treasury Bills. In our framework this would prevent deposit franchise runs by raising the value of banks' assets when interest rates rise. However, it would also make banks unhedged to interest rates, which could make them insolvent when interest rates fall.[3] To avoid both runs and insolvency, banks in our framework need a combination of long-term assets and greater capital.

Within the literature on bank risk management (e.g., Freixas and Rochet, 2008; Nagel and Purnanandam, 2020), our paper belongs to the strand that focuses on interest rate risk (Begenau et al., 2015; English et al., 2018; Drechsler et al., 2021; Gomez et al., 2021; Di Tella and Kurlat, 2021; Greenwald et al., 2023; DeMarzo et al., 2024). Closest is Drechsler et al. (2021), which argues that banks invest in long-term assets to hedge the negative duration of their deposit franchise. Drechsler et al. (2021) consider a bank with a fixed deposit base. Our contribution is to incorporate deposit outflows and show that they weaken the deposit franchise hedge. In the case of uninsured depositors, the outflows can cause the hedge to fail and trigger a run. This point is related to Hanson et al. (2015), who argue that deposit insurance enables banks to invest in long-term assets.

Our emphasis on the deposit franchise builds on the large literature on the role of banks as providers of safe and liquid assets (e.g. Gorton and Pennacchi, 1990; Holmström and Tirole, 1998; Kashyap et al., 2002; Stein, 2012; DeAngelo and Stulz, 2015; Krishnamurthy and Vissing-Jorgensen, 2015; Greenwood et al., 2015; Sunderam, 2015; Dang et al., 2017; Moreira and Savov, 2017; Egan et al., 2021). An important theme in this literature is that private liquidity creation is fragile and that this creates scope for regulatory intervention. A distinguishing feature of our framework is that "low-beta" private liquid assets such as uninsured checking and savings accounts pose a particular risk (especially at high interest rates), hence they merit extra regulatory scrutiny.

Our paper is part of the literature inspired by the 2023 Regional Bank Crisis.[4] Jiang et al. (2023) estimate that banks suffered large mark-to-market asset losses (see also Granja, 2023), leading to widespread insolvency and risk of "insolvency runs" among banks with high uninsured leverage. A key difference with our paper is that we account for the value of the deposit franchise, insured and uninsured, and show that it predicts which banks failed and which did not. Haddad et al. (2023) share our focus on the fragility of the deposit franchise but argue that even insured deposits are a source of runs. While the line

[3]This point is related to the literature showing that low interest rates are harmful to bank profitability: Ulate (2021); Abadi et al. (2022); Wang (2022); Wang et al. (2022); Acharya et al. (2022).

[4]On the empirical side, Cookson et al. (2023), Koont et al. (2024), and Caglio et al. (2023) highlight the roles of social media, digital banking, and bank size, respectively, in driving deposit flows during the crisis, while Maingi (2023) uses a spatial model to study the impact of these flows on lending and output.

between "flighty" (i.e., run-prone) and "sleepy" deposits is not clear-cut, there is little evidence of insured depositors running during the Regional Bank Crisis. We also provide an empirical methodology for valuing the deposit franchise and assessing the risks of deposit franchise runs.

3 Model

We model a bank with a deposit franchise. The deposit franchise is the present value of profits the bank earns by paying below-market rates on deposits. The value of the deposit franchise is increasing in interest rates, which makes it a hedge for the bank's long-term loans and securities. However, the deposit franchise is *runnable* because when a deposit is withdrawn the bank loses the profits it would have earned on it. We show that this can lead to a self-fulfilling run among depositors. We call it a "deposit franchise run."

Timing. Time is discrete, $t = 0, 1, \ldots$. The initial interest rate is r. At the end of period $t = 0$, an interest rate shock is realized and the interest rate becomes r'. The shock can be positive or negative. In the baseline model, it is the only shock; in Section 5.2 we introduce other shocks such as credit losses. The interest rate remains r' for all $t \geq 1$.[5]

Deposit base. A bank enters period $t = 0$ with a deposit base D. There are two kinds of deposits, insured deposits D_I and uninsured deposits D_U:

$$D_I = (1-u)\,D, \tag{1}$$
$$D_U = uD, \tag{2}$$

where $u = D_U/D \in [0,1]$ is the bank's uninsured deposit share. As we discuss below, insured and uninsured depositors differ in their response to shocks to the bank's value.

Deposit pricing. The bank sets the interest rate on each type of deposit after the interest rate shock is realized according to a deposit pricing schedule $r_d^i(r')$ for $i = I, U$. We assume linear pricing as in Drechsler et al. (2021):

$$r_d^I\left(r'\right) = \beta^I r' \quad \text{and} \quad r_d^U\left(r'\right) = \beta^U r', \tag{3}$$

[5] The rate r' should be interpreted as a long-term rate. In Appendix C we generalize our model to allow for a rich yield curve.

where $\beta^I, \beta^U \in [0,1]$ are the bank's "deposit betas" on insured and uninsured deposits, respectively.[6] It is convenient to define the bank's overall deposit beta:

$$\beta = (1-u)\beta^I + u\beta^U. \tag{4}$$

The deposit pricing policy is in principle chosen endogenously by the bank, for instance to maximize profits on deposits as in Drechsler et al. (2017). However, since our focus is on the risks the bank faces, we take it as given.

Operating costs. The ability to pay below-market deposit rates ($\beta \leq 1$) does not come for free. The bank must pay operating costs of $c^I, c^U \geq 0$ per dollar of insured and uninsured deposits, respectively, in each period starting with period $t = 1$. Similar to beta, we define the overall operating cost as

$$c = (1-u)c^I + uc^U. \tag{5}$$

We adopt the timing convention that date-t interest expenses and operating costs are paid on outstanding deposits at the end of the previous period, D_{t-1}, whereas withdrawals take place at the end of the current period.

Exogenous outflows. In periods $t \geq 1$, the bank experiences exogenous outflows of both insured and uninsured deposits at a rate $\delta \geq 0$:

$$D_t = (1-\delta) D_{t-1}. \tag{6}$$

Thus, deposits have an average maturity of $1/\delta$. These outflows capture the natural decay of the bank's deposit base.[7]

Bank assets. The bank enters period $t = 0$ with a portfolio of loans and securities whose market value is $A = A(r)$. For tractability, we assume this portfolio is made up of two types of assets: short-term or floating-rate assets that have duration of zero, and long-term fixed-rate assets whose cash flows decline at the rate δ, matching the decay rate of

[6] In practice, banks issue different types of deposits (e.g., checking, savings, time), hence β^I and β^U are the average of the betas across the different products for insured and uninsured deposits, respectively.

[7] Banks in practice can avoid these outflows by expending additional resources to acquire new deposits. The acquisition cost can come in the form of higher non-interest expenses c or a higher β on new accounts. Under free entry, the acquisition cost equals the present value of the expected future profits on the new deposits. The value of the bank is therefore the same whether we value it based on existing deposits that decay at rate δ, or include the net present value of new deposits that keep its deposit base stable.

the bank's deposits. Their date-t cash flow is thus $(1-\delta)^t C_0$, where C_0 is their date-0 cash flow. Their value on date 0 is $C_0/(r+\delta)$.

Let $l = [C_0/(r+\delta)]/A$ be the share of long-term assets and $1-l$ be the share of short-term assets, which trade at par. Then, following the interest rate shock, the value of the bank's assets is

$$A(r') = \frac{C_0}{r'+\delta} + (1-l)A = \left[l\left(\frac{r+\delta}{r'+\delta}\right) + (1-l)\right]A. \tag{7}$$

Hence the dollar duration of the bank's assets at r is

$$T_A \equiv -\left.\frac{\partial A(r')}{\partial r'}\right|_{r'=r} = \frac{lA}{r+\delta}. \tag{8}$$

We first take l, and thus asset duration, as given. By varying l, we can compute comparative statics with respect to asset duration. However, asset duration is a choice of the bank, so we return to this choice in Section 3.3.

Uninsured deposit withdrawals. The key difference between insured and uninsured deposits is that uninsured depositors withdraw if they become concerned about the bank's solvency. To highlight this, we first assume there are no other withdrawals when the interest rate shock hits at $t=0$. Then, in Section 5.1, we allow for "rate-driven" outflows as in the deposits channel of monetary policy (Drechsler et al., 2017).

At the end of $t=0$, after the interest rate shock, uninsured depositors withdraw a fraction $1-\lambda$ of their initial deposits D_U, i.e., the bank is left with uninsured deposits

$$D'_U = \lambda D_U = u\lambda D. \tag{9}$$

Uninsured depositors are sensitive to the value of the bank. Let this value be V and let $v = V/D$ be the value per dollar of deposits. We refer to it as the bank's solvency ratio. We assume that the fraction of uninsured deposits that remain, λ, is a weakly increasing function of v:

$$\lambda = \Lambda(v), \tag{10}$$

where $\Lambda' \geq 0$. When $\lambda = 1$, there is no run and all depositors, insured and uninsured, remain with the bank; when $\lambda = 0$ there is a full uninsured run and only insured depositors remain.

The bank meets its withdrawals by selling assets of equal value. Since there are no other shocks, it does not matter whether the bank sells short- or long-term assets. Unlike

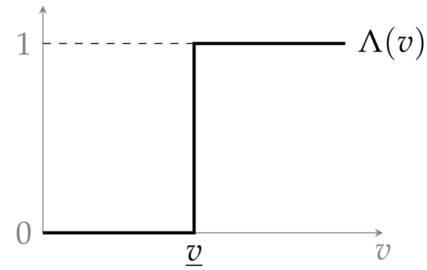

Figure 2: Fraction of remaining depositors $\Lambda(v)$ as a function of the solvency ratio v.

in Diamond and Dybvig (1983) and other bank run models, the bank's assets are fully liquid and selling them is costless.

We work directly with the function Λ and assume a step function around an insolvency threshold $\underline{v}$:

$$\Lambda(v) = \begin{cases} 0 & v < \underline{v} \\ 1 & v \geq \underline{v} \end{cases} \tag{11}$$

A natural threshold is $\underline{v} = 0$, but $\underline{v}$ may be positive, e.g., if uninsured depositors run when the bank is sufficiently distressed even if it is still solvent. It could also be negative, e.g., due to regulatory forbearance. Figure 2 displays the function $\lambda = \Lambda(v)$. When the solvency ratio v is below $\underline{v}$, all uninsured depositors run, $\lambda = 0$ and $D_U' = 0$; whereas when v is above $\underline{v}$ no uninsured depositors run, $\lambda = 1$ and $D_U' = D_U$.[8]

***Remark* 1 (Depositor attentiveness).** Our theory does not require all uninsured depositors to be fully attentive to the bank's value. In general, λ could be an increasing function with a finite slope capturing heterogeneity in depositors' attention to bank fundamentals such as earnings and the stock price. As these fundamentals start falling, the most attentive uninsured depositors notice start withdrawing. This makes fundamentals decline further, triggering withdrawals by depositors with intermediate attention, and so on. The slope of λ should also increase with depositor concentration, social media usage, and access to mobile banking (Cookson et al., 2023; Koont et al., 2023). Our step function corresponds to the conservative case of an extremely concentrated and coordinated uninsured depositor base with access to an almost instantaneous withdrawal technology, as in the case of the business checking and savings accounts at SVB.

***Remark* 2 (Insured vs. uninsured depositors).** Different types of depositors may be best defined in terms of whether they are "flighty", i.e. prone to runs, or "sleepy", i.e. not prone to runs. We map these types to observed characteristics by identifying uninsured

[8]Following the literature on fundamental-based runs (e.g., Rochet and Vives 2004; Goldstein and Pauzner 2005) the model can be extended a step further by deriving the probability of a run as a decreasing function of v, using a richer game with imperfect information among depositors.

depositors as flighty and insured depositors as sleepy. This is reasonable because insured depositors have no incentive to run, whereas uninsured depositors do. While useful, in practice this mapping may not be exact: some uninsured depositors may be sleepy (i.e., they do not monitor the bank's health), while some insured depositors may be flighty (i.e., they question the soundness of deposit insurance). We discuss this issue in the context of our empirical analysis in Section 4.

3.1 Valuing the deposit franchise

The ability to pay below-market rates on deposits makes the deposit franchise a valuable asset. We derive its value and show how it depends on interest rates. We start with the case of the bank as a going-concern, i.e., computing its value without runs. In that case, insured and uninsured deposits behave in the same way, hence we can focus on the overall deposit base D, deposit beta β, and operating cost c.

At a given interest rate r', the value of the bank is

$$V\left(r'\right) = A\left(r'\right) - L\left(r'\right),$$

where $L(r')$ is the market value of the bank's liabilities. This value is the present value of all future cash outlays that the bank has to make for deposit withdrawals, interest expenses, and operating costs:

$$L\left(r'\right) = X_0 + \sum_{t=1}^{\infty} \frac{X_t}{\left(1+r'\right)^t} + \sum_{t=1}^{\infty} \frac{\left(\beta r' + c\right) D_{t-1}}{\left(1+r'\right)^t}, \tag{12}$$

where $X_t = D_{t-1} - D_t$ are outflows in period t. Absent a run, outflows are

$$X_0 = 0, \tag{13}$$

$$X_t = \delta(1-\delta)^{t-1} D \quad \text{for } t \geq 1. \tag{14}$$

The first term in (12) corresponds to date-0 withdrawals, which are zero absent a run, and the second to exogenous withdrawals in periods $t \geq 1$. The third term captures interest expenses and operating costs on the remaining deposits in each period.

It is convenient to decompose the value of the bank as

$$V\left(r'\right) = A\left(r'\right) - D + DF\left(r'\right), \tag{15}$$

where $DF(r')$ is the value of the bank's deposit franchise:

$$DF(r') = D - L(r'). \tag{16}$$

The deposit franchise is an intangible asset that arises from the bank's ability to pay below-market rates on deposits. To see why, consider a bank that pays the market rate ($\beta = 1$) and incurs no operating cost ($c = 0$), e.g., a money market fund. In this case (12) gives $L = D$, hence deposits are worth their book value and the deposit franchise is worth $DF = 0$. The value of the bank is then just $V(r') = A(r') - D$. [9]

In general, the deposit franchise value will not be zero as the present value of the payments the bank makes on its liabilities in (12) does not equal their book value. Our first result derives the value of the deposit franchise in this general case and shows it has negative duration:

Proposition 1 (Deposit Franchise Valuation)**.** *If there are no runs, then the value of the deposit franchise after the interest rate shock is*

$$DF(r') = \left[\frac{(1-\beta)r' - c}{r' + \delta}\right] D. \tag{17}$$

The dollar duration of the deposit franchise prior to the interest rate shock is

$$T_{DF} \equiv -\left.\frac{\partial DF(r')}{\partial r'}\right|_{r'=r} = -\frac{c + (1-\beta)\delta}{(r+\delta)^2} D \leq 0. \tag{18}$$

Equation (17) is a simple valuation equation similar to a Gordon Growth formula. The first term is the deposit franchise value per dollar of deposits and the second term scales it up by the deposit base D. The value per dollar is the net cash flow, $(1-\beta)r' - c$ (the deposit spread net of operating costs), divided by the discount rate r minus the growth rate $-\delta$. The deposit franchise value can be positive or negative, depending on the interest rate r'. It is positive when r' is high enough for the deposit spread to exceed the operating cost, $(1-\beta)r' > c$. Conversely, it becomes negative if rates fall so that $(1-\beta)r' < c$.[10]

Equation (18) shows the dollar duration of the deposit franchise. The deposit franchise has a *negative dollar duration*, i.e., the deposit franchise becomes more valuable when interest rates rise. There are two reasons for this. First, a higher interest rate lowers the

[9]We focus on the role of banks as deposit providers and abstract from the loan franchise value coming from, e.g., monitoring (Diamond, 1984) or relationship lending (Petersen and Rajan, 1994). Implicitly, this value can be incorporated into the asset portfolio, A.

[10]In Appendix C we show how to value the deposit franchise in a richer environment with a yield curve that is not perfectly flat. The deposit franchise can be valuable even if deposit spreads are temporarily below operating costs, as long as long-term yields price in sufficiently higher future spreads.

present value of operating costs c. Second, it raises the present value of deposit spreads $(1-\beta)r'$ as long as $\delta > 0$. This occurs because a higher interest rate r' means that more of the present value of the future spreads $(1-\beta)r'$ is earned in the near future, before the deposit franchise decays significantly. As $\delta \to 0$, which is the case in Drechsler et al. (2021), the deposit franchise becomes infinitely lived and the bank captures the whole present value of the future spreads $1-\beta$ regardless of r'. In this case, the income side of the deposit franchise has zero duration, and the duration of the deposit franchise comes solely from the present value of future operating costs.

Numerical example: We use a numerical example to give a sense of magnitudes. U.S. commercial bank deposits stood at $D = \$17.5$ trillion at the end of 2022. The long-term (10-year) interest rate was $r' = 4\%$, up from $r = 1.5\%$ in 2021. Using the historical average deposit beta $\beta = 0.4$, operating cost $c = 1.2\%$ (see Section 4), and average deposit maturity $1/\delta = 10$ years (e.g., Stanton, 2023), the aggregate value of U.S. banks' deposit franchise was

$$DF\left(r'\right) \;=\; \$1.5 \text{ trillion}, \tag{19}$$

up from $DF(r) = -\$0.45$ trillion in 2021. The increase in the value of banks' deposit franchise is thus comparable to the unrealized losses on their loans and securities. This means that accounting for the deposit franchise has a large impact on the value of banks. We provide a comprehensive valuation at the bank level in Section 4.

3.2 Deposit franchise runs

We now analyze runs by uninsured depositors. This requires decomposing the deposit franchise into an insured and uninsured component:

$$DF\left(\lambda, r'\right) \;=\; DF_I\left(r'\right) + DF_U\left(\lambda, r'\right). \tag{20}$$

The insured and uninsured components have the same form as (17) but with the corresponding deposit base D'_i, deposit beta β^i, and operating cost c^i, $i \in \{I, U\}$. The uninsured component further depends on the fraction of uninsured depositors that remain, λ.

The insured deposit base is unchanged after the interest rate shock, $D'_I = D_I$, while the uninsured deposit base potentially shrinks, $D'_U = \lambda D_U$. The uninsured deposit franchise, if positive, therefore also shrinks:

$$DF_U\left(\lambda, r'\right) \;=\; \lambda DF_U\left(1, r'\right). \tag{21}$$

The risk for the bank is that outflows of uninsured deposits reduce its uninsured deposit franchise value and hence its overall value. This lowers its solvency ratio, which triggers more outflows, and so on, potentially ending in a run. To see how it works, consider the bank's solvency ratio at a given level of outflows:

$$v\left(\lambda, r'\right) \quad = \quad v\left(0, r'\right) + \underbrace{\lambda u\left[\frac{(1-\beta^{U})r' - c^{U}}{r'+\delta}\right]}_{=DF_{U}/D}, \tag{22}$$

where

$$v\left(0, r'\right) \quad = \quad \frac{A(r') - D + DF_{I}(r')}{D} \tag{23}$$

is the solvency ratio if all uninsured depositors withdraw ($\lambda = 0$). Note that it includes the value of the assets because they are fully liquid. It also includes the value of the insured deposit franchise because insured depositors do not run.

The solvency ratio $v\left(\lambda, r'\right)$ is monotone in the fraction of remaining depositors λ: increasing if $DF_U > 0$ and decreasing if $DF_U < 0$. An equilibrium solves a fixed-point problem where the remaining fraction of uninsured depositors $\lambda = \Lambda\left(v\right)$ is justified by the bank's resulting solvency ratio $v\left(\lambda, r'\right)$:

Definition 1 (Equilibrium)**.** Given r' and bank assets $A(r')$, an equilibrium is given by a fraction of remaining depositors λ such that

$$\lambda \quad = \quad \Lambda\left(v\left(\lambda, r'\right)\right). \tag{24}$$

The following result shows that a large uninsured deposit franchise creates the potential for runs, particularly when interest rates are high:

Proposition 2 (Deposit Franchise Runs)**.** *Suppose $\left(1-\beta^{U}\right) r' > c^{U}$, so that the uninsured deposit franchise is valuable. Then:*

(i) If $v\left(0, r'\right) \geq \underline{v}$, then the unique equilibrium is $\lambda = 1$, i.e., there is no run.

(ii) If $v\left(1, r'\right) < \underline{v}$, then the unique equilibrium is $\lambda = 0$, i.e., all uninsured depositors run.

(iii) If $v\left(0, r'\right) < \underline{v} \leq v\left(1, r'\right)$, then there are two possible equilibria, $\lambda = 0$ (run) and $\lambda = 1$ (no run).

Holding fixed the no-run value of the bank, $v\left(1, r'\right)$, a run equilibrium is more likely if the uninsured franchise is more valuable, i.e., if the share of uninsured deposits u is higher, the uninsured beta β^{U} or operating cost c^{U} is lower, or the interest rate r' is higher.

Proposition 2 characterizes the conditions under which a run can occur. A run equilibrium arises when uninsured outflows sufficiently harm the bank's solvency by reducing the value of its deposit franchise. Once solvency falls below the threshold $\underline{v}$, the outflows are justified and the run becomes self-fulfilling. This is different from standard bank run models such as Diamond and Dybvig (1983), where outflows harm solvency due to the costs of early liquidation of the bank's loan portfolio, that can be either technological or due to fire sales. Here, loans are fully liquid and there are no fire sales. Instead it is the deposit franchise itself that is the runnable asset. This distinction is important because it means that a run can occur even if only a single bank is affected, and even if it holds only high-quality liquid assets (HQLA), as SVB did. To highlight the distinction, we refer to this type of run as a *deposit franchise run*.

The destructiveness of a deposit franchise run, and hence its likelihood, increases with the value of the uninsured deposit franchise absent a run, $DF_U(1, r')$. This value is high when uninsured deposits are a large profit center for the bank, either because there are more of them (u is high), or they are more profitable (β^U and c^U are low). Thus, the banks at risk of a deposit franchise run are those with large amounts of uninsured low-beta deposits, which again describes SVB.

We highlight that a deposit franchise run cannot occur if uninsured deposits are high-beta ($\beta^U \approx 1$), as in the case of wholesale funding or money market fund shares. In that case the uninsured deposit franchise earns little or no deposit spread and is not valuable. Hence, outflows do not harm the bank's solvency and a run is not an equilibrium. This isolates the special risk posed by low-beta uninsured deposits rather than uninsured deposits generally. There can still be runs if assets are illiquid, but they cannot be deposit franchise runs.

The value of the uninsured deposit franchise is also increasing in the level of interest rates r'. This makes a run more damaging and hence more likely unless the value of the bank's other assets (its loans and insured deposit franchise) simultaneously rises enough to offset the greater potential loss. If the value of the other assets falls, then the risk of a run increases with interest rates. This aspect of franchise runs is also different from traditional fire sale-driven runs, which have no direct connection to interest rates. Deposit franchise runs are therefore a novel channel by which tighter monetary policy can lead to financial instability.

Figure 3 illustrates the shift that occurs from a unique run-free equilibrium to equilibrium multiplicity when interest rates rise. Holding fixed the going-concern value of the bank, $v(1, r')$, a higher interest rate r' raises the value of the uninsured deposit franchise. This makes the run more harmful, $v(0, r') < v(0, r)$, potentially pushing the bank's solvency below the threshold $\underline{v}$, and making the run self-fulfilling.

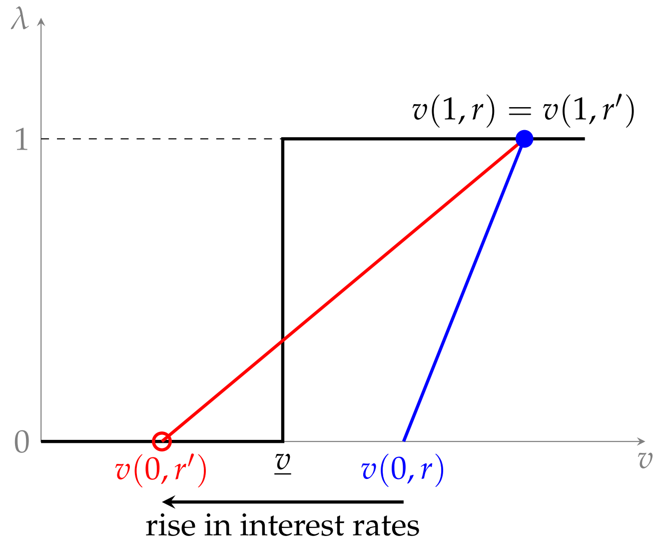

Figure 3: Unique equilibrium (blue dot) at rate r, two equilibria (blue dot and red circle) at higher rate $r' > r$.

Of course, the no-run value of the bank will generally also change with interest rates. The exception is if the bank hedges interest rate risk perfectly as in Drechsler et al. (2021) by setting the positive duration of its assets to exactly offset the negative duration of its deposit franchise. If it instead sets asset duration higher, then its no-run value will have positive duration and fall with r', reinforcing the increased run risk from the uninsured deposit franchise. If it sets asset duration lower, then it will have negative duration and rise with r', mitigating run risk. The following proposition characterizes the impact of interest rates on run risk in this general case:

Proposition 3 (Interest rates and run risk)**.** *Suppose there is no risk of a run prior to the interest rate shock, i.e.,* $\underline{v} \leq v(0,r) \leq v(1,r)$*. Then there are asset duration thresholds* T_A^{Run} *and* T_A^{Insolv}*, and associated interest rate thresholds* r^{Run} *and* r^{Insolv} *such that:*

(i) If the bank's asset duration is $T_A > T_A^{Run}$*, then when* $r' > r^{Run}$ *the bank is exposed to a run equilibrium, i.e.,* $v(0,r') < \underline{v}$*.*

- *however, as long as* $T_A < T_A^{Run} + \frac{(1-\beta^U)u}{r+\delta}$*, there is also a no-run equilibrium, i.e.,* $v(1,r') \geq \underline{v}$ *for* $r' > r^{Run}$*.*

(ii) If the bank's asset duration is $T_A < T_A^{Insolv}$*, then when* $r' < r^{Insolv}$ *the bank becomes insolvent, i.e.,* $v(\lambda,r') \leq \underline{v}$ *in any equilibrium, and* $\lambda < 1$*.*

In setting its asset duration, the bank has to navigate two risks. The first is that if asset duration is too high, $T_A > T_A^{Run}$, the bank opens itself up to runs if interest rates rise sufficiently, $r' > r^{Run}$. The reason is that the value of the bank's asset portfolio falls faster than the value of its insured deposit franchise rises, which makes the *uninsured* franchise account for an increasing fraction of the bank's total value. When this fraction gets high enough ($r' > r^{Run}$), a run leaves the bank insolvent, $v(0, r') < \underline{v}$, and hence a run equilibrium exists.

This is not the only possible equilibrium. As the proposition shows, there is also a no-run equilibrium for a range of asset durations exceeding T_A^{Run}. The reason is that the uninsured deposit franchise pushes up the no-run value of the bank as interest rates rise. This works to offset the bank's asset losses. If the uninsured franchise is large enough and the asset losses small enough, the value of the bank actually rises with interest rates. This preserves the no-run equilibrium even if a run equilibrium emerges. More generally, as interest rates rise the uninsured deposit franchise drives an increasing wedge between the run and no-run values of the bank. This wedge gives rise to multiple equilibria.

The second risk the bank faces, highlighted by (ii) of Proposition (3), is if the bank's asset duration is too low, $T_A < T_A^{Insolv}$, and the interest rate falls sufficiently, $r' < r^{Insolv}$. If this happens the bank becomes insolvent, as its value falls to $\underline{v}$. The reason is that at low rates the value of the deposit franchise falls (insured and uninsured), since deposit spreads shrink while operating costs remain the same. To offset the decreased spread income, the bank requires interest income from its assets. If those assets are short-term or floating-rate, their interest income will also be low and the bank will become insolvent. Rather, the bank needs interest income to remain high enough to cover its operating costs when the interest rate falls. Therefore, a sufficiently high share of the bank's portfolio must be long-term fixed-rate assets. Equivalently, the increase in the value of the bank's long-term assets needs to offset the fall in the value of its deposit franchise, so that its no-run value $v(1, r')$ remains above $\underline{v}$.

Note that when rates are low, there is only a single equilibrium if the bank is solvent, i.e. if $v(1, r') > \underline{v}$. This is the case because the deposit franchise is not valuable, hence a run on the franchise does not damage the bank's value and there is no incentive to run. The fundamental asymmetry underlying this difference is that when rates fall, the bank's value is derived mostly from the gain in its asset portfolio, which can be captured independently of depositors' behavior (since the assets are assumed to be liquid). In contrast, when rates are high the bank's value is derived mostly from earning large deposit spreads, which crucially requires depositors to stay with the bank.

The two thresholds T_A^{Insolv} and T_A^{Run} have natural interpretations (we provide closed-form expressions in the proof of Proposition 3). T_A^{Insolv} is the asset duration that perfectly hedges the no-run value of the bank $v(1, r')$ to interest rates. It corresponds to investing a share

$$l = \frac{(1-\beta)\delta + c}{(1+e)(r+\delta)} \tag{25}$$

of the bank's initial assets A in long-term assets, which hedges the negative duration of the bank's deposit franchise. where $e = \frac{A-D}{D}$. If the bank's long-term holdings share is less than this threshold, it will be unable to meet its operating costs should the interest rate fall sufficiently. The threshold long-term share is higher the larger is the bank's operating cost c, and the lower is its deposit beta (i.e., the more sensitive to the interest rate are its deposit spreads).

On the other side, the bank's asset duration cannot be too large. To prevent a run equilibrium from emerging when rates are high, the bank must set its asset duration less than or equal to T_A^{Run}, which corresponds to a maximum long-term holdings share of

$$l = 1 - \frac{u + \beta^I(1-u) + \underline{v}}{1+e}. \tag{26}$$

The intuition for this expression is that at high rates the value of the bank's long-term assets declines toward zero, so its short-term asset share must be sufficient to (i) pay back the uninsured depositors u if they run, (ii) pay insured depositors their deposit rate (which requires $\beta^I(1-u)$ in short-term assets), and (iii) cover the solvency ratio $\underline{v}$. The remaining asset share, given by (26), is the maximum share that can be invested in long term assets. All else equal, a bank with more uninsured deposits (higher u) must hold less in long-term assets (set a shorter asset duration) to avoid runs.

The long-term asset share that avoids insolvency (25) is generally not equal to the one that avoids runs (26). This creates a risk management dilemma for the bank, which we analyze below.

***Remark* 3 (Cash flow hedging vs. present value hedging).** Drechsler et al. (2021) consider the special case where $\delta = 0$, depositors do not run, and there is a free-entry condition on the initial deposit franchise, $DF(r) = 0$, equivalently $(1-\beta)r = c$. In this case the long-term share that perfectly hedges the bank's going-concern market value $v(1, r')$ to interest rates simplifies to $l = \frac{1-\beta}{1+e}$.

An alternative target often mentioned by banks is a constant net interest margin (NIM), that is, cash flow hedging instead of market value hedging.[11] With a constant operating cost c, this is equivalent to a constant return on assets (ROA). Since a constant stream of cashflows has positive duration, so does a bank that earns a constant ROA. Starting from the perfectly hedged bank, we can obtain the constant-NIM bank by increasing its

[11]The NIM is defined as $\frac{1}{A}\left[(1-l)Ar' + lAr - D\beta r'\right]$.

long-term asset share until the additional fixed interest generated equals the ROA. By construction this additional share is the present value of the ROA, which is given by the bank's market equity (per dollar of assets). With free-entry and $\delta = 0$, equity per dollar of assets is $\frac{e}{1+e}$. Adding this to the long-term share of the perfectly-hedged bank gives $l = 1 - \frac{\beta}{1+e}$, the long-term share of the constant-NIM bank.

Hence, the only difference between the two banks is that the constant-NIM bank invests its equity in long-term assets rather than short-term assets. If $e = 0$, there is no equity, and the two banks are identical. For $e > 0$ the constant-NIM bank's long-term asset share is larger than the perfectly-hedged bank's by the market equity ratio.practice).

***Remark* 4 (Repeated shocks and gradualism.).** Our framework implies that the risk of deposit franchise runs is higher when interest rates rise suddenly than when they do so gradually. A gradual rise in rates allows banks to earn higher deposit spreads in the meantime, helping to recoup their asset losses. If the rise is gradual enough, banks will never enter the run region even if they would have done so if it had been sudden. Our framework thus provides a rationale for monetary policy "gradualism" based on financial stability concerns, similar to Stein and Sunderam (2018). The gradual rise in rates must be unanticipated, however, otherwise long-term rates would rise suddenly on the expectation of higher future short-term rates, which could trigger a run. Deposit franchise runs thus arise from large and sudden increases in long-term interest rates as opposed to gradual ones or high interest rate levels.

***Remark* 5 (Mark-to-market accounting.).** Runs in our model depend on the market value of the bank $v(r')$ (per deposit dollar), inclusive of any "unrealized losses" caused by the interest rate shock. This value differs from $e(r')$, which is the value of the bank's equity using market prices for its assets, but book values for its liabilities. The difference between the book value of deposits (D) and their market value (L) is the value of the deposit franchise, $DF(r')$. Thus:

$$v\left(r'\right) \quad = \quad e\left(r'\right) + \frac{DF\left(r'\right)}{D}. \tag{27}$$

This shows that instituting fair-value accounting for banks' assets requires that accounting also correctly value the deposit franchise. To highlight the importance of this, consider a bank with positive asset duration that is perfectly hedged (i.e., its asset duration equals T_A^{Insolv}), and suppose the interest rate increases ($r' > r$). The value of the bank's assets declines, $e(r') < e(r)$, and will have significant unrealized losses relative to book value. Because the bank is hedged, there is an increase in its deposit franchise, $DF(r') > DF(r)$, which exactly offsets the asset losses, hence its market value is unchanged, $v(r') = v(r)$. Thus, if regulation were to account for unrealized asset losses, it would also need to capitalize the unrealized deposit franchise gains.

3.3 Bank capital and asset choice

Propositions 2 and 3 examine the bank's exposure to deposit franchise runs, taking its asset duration as given. A natural question is how banks should set their duration in light of this exposure. Endogenizing asset duration requires a richer model of the objective function of the bank that specifies, e.g., the costs of financial distress and equity issuance. However, we can highlight the risk management tradeoffs created by the risk of deposit franchise runs without deriving the bank's optimal choice of how to balance these tradeoffs.

Can the bank avoid the risks from both high and low interest rates with an intermediate asset duration? This requires $T_A^{Insolv} \leq T_A^{Run}$ so that the run and insolvency regions do not overlap. If instead $T_A^{Insolv} > T_A^{Run}$, the bank faces a "hedging dilemma"; there is no asset duration that avoids both a run if rates rise and insolvency if rates fall. The following result shows that escaping the hedging dilemma requires additional capital:

Proposition 4 (Bank capital and avoiding the hedging dilemma)**.** *$T_A^{Insolv} \leq T_A^{Run}$, i.e. there is no hedging dilemma, if and only if the bank's initial value is sufficiently high,*

$$v(r) \quad \geq \quad \underline{v} + u\left(1 - \beta^U\right). \tag{28}$$

In this case the bank can choose $T_A \in [T_A^{Insolv}, T_A^{Run}]$ to avoid both a run for any $r' > r$ and insolvency for any $r' < r$.

Proposition 4 shows that unless the bank's initial value $v\left(r\right)$ is high enough above the insolvency threshold $\underline{v}$, there is no asset duration that simultaneously avoids runs at high rates and insolvency at low rates. The natural interpretation is that the bank does not have enough capital. Our model therefore implies that weakly capitalized banks are destabilized by changes in interest rates no matter how they set their asset portfolios.

This is illustrated in Figure 4, which plots the asset durations for which the bank is exposed to either runs or insolvency for different levels of initial bank value $v\left(r\right)$. When bank value is below the threshold in (28), i.e. the bank is weakly capitalized, the run and insolvency risk regions overlap. The bank can either avoid insolvency at low rates by setting $T_A \geq T_A^{Insolv}$ or a run at high rates by setting $T_A \leq T_A^{Run}$. It cannot do both.

Figure 4 further shows that as the bank becomes better capitalized ($v\left(r\right)$ rises), the run risk and insolvency risk regions pull apart. The bank can now satisfy both risk management goals with an intermediate asset duration $T_A \in [T_A^{Insolv}, T_A^{Run}]$. With sufficient capital, the bank has enough assets to cover the loss of its uninsured deposit franchise at high rates even if it has a relatively high duration. In turn, a relatively high duration protects the bank from insolvency at low rates, when its deposit franchise value is low. Capital thus allows the bank to use the quantity of its assets to achieve what it could not with their duration alone.

Importantly, the amount of additional capital the bank needs to escape its risk management dilemma, $u\left(1-\beta^{U}\right)$, depends only on the nature of its uninsured deposit business. If uninsured deposits are a big profit center for the bank, either because they make up a lot of its deposit base (u is high) or are very profitable (β^{U} is low), the bank stands to lose more in a run, and therefore needs a larger capital buffer. This again contrasts with models such as Diamond and Dybvig (1983), where runs are driven by asset-side illiquidity. In these models, any uninsured funding creates run risk, regardless of whether it is low-beta (e.g. corporate checking) or high-beta (e.g. wholesale funding).

***Remark* 6 (Required capital with bounded interest rate shocks).** Proposition 4 provides an extremely simple formula for the amount of capital needed to avoid the risk management dilemma. It relies on the conservative assumption that the bank avoid a run for *any* increase in rates. If we assume instead that r' cannot exceed some upper bound $\bar{r}$, or that the bank raises additional capital whenever $\bar{r}$ is reached, then Propositions 3 and 4 still apply, but with a higher duration threshold T_A^{Run}. The bank can set a higher asset duration without risking a run because the upper bound on r' translates into an upper bound on asset losses and the appreciation of the uninsured deposit franchise. The higher asset duration in turn allows the bank to avoid insolvency at low rates. The condition $T_A^{Insolv} \leq T_A^{Run}$ becomes

$$v\left(r\right) \quad \geq \quad \underline{v}+u\,\frac{(1-\beta^{U})\bar{r}-c^{U}}{\bar{r}+\delta}. \tag{29}$$

The term $u\frac{(1-\beta^{U})\bar{r}-c^{U}}{\bar{r}+\delta}$ is simply the uninsured deposit franchise per dollar of total deposits, and it is bounded above by $u\left(1-\beta^{U}\right)$, the expression that appears in Proposition 4. The generalized condition (29) clarifies that the capital needed to escape the risk management dilemma is the maximal uninsured deposit franchise value that the bank stands to lose in the event of an interest rate shock.

Quantification. Under plausible parameter values, the minimum capital requirement implied by Proposition 4 is significantly higher than what current capital regulation requires. Note that our results should be interpreted as characterizing the additional capital to address risks inherent to the uninsured deposit franchise, over and above the capital required to address the usual credit risk.

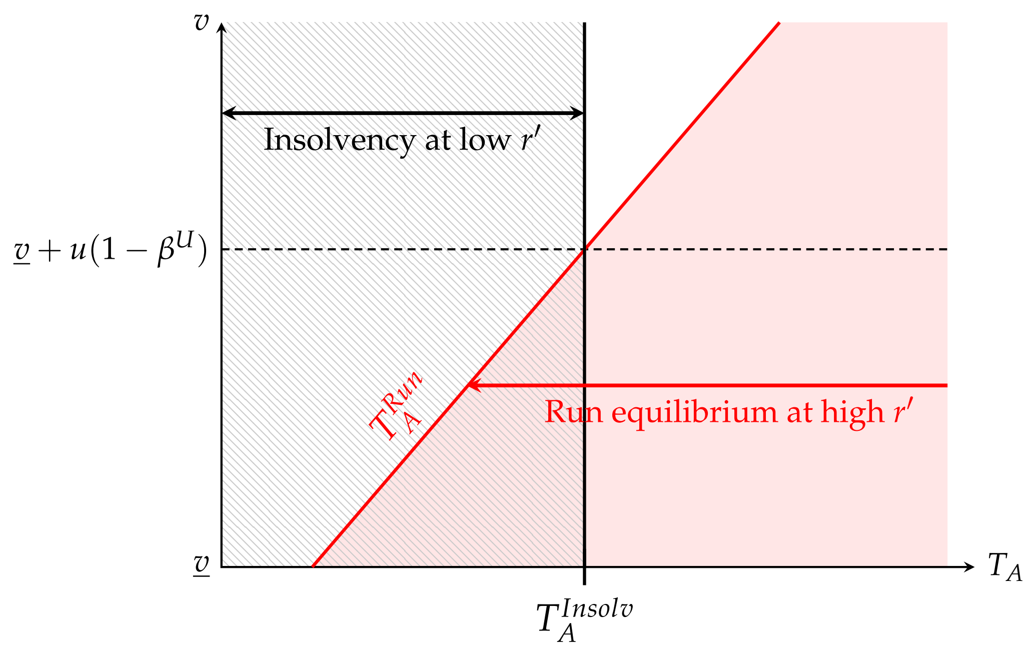

Figure 4: Risk management dilemma for weakly capitalized banks. The figure plots the regions where (i) a run equilibrium exists at a sufficiently high interest rate (red) and (ii) the bank is insolvent at a sufficiently low interest rate (black) as a function of asset maturity T_A and bank value v. The dilemma occurs when $v < \underline{v} + u\left(1-\beta^U\right)$ (dashed line). In that case there is no asset maturity that avoids both run and insolvency risk. Banks with an uninsured deposit franchise ($u > 0$ and $\beta^U < 1$) thus need additional capital of $u\left(1-\beta^U\right)$ to avoid instability.

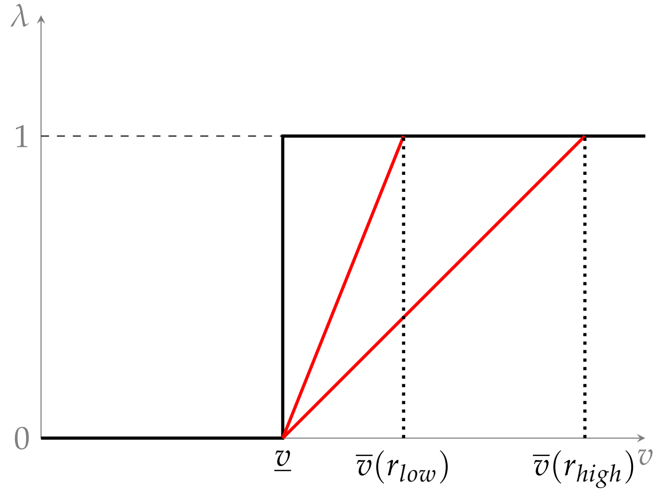

Figure 5: Capital requirement $\bar{v}$ at low rate r_{low} and high rate r_{high}.

Suppose that $\underline{v} = 0$ and we start from a rate r such that the bank breaks even on its deposit franchise, $DF(r) = 0$. Then to avoid the risk management dilemma the bank needs

$$e \geq u\left(1 - \beta^U\right) \tag{30}$$

With an uninsured ratio $u = 50\%$ and an uninsured deposit beta $\beta^U = 0.5$, and reformulating the equity ratio in terms of book equity over assets $\frac{A-D}{A}$ (which is equal to $\frac{e}{1+e}$), we get that the bank needs a 20% book equity ratio.

As explained above, this is a rather conservative estimate that requires the bank to avoid a run for any increase in rates. If instead we assume that the interest rate r' is bounded above by $\bar{r} = 15\%$, and use the generalized formula (29) with a cost $c^U = 1\%$, the required book equity ratio required falls to 12%.

Rate-cyclical capital. Instead of raising enough capital ex ante to protect itself against any interest rate realization, the bank can address its risk management dilemma by raising additional capital as interest rates change. Our model shows how such a capital buffer would depend on interest rates:

Proposition 5. *The minimum solvency ratio $\overline{v}(r')$ that prevents runs at r' is*

$$\overline{v}(r') = \underline{v} + u\,\frac{(1-\beta^U)r' - c^U}{r' + \delta}. \tag{31}$$

It increases with the interest rate r' and the uninsured deposit ratio u and decreases with β^U and

c^U.

Proposition 5 characterizes the level of capital the bank needs to deter runs as a function of the realized interest rate r'. This level is increasing in r' as illustrated in Figure 5.

Implementing $v(r') \geq \overline{v}(r')$ with a capital requirement can be interpreted as attributing a risk-weight to the uninsured deposit franchise. The risk-weight accounts for both cross-sectional differences in u and β^U, and time-series variation in the liquidity risk of each bank as interest rates rise. The behavior of liquidity risk thus yields a new rationale for procyclical capital requirements. Unlike standard arguments, the procyclicality here comes from a pure interest rate effect, not the state of the economy. While we frame the result in terms of a capital requirement, depending on the cost of issuing equity banks may wish to follow this strategy independent of regulation in order to prevent runs.

***Remark* 7 (Raising capital ex ante vs. ex post).** Our previous Proposition 4 describes the ex-ante level of capital that, combined with the correct asset duration, deters runs for any realization of r'. One advantage of raising capital ex ante, before negative shocks are realized, is that raising capital is difficult in times of stress. Incomplete information about bank strength means that going to the equity market is viewed as a signal of weakness. This stigma effect may be dampened, however, if equity issuance is mandated according to a well-understood rule that depends on the aggregate interest rate as in Proposition 5.

4 Empirical analysis

In this section we show how to apply our framework to identify banks' exposures to interest rate risk and deposit franchise runs. Our setting is U.S. banks during the recent rate-hiking cycle, which included the 2023 Regional Bank Crisis.

4.1 Data and sample

Our main data source are the U.S. call reports from June 2015 to December 2023. We restrict the sample to commercial banks with at least $1 billion of assets as of December 2021. We exclude banks without a significant domestic deposit base, specifically broker-dealers, credit cards banks, custodians, foreign-owned banks, and banks with a deposits to assets ratio of less than 65%. This leaves 715 banks.

Column 1 of Table 1 provides summary statistics as of December 2021, on the eve of the hiking cycle. The average bank in our sample has $23 billion in assets, consisting of loans (68%), securities (22%), and cash (5%). Its main source of funding are domestic deposits (85%), 37% of which are uninsured. Its book equity ratio is 9%.

Column 2 breaks out large banks, which we define as those with at least \$100 billion in assets. There are 17 large banks in our sample. Their average assets are \$740 billion, 58% of which are loans, 24% securities, and 8% cash. Large banks also finance themselves primarily with domestic deposits (78%), but with a higher uninsured share (56%). Their equity ratio is also 9%.

The last row of Table 1 reports the average net non-interest expense rate for all banks (1.66%) and large banks (1.1%). We use it to estimate the cost of running a deposit franchise.

We supplement the call reports with data on the stock prices of public banks from CRSP, interest rate data from FRED, and Treasury and MBS index prices from Bloomberg. Additional details are provided in Appendix B.

4.2 Estimation

We implement our framework by estimating bank values on three distinct dates: December 2021, February 2023, and February 2024. December 2021 is the end of the last quarter before the Fed began raising rates. We think of it as the initial date in the model. At the time, the 10-year Treasury yield was $r = 1.52\%$.[12] It rose sharply from there, reaching $r' = 3.92\%$ in February 2023. This is a natural choice for our second date because it immediately precedes the failure of SVB in early March 2023. The third date, February 2024, is one year later and corresponds to $r' = 4.25\%$.[13]

Estimating bank values in our framework requires three separate components: the market value of the bank's assets, the value of its insured deposit franchise, and the value of its uninsured deposit franchise. We need to separate the insured and uninsured franchise values because they behave differently in a run. For this we need to estimate their respective deposit betas and costs. We explain how we do this next.

Deposit betas. The literature (Drechsler et al., 2017, 2021) typically estimates deposit betas from banks' interest expense on deposits. A key challenge we face is that banks do not break out interest expense on insured and uninsured deposits. We develop a two-step estimation procedure to overcome this challenge.

The first step is to estimate each bank's overall deposit beta, as in (4). We do this by simply dividing the change in the bank's deposit rate (deposit interest expense over

[12]Note that valuations depend on long-term rates like the 10-year rate, not short-term rates like the Fed funds rate. See Appendix C for a derivation.

[13]While we have interest rates and asset prices daily, we only have call reports at quarter ends. We therefore use the December 2022 and 2023 call reports for our February 2023 and 2024 valuations, respectively.

deposits) by the change in the Fed funds rate over a given period 0 to t:

$$\beta_{i,t} \;=\; \frac{\text{Deposit Rate}_{i,t} - \text{Deposit Rate}_{i,0}}{\text{Fed Funds Rate}_t - \text{Fed Funds Rate}_0}. \tag{32}$$

For the initial date, December 2021, we take these betas from the previous cycle (December 2015 to June 2019). For the second and third dates (February 2023 and 2024), we take them from December 2021 up to that point in the current cycle.

Since the current cycle is ongoing and deposit rates tend to lag policy rates, the estimated betas for February 2023 and 2024 are likely below the true, forward-looking betas that enter banks' valuations. We address this by scaling them up using survey data on banks' current and expected future deposit betas from the Fed's Senior Financial Officer Survey (see details in Appendix B).

Panel A of Table 2 presents our estimated betas. The average beta in December 2021, which is calculated from the previous hiking cycle, is 0.25 (standard deviation 0.14). The scaled betas for February 2023 are similar with a mean of 0.21 (standard deviation 0.16). Thus, early in the current cycle betas behaved similarly to the previous cycle. The average beta for February 2024, on the other hand, is 0.42 (standard deviation of 0.16). Betas thus increased significantly later in the cycle. A likely explanation is that the previous cycle was slower and shallower than the current one, which allowed banks to keep betas low. By February 2024, the current cycle had turned out to be much steeper and faster, forcing banks to raise their betas.[14]

The second step is to separate the insured and uninsured betas. We do so by assuming that the difference between the insured and uninsured beta is constant across banks. This allows us to identify it from a cross-sectional regression of overall betas on the uninsured deposit share:

$$\beta_i \;=\; \alpha + \gamma \times \text{Uninsured Deposit Share}_i + \epsilon_i, \tag{33}$$

where Uninsured Deposit Share_i is bank i's ratio of uninsured deposits to domestic deposits, averaged over the period during which β_i is estimated. We run this regression separately for each of our three dates.

Figure 7 provides a binscatter plot of the deposit beta against the uninsured deposit share for February 2023 (plots for the other dates look similar). The figure shows a robust positive relationship, indicating that uninsured deposits have significantly higher betas. Panel B of Table 2 reports the regression results. The coefficients are 0.13 in December

[14]Interestingly, the historical average beta over all cycles is about 0.4, very close to the February 2024 estimate (see https://pages.stern.nyu.edu/~pschnabl/data/data_deposit_beta.htm). Thus, after a period of unusually low betas (possibly due to the zero lower bound), betas have reverted to their historical mean.

2021, 0.26 in February 2023, and 0.25 in February 2024, all highly significant. The increase over time is consistent with the fact that betas were compressed during the previous cycle, which is used to compute the December 2021 betas. The magnitudes imply that on average uninsured deposits have betas that are between 0.13 (December 2021) and 0.25–0.26 (February 2023 and 2024) higher than insured deposits.

We use these estimates to back out an insured and uninsured deposit beta for each bank as follows:

$$\beta_i^I = \beta_i - \widehat{\gamma} \times \text{Uninsured Deposit Share}_i \quad (34)$$

$$\beta_i^U = \beta_i^I + \widehat{\gamma}. \quad (35)$$

The implicit assumption is that insured and uninsured betas differ by the same amount, estimated as $\widehat{\gamma}$ in Table 2 Panel B separately for each date. In a final step, we winsorize the betas at the 5%-level to reduce the impact of outliers.

Panel C of Table 2 reports the results. In December 2021, the average insured and uninsured deposit betas are 0.21 and 0.34, respectively. In February 2023, they are similar: 0.11 and 0.37. Then in February 2024 they are higher: 0.33 and 0.58. Thus, early on in the cycle betas behaved as in the previous, shallow cycle. They increased later as the cycle became much steeper. The increase was similar for insured and uninsured betas.[15]

Deposit costs. The next task is to estimate the cost of deposit provision. We cannot measure it directly because the call reports do not break out deposit costs from other expenses. We therefore use a hedonic approach similar to Hanson et al. (2015). We regress banks' net non-interest expense (non-interest expense minus income over assets) on deposits while controlling for other balance sheet items. The coefficient on deposits identifies deposit costs under the identifying assumption that deposits are not correlated with unobserved variables that drive costs independently of deposits.

We focus on core deposit costs, taking out large time deposits, which are a form of wholesale funding. We break up core deposits into three types to capture their cost differences: insured zero-maturity (i.e. checking and savings) deposits, uninsured zero-maturity deposits, and small time deposits. This gives us separate insured and uninsured deposit cost estimates. We also interact deposits with size controls to capture differences

[15]It is plausible that part of the increase in betas is due to the Regional Bank Crisis, which may have "awakened" some depositors. However, from Figure A.3, there is no clear discontinuity or inflection point in betas following that episode. Rather, betas have been rising steadily as rates have risen sharply.

in costs by bank size. Our regressions thus have the form:

$$\text{Net Non-Interest Expense}_{i,t} = \alpha_t + \gamma^j + \sum_{j,k} \beta^{j,k}\, \text{Size}^j_{i,t} \times \text{Deposits}^k_{i,t} + X_{i,t} + \epsilon_{i,t}, \quad (36)$$

where Net Non-Interest Expense$_i$ is bank i's annualized net non-interest expense over assets, α_t are time fixed effects, γ^j are size quartile fixed effects for $j = 1, \ldots, 4$, Size^j are size quartile indicators, Deposits^k are deposits of type k (uninsured zero-maturity deposits, insured zero-maturity deposits, and small time deposits), and X are balance sheet controls. We cluster standard errors at the bank level. We estimate the regression over the previous hiking cycle, from December 2015 to December 2019.

Like Hanson et al. (2015), the balance sheet controls we include are such that the omitted category is a bank that funds itself with wholesale funding (large time deposits and repo) and invests in cash and securities.[16] The cost of running such a bank is absorbed in the size fixed effects γ^j. We expect this cost to be close to zero, which gives us a simple diagnostic for potential misspecification.

Panel A in Table 3 presents the results. Column (1) gives the average cost of core deposits without breaking them up by type or differentiating by bank size. This cost is 1.311% per dollar of deposits. This number is very similar to Hanson et al. (2015), who estimate a cost of 1.3% for checking and savings deposits.

Column (2) splits core deposits into the three types. It finds a cost of 1.130% for uninsured zero-maturity deposits, 1.558% for insured, and 1.535% for small time deposits. Uninsured deposits thus have lower per-dollar costs than insured deposits, which is expected given their larger account sizes.

Column (3) presents the full specification with size interactions. We do not interact uninsured deposits with size because they are concentrated among the largest banks. The cost of uninsured deposits dips slightly to 1.061%. The costs of insured deposits are decreasing in size. Banks in the bottom quartile of our sample have insured zero-maturity deposit costs of 1.602% versus 1.250% for banks in the top quartile. For small time deposits, costs are 1.840% in the bottom quartile and 0.829% in the top quartile. This pattern is consistent with economies of scale in the deposit business.

The last four rows in Column (3) show the size fixed effects. They are all close to zero and statistically insignificant. This is consistent with the prediction that wholesale-funded banks that invest in cash and securities have near-zero costs, and suggests that the regression is reasonably well specified.

[16]The specific controls we use are loans, foreign deposits, other borrowed money, equity, trading assets and liabilities, and other assets and liabilities. Other assets and liabilities are those that exclude deposits, the controls, and the omitted categories of cash, securities, large-time deposits and repo (these are absorbed in the size fixed effects). All items are scaled by assets.

We use the estimates in Panel A in Table 3 to compute bank-level insured and uninsured deposit costs. For each bank, the insured deposit cost is the weighted average of the coefficients in Column (3) on zero-maturity insured deposits and small time deposits for the bank's size quartile, where the weights are the deposit shares. The uninsured deposit cost is a weighted average of the coefficient on uninsured zero-maturity deposits and the cost of large (uninsured) time deposits, which is zero. We also calculate an overall deposit cost as the weighted average of the insured and uninsured costs.

Panel B in Table 3 summarizes the deposit cost estimates. The average cost of insured deposits across all banks is 1.497% with a standard deviation across banks of 0.198%. Insured costs are higher for the smallest quartile (1.647%) than the largest (1.202%). Uninsured deposit costs are 0.933% on average and similar across the size distribution. The average overall cost is 1.296% (again very similar to the Hanson et al., 2015, estimate) and falls to 1.109% for the largest size quartile.[17]

To help validate our methodology, we compare the estimated insured deposit cost with the insured deposit beta across banks. The two are estimated from unrelated outcome variables, hence there is no mechanical relationship between them. Figure 8 shows a binscatter plot of the insured deposit cost against the insured beta across banks. There is a clear negative relationship: deposit costs decline from 1.54% for a beta of 0.1 to 1.44% for a beta of 0.6 (the slope coefficient is -0.194 and highly significant). This supports the view that banks incur higher costs to reduce their deposit betas (Drechsler et al., 2021). Based o

Exogenous outflows. The deposit franchise value depends on the exogenous outflow rate δ, which captures the natural rate of decay of a bank's deposit base. Banks do not disclose their deposit decay rates, hence we rely on estimates from the literature. These estimates differ substantially for both conceptual and measurement reasons. The conceptual reason is that as existing deposits decay, banks incur deposit acquisition costs to replace them (for marketing, promotional pricing, etc.). These costs are difficult to capture because they rise with the profitability of the marginal deposit dollar. To the extent they are not fully captured, a higher decay rate is appropriate. Ellis and Jordan (2001) discuss this issue in detail.

An obvious source of decay rate estimates comes from the OCC's "Interest Rate Risk Statistics Report." The most recent report (Office of the Comptroller of the Currency,

[17] Bank of America is unusual in that it breaks out its non-interest expense and income related to deposits. For 2023, they report $10.477 billion in net non-interest expense on $987.675 billion of deposits (Bank of America, 2023). This gives a per-dollar deposit cost of 1.061%, which is very close to our estimate of 1.109% for large banks in Panel B of Table 3. It is even closer to our point estimate for Bank of America, which is 1.106% at the end of 2023. This helps to validate our deposit cost methodology.

2024) shows an average life of between five and six years for zero-maturity deposits at banks with over $10 billion in assets (similar to our sample). However, Sheehan (2013) argues that the OCC's estimates are too low and finds an average life of about ten years for most types of deposits (Sheehan, 2013, Table 4). This implies an annual decay rate of 10%. Artavanis et al. (2022) also find a 10% decay rate using Greek data. Wilary Winn (2016) and Stanton (2023) are studies by consulting firms that provide advisory services to banks. They also find decay rates of about 10%. Based on this reading of the academic literature and industry practice, we use $\delta = 10\%$ as our baseline rate of exogenous outflows.[18]

Marking assets to market. Banks report the book value of their assets but we need market values for valuation. We estimate them as follows. We first assume that book and market values are the same in December 2021, before the interest rate shock.[19] We then estimate the mark-to-market losses on the assets as interest rates went up.

Banks report the distribution of their assets by repricing maturity bins.[20] We match each bin to a Bloomberg total return index with the nearest maturity. We use Treasury indices for non-real estate assets and MBS indices for real estate assets. This is important because the duration of mortgages is greatly affected by their amortization and prepayment schedules. Using MBS indices for real estate assets accounts for this. The exact indices and how we match them to repricing maturity bins are listed in Appendix B.

We calculate the mark-to-market losses of each bank by multiplying its holdings in a given asset bin as of December 2021 by the percentage change in the matched Bloomberg index from December 2021 to February 2023 and February 2024 (the dates we focus on). We then sum up the losses across bins to get the loss for the whole bank (we assume zero loss on cash). We divide it by the sum of securities, loans, and cash as of December 2021 to convert it to a percentage asset loss.[21]

Table 4 reports summary statistics for the mark-to-market asset losses. The average bank lost 8.22% of assets from December 2021 to February 2023. There is substantial variation in this number, with a standard deviation of 2.41%. Asset losses recover slightly to 7.36% as of February 2024. Large banks incur slightly smaller losses of 6.75% as of February 2023 and 5.98% as of February 2024.[22] These losses are large compared to banks'

[18] In Appendix D we provide robustness using an average deposit life of six years ($\delta = 1/6$), in line with the OCC's "Interest Rate Risk Statistics Report."

[19] To validate this assumption, we take advantage of the fact that banks report market (or "fair") values for their securities portfolios. We find that book and fair values are nearly identical in December 2021.

[20] The repricing maturity of an asset is the time until its interest rate resets.

[21] The implicit assumption is that banks have the same percentage loss on assets whose repricing maturity they do not report. These assets are small, representing only 6.2% of the balance sheet, hence their impact is likely small.

[22] Our losses are similar but slightly smaller than Drechsler et al. (2023) who estimate an aggregate loss

average equity ratio of 9%.

4.3 Results

Deposit franchise values. We plug our bank-level estimates of deposit betas, costs, and outflows into the deposit franchise valuation formula in Proposition 1. We do so separately for the insured and uninsured deposit franchise values. We use the 10-year Treasury rate at each date as the interest rate.[23] We scale deposit franchise values by assets as of December 2021.

The results are summarized in Table 5. Panel A looks at all banks. The average insured deposit franchise (DF_I) is -1.42% of assets in December 2021. The slightly negative value highlights that deposits were not profitable at the time. This is due to the very low 10-year rate, 1.52%, which compresses deposit spreads relative to operating costs.[24] The uninsured deposit franchise (DF_U) is slightly positive, 0.13%, due to its lower operating cost. The combined value, -1.29% is close to zero, hence banks were roughly breaking even on deposits at this time.

Deposit franchise values increase sharply by February 2023 as the 10-year rate reaches 3.92%. This highlights the negative duration of the deposit franchise. The average insured deposit franchise value rises to 7.67%, nearly offsetting the asset losses in Table 4. The uninsured deposit franchise value contributes an additional 3.48%, for a combined deposit franchise value of 11.34%, more than offsetting the asset losses. This number is very large relative to the average equity ratio of 9%, which shows the importance of the deposit franchise for bank valuation.

Deposit franchise values decline to 5.20% (insured) and 1.91% (uninsured) in February 2024. This is due to the substantial increase in deposit betas (see Table 2). The combined deposit franchise remains high, 7.10%, roughly offsetting the asset losses in Table 4.

Panel B of Table 5 shows the results for large banks. The numbers are similar. Large banks slightly lower operating costs, which makes their deposit franchise break even at very low interest rates in December 2021. We estimate that the average large bank's insured and uninsured deposit franchise were each worth -0.02% of assets in December 2021 for a combined franchise value of -0.04%. The insured franchise value rises to 5.64% in February 2023, which is enough to offset 84% of the asset losses in Table 4. The unin-

of 10% and Jiang et al. (2023) who estimate a loss of 9.2% for all banks and 10% for large banks.

[23]While in the model there is a single interest rate and a flat yield curve, in practice the yield curve takes different shapes. In Appendix C we show that the same interest rate is appropriate in the numerator (cash flow) and denominator (discount rate) of our valuation formula regardless of the shape of the yield curve. The 10-year rate is appropriate given our assumption that the maturity of deposits is 10 years ($1/\delta = 10$).

[24]In principle, banks could shut down an unprofitable deposit franchise but this may not fully recoup its cost. We provide such an extension in Appendix G.1.

sured deposit franchise contributes an additional 3.85% for a combined franchise value of 9.49%, more than enough to offset the asset losses. The insured and uninsured deposit franchise values drop to 5.18% and 1.91%, respectively, in February 2024 due to the higher deposit betas. The drop is larger for the uninsured portion because the uninsured betas for large banks increased by more than the insured betas. It is plausible that this is a consequence of the failure of SVB. Nevertheless, large banks' franchise values remain high and offset their asset losses.

An important difference between large banks and all banks is that large banks have more uninsured deposits (56% versus 37%, see Table 1). This makes the uninsured deposit franchise more important in the valuation of large banks. In February 2023, 40% of their deposit franchise value was due to uninsured deposits. Since the uninsured deposit franchise is a runnable asset, large banks were at greater risk of a deposit franchise run. In contrast, the uninsured deposit franchise made up just 30% of the deposit franchise value of all banks, leaving them relatively insulated.

Bank values and deposit franchise runs. We now add up the deposit franchise value estimates and the mark-to-market asset loss estimates to characterize total bank values and the banking system's vulnerability to deposit franchise runs.

We compare three notions of bank value. The first follows the literature and ignores the deposit franchise. It simply marks assets to market and subtracts the book value of deposits: $A(r) - D$. The implicit assumption is that deposits are worth their book value because they can be withdrawn at any time. We measure this value starting from the bank's initial equity ratio in December 2021 and subtracting the mark-to-market asset losses.[25]

The results are in the first row of Table 6, Panel A. The average bank value without the deposit franchise is 10.26% of assets in December 2021. It then drops sharply to 2.03% in February 2023, on the eve of the Regional Bank Crisis, before recovering slightly to 2.91% in February 2024. White the average bank remains solvent under this valuation, there is substantial heterogeneity with a standard deviation of 3.22%. Below the standard deviations, we report the percentage of banks with negative value. It rises from 0% in December 2021 to 26.43% in February 2023 and then falls slightly to 17.10% in February 2024. Thus, over a quarter of banks were insolvent in February 2023 if we ignore their deposit franchise values. A sixth are still insolvent at the end of the sample. This echoes popular concerns about the solvency of the banking system.

[25]We use the book equity ratio primarily because most banks are not public. Banks' market-to-book ratios are on average very close to one though there is significant variation. Market-to-book ratios contain additional information about intangibles such as the deposit franchise, a loan franchise (if any), and implicit government guarantees, which are difficult to separate for our purposes.

Panel B looks at large banks. Their initial value is similar at 9.96%. It also drops sharply to 2.95% in February 2023 and 4.20% in February 2024. These averages again come with substantial heterogeneity: the standard deviations are 2.57% and 1.83%, respectively. Below them, we report the number of large banks with negative value (as opposed to the percentage). It rises from 0 in December 2021 to 2 in February 2023. As we will see below, the two are First Republic and SVB. The number of banks with negative value drops to zero in February 2024 as the these two banks exit the sample.

The precipitous drop in these values from December 2021 to February 2023 is due to the large mark-to-market asset losses we saw in Table 4. These losses average over 80% of equity values. Yet, as we saw in Figure 1, bank stocks did not decline by anywhere near 80% during this period (their decline was on par with the overall market). This suggests that there is more to bank values than marking assets to market. Our model provides an answer for what that is.

There are two notions of bank value in the model, one with a run ($\lambda = 0$) and one without a run ($\lambda = 1$):

$$V(0,r) = A(r) - D + DF_I(r) \quad \text{(Run)} \tag{37}$$

$$V(1,r) = A(r) - D + DF_I(r) + DF_U(1,r) \quad \text{(No run).} \tag{38}$$

In a run, the bank retains its assets (marked to market) net of deposits, $A(r) - D$, because assets are fully liquid. It also retains its insured deposit franchise, $DF_I(r)$, because insured depositors do not run.[26] It loses its uninsured deposit franchise, $DF_U(r)$, because uninsured depositors run.[27]

The second set of estimates in Panel A of Table 6 show the run values, $V(0,r)$, for all banks. They start at 8.84% of assets in December 2021, slightly below the no-franchise value because insured deposits were unprofitable at the time. Importantly, unlike the no-franchise value, the run value does not decline and actually rises to 9.70% in February 2023 before decreasing slightly to 8.10% in February 2024 due to the higher betas. Thus, for the average bank the increase in the value of the insured deposit franchise fully offset

[26] It is possible that some insured depositors run to avoid any inconvenience. In Appendix E we show robustness results if 15% of insured depositors run. This has limited impact because it primarily affects banks with a large insured deposit franchise, which are less at risk of deposit franchise runs.

[27] The assumption that the uninsured deposit franchise is lost in a run is supported by the results of FDIC auctions for failed banks. The FDIC reports that of 20 bids for SVB, 19 offered a 0% "deposit premium" (one offered a 0.5% premium). A deposit premium is paid when an acquiring bank assumes the deposit liabilities of the target for less than their book value. Deposit premiums are very common in bank M&A, averaging 7% of core deposits in 2023 (Stanton, 2023). For robustness, in Appendix F we show results if 15% of uninsured depositors do not run so the bank retains 15% of its uninsured deposit franchise value. This has the expected effect: banks with a large uninsured deposit franchise like SVB, First Republic, and Signature have higher run values though SVB's remains marginally negative.

the asset losses from the rise in interest rates. Panel B shows similar results for large banks: their run values go from 9.94% in December 2021 to 8.60% in February 2023 and 9.38% in February 2024. By this measure, banks were no less solvent on the eve of the Regional Bank Crisis than they were prior to the rate hikes, which helps to explain the behavior of their stock prices.

There is still substantial heterogeneity, but only 0.7% of all banks have negative run values in February 2023 (versus 26.43% when we ignore the deposit franchise). These are the banks exposed to deposit franchise runs according to the model with a solvency threshold of zero ($\underline{v} = 0$). Among the large banks, there is one: SVB.[28] This shows that accounting for the insured deposit franchise has a large impact on the solvency of the banking system.

The final set of estimates in Table 6 look at bank values without a run, $V(1, r)$. No-run values start at 8.97% for all banks and 9.92% for large banks in December 2021. They increase to 13.18% and 12.45%, respectively, in February 2023, before dipping slightly to 10.01% and 11.32% in February 2024. The uninsured deposit franchise therefore forms a large portion of bank values, especially for large banks.

Average bank values mask large differences across banks. Figure 9 shows a binscatter plot of bank values against the uninsured share of deposits. Values ignoring the deposit franchise ($A - D$) are in red, values with the insured deposit franchise ($A - D + DF_I$) are in blue, and values with the insured and uninsured deposit franchise ($A - D + DF_I + DF_U$) are in yellow. Panel A looks at December 2021, before the interest rate shock. Bank values are similar across all three measures and do not vary systematically with the uninsured deposit share. This is because deposit franchise values, both insured and uninsured, were close to zero given the low interest rates. Bank values are also comfortably above zero, indicating solvency.

Panel B looks at February 2023.[29] Bank values ignoring the deposit franchise are now much lower, barely above zero, suggesting widespread insolvency. This is due to the large asset losses from the rise in interest rates. The binscatter is also flat in the uninsured deposits share, which shows that banks with a lot of uninsured deposits had similar asset losses as other banks, i.e. their maturity mismatch was not particularly high.

Adding in the insured deposit franchise raises bank values substantially, and comfortably above zero, but only for banks with few uninsured deposits. For banks with 10% uninsured deposits, bank values rise from less than 2% to 12%, whereas for banks with 80% uninsured deposits they increase only from 3% to just 5%. Thus, banks with few uninsured deposits were just as able to sustain a run as they had been in December 2021,

[28]First Republic and Signature become exposed under a slightly higher threshold of 2% ($\underline{v} = 0.02$).

[29]We leave out February 2024, which looks very similar.

while banks with a lot of uninsured deposits were more vulnerable. For these banks, the monetary tightening led to a much greater risk of failure.

Adding in the uninsured deposit franchise levels out bank values across the uninsured deposit share distribution. These no-run bank values are slightly higher than in December 2021 due to the increased deposit franchise values. However, there is a large wedge between the run and no-run bank values for banks with a lot of uninsured deposits. These banks stood to lose 9 percentage points of value in case of a run, on average. Thus, while banks were hedged to the interest rate shock in the absence of a run, those with a high uninsured deposit share became exposed to a run.

Figure 10 breaks out the results for large banks, plotting their values against their uninsured deposit share in December 2021 (Panel A) and February 2023 (Panel B). Bank values ignoring the deposit franchise ($A - D$) are in red, bank values if there is a run ($A - D + DF_I$) are in blue, and bank values if there is no run ($A - D + DF_I + DF_U$) are in yellow.

From Panel A, bank values cluster around 10% of assets under all measures and flat across the uninsured share distribution in December 2021. This is because the deposit franchise was not valuable at the time due to the lower interest rates. Panel B shows a very different picture in February 2023. Almost all bank values without the deposit franchise are now below 5%, many are close to zero, and two are negative: SVB and First Republic. Nevertheless, the differences across banks by this measure are relatively narrow with many banks potentially at risk.

The differences across banks widen when we add in the insured deposit franchise to compute bank values in a run. Most large banks experience a large increase in value that pushes them back up to around 10%. These banks can survive a deposit franchise run and therefore, according to our model, they are not vulnerable to one. The exceptions to this are SVB, First Republic, and Signature. These three banks see only a small increase in value from adding in the insured deposit franchise. In the case of SVB, its value remains negative. The values of First Republic and Signature are about 2%. All other banks are at 5% or higher. Thus, SVB, First Republic and Signature are uniquely exposed to deposit franchise runs under a solvency threshold of $\underline{v} = 2\%$.[30] SVB is exposed under a solvency threshold of $\underline{v} = 0\%$.

Figure 10 thus shows that our model and estimation procedure accurately identify which banks were exposed to deposit franchise runs on the eve of the Regional Bank Crisis. Equally important, they also identify which banks were *not* exposed. This contrasts with measures that focus solely on asset losses and ignore the deposit franchise, which

[30]This is consistent with Basel III, under which banks with capitalization ratios of less than 3% are considered severely undercapitalized.

tend to over-predict bank failure.

Event study: the Regional Bank Crisis. Our framework can also shed light on changes in bank values during the Regional Bank Crisis in March 2023. If the failure of SVB was a deposit franchise run, then other banks with a large uninsured deposit franchise value should have experienced larger declines in market value during the episode. We can use bank stock prices to test this prediction.

We construct an "SVB beta" for each public bank in our sample. The SVB beta is simply the bank's stock return in a window around the failure of SVB. We use March 6 and March 13, 2013, as the start and end points of the window. March 6 is just before SVB's ill-fated earnings announcement, and March 13 is the Monday after its takeover by the FDIC. Since not all banks in our sample are public, we obtain 171 SVB betas.

Table 7 shows the results of regressing the SVB beta on the uninsured share of deposits, the uninsured deposit beta, and both. Our model predicts that these are the two main ingredients of the uninsured deposit franchise. Banks with a lot of uninsured low-beta deposits have a large uninsured deposit franchise and are therefore more exposed to a deposit franchise run.

Column (1) shows that banks with a larger uninsured share of deposits had a more negative SVB beta. The relationship is strong, with an R^2 of 28% and a constant of zero, implying that banks with no uninsured deposits are predicted to have an SVB beta of zero.

Column (2) adds in the uninsured deposit beta, as well as its interaction with the uninsured deposit share.[31] The reason for the interaction is that according to the model uninsured deposits increase the risk of a deposit franchise run only if they are low-beta deposits.

This is indeed what we find. Summing the stand-alone coefficient on the uninsured deposit share and the interaction coefficient, a bank with an uninsured deposit beta of one has a flat (and in fact increasing) relationship between uninsured deposit share and SVB beta. In contrast, a bank with an uninsured deposit beta of zero has a steeply decreasing relationship. Uninsured deposits thus only matter if they are low-beta, consistent with our model. Relative to column (3), the R^2 is also increased to 35.6%, hence the uninsured beta and its interaction add significant explanatory power.

Column (3) replaces the right-hand variables with the product of the uninsured share and one minus the uninsured beta, $u\left(1-\beta^U\right)$. This is a simplified expression for the value of the uninsured deposit franchise that holds at very high interest rates (see Propo-

[31] We use the December 2021 beta, which is estimated from the previous cycle. The reason is that the February 2023 may already incorporate information about deposit flight.

sition 4). As such, it should predict the SVB beta about as well as the reduced-form interaction regression. We find that this is roughly the case. The R^2 declines slightly (this is not surprising since we are in effect restricting the coefficients) but remains high. The coefficient is large: a bank with uninsured beta of zero and uninsured share of one (a large uninsured deposit franchise) is predicted to have a 63% lower stock return than a bank with either an uninsured beta of one or uninsured share of zero (small uninsured deposit franchise).

Column (4) uses our actual estimate of the uninsured deposit franchise, DF_U. We scale it by the total bank value ($V(1,r)$) to turn it into a percentage loss of value in case of a run. The dependent variable, the SVB beta, is a return, hence it measures the actual percentage loss of value during the crisis. The result shows that banks with a large uninsured deposit franchise had significantly lower returns during the SVB crisis. The coefficient implies that banks on average lost 41.5% of their uninsured deposit franchise values. The R^2 is slightly lower than the reduced-form estimates but still high.

Column (5) adds the insured deposit franchise, DF_I, as an additional control. Unlike the uninsured deposit franchise, the insured deposit franchise comes in with a positive and significant coefficient that roughly offsets the negative constant. Thus, banks with only an insured deposit franchise are predicted to have an SVB return of about zero, whereas banks with only an uninsured deposit franchise are predicted to have an SVB return of -50%.

The opposing signs of the coefficients on the insured and uninsured deposit franchise values show that markets perceived one as a source of stability and the other as a source of instability. This confirms our assumption that uninsured deposits are runnable while insured deposits are not. Overall, the results in Table 7 support the prediction of our model that an uninsured deposit franchise is a source of run risk for banks.

5 Extensions

In this section we consider two extensions of the model that bring it closer to the data. We first allow for "rate-driven" deposit outflows to high-yield alternatives such as money market funds. We then show how exposure to credit risk interacts with interest rates. An important point is that while we focused on interest rate shocks, *any* asset loss can trigger a deposit franchise run.[32]

[32]In Appendix G, we consider three additional extensions: (*i*) we allow for fixed as well as variable operating costs, (*ii*) we study capital requirements that depend on the level of interest rates, and (*iii*) we show how a lender of last resort policy similar to the Fed's Bank Term Funding Program introduced after SVB's failure works in our framework.

5.1 Rate-driven outflows

Our baseline model captures deposit outflows due to runs by uninsured depositors (λ) and the natural decay of the deposit base (δ). In practice banks also experience "rate-driven" outflows, which arise in response to changes in interest rates. When interest rates rise and the opportunity cost of holding deposits (the deposit spread) widens, some depositors reallocate their funds to money market funds and other assets (Drechsler et al., 2017; Xiao, 2020). These rate-driven outflows apply to both insured and uninsured depositors.

We capture them as follows. The bank enters with a deposit base $D_{-1} = D$ as before. Then, at the end of $t = 0$, after the interest rate shock r' is realized, depositors withdraw a fraction $w(r')$, which is increasing in r'. The bank is thus left with deposits

$$D_0 = \left[1 - w\left(r'\right)\right] D. \tag{39}$$

We normalize outflows to zero at the initial interest rate: $w(r) = 0$.[33] Given this, $w'(r) > 0$ is a local measure of rate-driven outflows.

The following proposition generalizes Proposition 1 to the case with rate-driven outflows:

Proposition 6 (Deposit Franchise Valuation with Rate-Driven Outflows)**.** *If there are no runs, then the value of the deposit franchise with rate-driven outflows after the interest rate shock is*

$$DF\left(r'\right) = \left[1 - w\left(r'\right)\right] \left[\frac{(1-\beta) r' - c}{r' + \delta}\right] D. \tag{40}$$

The dollar duration of the deposit franchise with rate-driven outflows before the interest rate shock is

$$T_{DF} \equiv - \left.\frac{\partial DF\left(r'\right)}{\partial r'}\right|_{r'=r} = T_{DF}^{w=0} + w'(r)\, DF^{w=0}(r), \tag{41}$$

where $T_{DF}^{w=0}$ and $DF^{w=0}(r)$ are the duration and deposit franchise values without rate-driven outflows, as in Proposition 1.

Rate-driven outflows shrink the deposit base when interest rates rise. This limits the appreciation of the deposit franchise, making its duration less negative. Intuitively, while deposits are becoming more profitable, there are fewer of them, so total profits and their

[33] Note that $w(r')$ is the reduced-form withdrawal rate, implicitly capturing the bank's deposit pricing policy (see (3)). We discuss how the reduced-form withdrawal rate arises and how our results extend to a nonlinear deposit pricing policy in Appendix G.2 and G.3.

present value rise less. The amount by which it does so is equal to the outflows times the present value of profits per deposit dollar. Under the market power mechanism in Drechsler et al. (2017), total deposit profits still rise, hence the duration of the deposit franchise remains negative. In our reduced-form setting, this requires that rate-driven outflows $w'(r)$ are not too large:

$$\frac{c + (1-\beta)\,\delta}{r+\delta} \;\geq\; w'(r)\,[(1-\beta)\,r - c]\,. \tag{42}$$

This condition says that when rates rise, the bank gains more on the deposits that remain (left side) than it loses on the deposits that leave (right side). Given our estimates of β and w' described below, this condition is easily satisfied in the data.

The prior discussion shows that rate-driven outflows affect the bank in the same way as a higher deposit beta. Whether the bank loses profitable deposits or earns less profit per deposit dollar, the impact on total profits is the same. The model with rate-driven outflows can thus be re-cast as our baseline model without rate-driven outflows but with a higher deposit beta, allowing the rest of our result to go through:

Proposition 7 (Effective Deposit Beta with Rate-Driven Outflows)**.** *For hedging purposes, rate-driven outflows $w'(r) > 0$ are equivalent to assuming $w'(r) = 0$ with an effective deposit beta*

$$\tilde{\beta} \;=\; \beta + w'(r)\,[(1-\beta)\,r - c]\,(1 + r/\delta). \tag{43}$$

The effective deposit beta is higher than the true beta, $\tilde{\beta} > \beta$, if and only if the deposit franchise is valuable, $(1-\beta)\,r > c$.

Proposition 7 shows that when deposits are valuable, a bank facing rate-driven outflows $w'(r)$ should act as if its deposit beta is higher than it really is. The effective beta, $\tilde{\beta}$, captures the loss of profits the bank faces from outflows as interest rates increase. To hedge this loss, the bank has to make sure its assets fall less as interest rates rise, i.e. it needs a shorter asset duration.[34]

Note that the effective beta depends on the interest rate. It tends to be increasing in the interest rate if rate-driven outflows do not diminish too quickly. This means that outflows create negative convexity in the value of the bank's deposit franchise. The convexity has no effect in our single-shock model, but in a dynamic model it would require the

[34] A surprising implication of Proposition 7 is that the impact of outflows reverses sign at low rates. When rates are so low that deposits are unprofitable, $(1-\beta)r < c$, the effective beta is lower than the true beta, $\tilde{\beta} < \beta$, hence hedging with rate-driven outflows calls for *longer* asset duration. In this case outflows benefit the bank by shrinking its unprofitable deposit business. To hedge this increase in value the bank sets a longer asset duration.

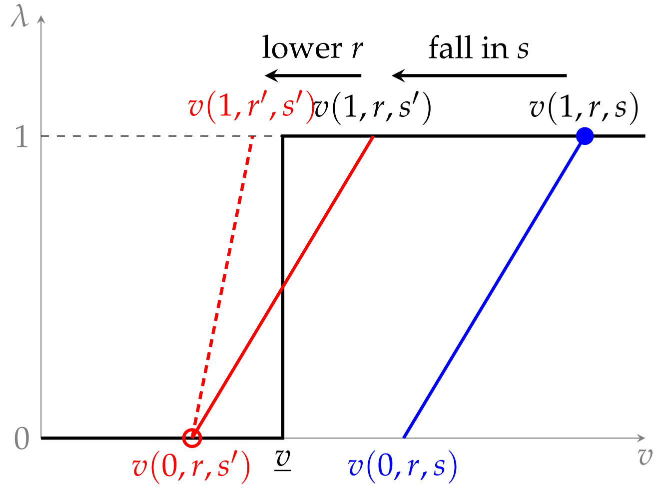

Figure 6: Effect of a shock to asset values $s' < s$ and policy response $r' < r$.

bank's interest rate hedging strategy to be time-varying. Specifically, as the effective beta increases, the bank's duration would need to shorten.[35]

The impact of outflows on the effective beta is particularly stark because we assume that all operating costs are variable. When depositors leave, the bank recoups the costs it would have paid to service them. In Appendix G.1 we introduce fixed costs that still need to be paid even if depositors leave. We show that if the fixed costs are large enough, outflows always shrink asset duration.[36]

The strength of the rate-driven outflows w' can be calibrated using estimates from Drechsler et al. (2017). They show that the typical 400 bps Fed hiking cycle corresponds to a 12% outflow, hence $w' \approx 3$. For an average bank with $\beta = 0.3$, this implies an effective beta of $\tilde{\beta} = 0.35$.[37] In Appendix G.4 we show how the correction $\tilde{\beta}_i - \beta_i$ varies across banks i given the negative relationship between β_i and w'_i documented in Drechsler et al. (2017).

5.2 Deposit franchise runs triggered by credit losses

We have focused on interest rate shocks but banks are also exposed to credit risk. We show that as long as the bank has an uninsured deposit franchise value, any shock to its asset value can trigger a deposit franchise run. Since the deposit franchise is particularly high when interest rates are high, credit losses are more likely to trigger deposit franchise runs in a high-rate environment.

Let s denote the unhedged credit risk shock so that the value of assets is decreasing in s ($\partial A/\partial s < 0$). Suppose that initially only the run-free equilibrium exists and

$$v(1, r, s) = \frac{A(r, s) - D + DF_I(r) + DF_U(1, r)}{D}.$$

In our framework the deposit franchise does not hedge credit shocks because they do not enter into the deposit demand function.[38] This leaves the bank overall unhedged. An adverse shock s triggers a fall in A, and hence lowers bank solvency v. If the fall in v is large enough, some uninsured depositors withdraw ($\lambda < 1$), reducing the value of the deposit franchise DF_U. If the deposit franchise is large, as it is at high interest rates, the fall in its value hurts v further and triggers more withdrawals, and so on. The mechanism is shown in Figure 6. It highlights that credit risk in our framework is amplified by high interest rates.[39]

5.3 Constraints on monetary policy

How should the central bank set interest rates, taking into account the impact on financial stability? Our framework implies that it depends on banks' risk management policy.

If banks hedge their going-concern value against interest rate risks, then an interest rate increase can expose them to deposit franchise runs. Conversely, an interest rate cut makes runs less likely. However, the rate cut does not increase the value of banks in

[35]This complements Greenwald et al. (2023) where the actual deposit beta rises with rates. In Appendix G.3 we allow for variable betas and show that they have the same effect as rate-driven outflows.

[36]It is difficult to know the mix of fixed and variable costs in practice. Some costs, like branches, are relatively fixed while others, like transaction services, are variable. One component of variable costs are regulations like the supplementary leverage ratio (SLR), which led large banks to turn away deposits in 2021 when rates were low and deposits were not profitable (see Bolton et al., 2020).

[37]The numbers for the current hiking cycle are similar. Between March 2022 and May 2023, the Fed funds rate rose by 5% and deposits declined by 9%. This gives $w' \approx 1.8$. Deposit outflows tend to lag, hence w' is likely to increase toward the historical norm.

[38]For large banks that are considered too-big-to-fail, adverse macroeconomic shocks may lead to an inflow of "flight-to-safety" deposits which can be captured through a net outflow function $w(r, s)$.

[39]An interesting extension outside the scope of our model would be to include imperfect and dispersed information about s and other characteristics such as β and w'. In that case, uninsured depositors could even interpret ordinary rate-driven withdrawals as a signal of poor asset quality s.

the no-run equilibrium (asset values rise but deposit franchise value falls). Thus, accommodative monetary policy, for example following credit losses, does not improve bank solvency.

If banks hedge liquidity risk by holding short-term assets, then interest rate cuts actually hurt bank solvency. The reason is that asset values rise less than the amount by which the deposit franchise value shrinks. A rate cut then worsens the impact of a negative credit shock. If the deposit franchise is very valuable, accommodative monetary policy can even make the good equilibrium disappear, as depicted by the dotted red line in Figure 6.

This reinforces the case for capital requirements that allow banks to keep their deposit franchise valuable and hedge interest rate risk based on the good equilibrium (see Section 3.3). When banks have enough capital to do so the central bank can set interest rates without adversely affecting bank health.

6 Conclusion

Banks are in the business of issuing deposits. They earn profits by paying low deposit rates while incurring substantial servicing costs. The net present value of these profits is the value of the deposit franchise. It is an intangible asset that banks must carefully manage. Our paper is about whether it exposes banks to runs.

The deposit franchise is only valuable if deposits remain in the bank. If they leave, the bank loses the stream of profits it would have earned on them and the deposit franchise is destroyed. If the loss exceeds the bank's equity, it gives uninsured depositors a self-fulfilling incentive to run. Unlike in existing models, this type of run can occur even if the bank's loans are fully liquid. We call it a deposit franchise run.

A deposit franchise run is more likely when interest rates are high. This is because the value of the deposit franchise is increasing in interest rates (it has negative duration). To avoid a run, the bank needs the value of its assets to remain sufficiently high as interest rates rise. However, the bank cannot simply shorten the duration of its portfolio to achieve this. The reason is that it needs enough long-term assets to avoid insolvency if interest rates fall. To avoid both runs and insolvency, the bank therefore needs more assets in general, i.e. it needs more capital.

Our model provides a channel by which monetary tightening can lead to financial instability. It arises when banks have a large uninsured deposit franchise, i.e. when they have a lot of low-beta uninsured deposits relative to their capital. This was the case during the recent hiking cycle, which triggered the collapse of Silicon Valley Bank. Our results thus highlight the need to monitor banks' uninsured deposit franchise in order to avoid an adverse tradeoff between monetary policy and financial stability.

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7 Tables

Table 1: **Summary statistics**

This table provides summary statistics for all banks in the sample as of December 2021. The sample is restricted to commercial banks with over $1 billion in assets and deposits over assets of at least 65%. Credit card banks, trusts, foreign banks, and broker dealers are excluded. The data are from the U.S. call reports. Large banks have at least $100 billion in assets. All shares are scaled by assets except the uninsured deposit share, which is scaled by domestic deposits. Standard deviations in parentheses.

	All banks	Large banks
	(1)	(2)
Assets ($ bill)	23.62	740.39
	(180.166)	(940.039)
Loan %	0.68	0.58
	(0.134)	(0.128)
Securities %	0.22	0.24
	(0.126)	(0.098)
Cash %	0.05	0.08
	(0.059)	(0.049)
Equity %	0.09	0.09
	(0.027)	(0.014)
Domestic deposit %	0.85	0.78
	(0.055)	(0.100)
Uninsured %	0.37	0.56
	(0.165)	(0.169)
Net non-interest expense %	1.66	1.10
	(0.732)	(0.281)
Observations	715	17

Table 2: **Deposit betas**

The table presents estimates of deposit betas. Panel A shows average deposit betas in December 2021, February 2023, and February 2024. The December 2021 betas are calculated based on the previous cycle from December 2015 to June 2019. The betas in February 2023 and 2024 are calculated as of that date in the current cycle and scaled up using survey data on expected betas from the Fed's Senior Financial Officer Survey. Panel B shows regressions of the deposit beta on the uninsured share of deposits. Panel C reports summary statistics for the estimated insured and uninsured betas, which are obtained under the assumption that they differ by a constant amount for each bank, obtained from the regression in Panel B. Panels A and C show standard deviations in parentheses.

Panel A: Deposit betas

	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
Deposit beta	0.254	0.213	0.421
	(0.139)	(0.162)	(0.163)
Obs.	710	715	690

Panel B: Regressing beta on the uninsured deposit share

	Deposit beta		
	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
Uninsured Share	0.129***	0.262***	0.252***
	(0.036)	(0.036)	(0.043)
Constant	0.215***	0.114***	0.330***
	(0.012)	(0.015)	(0.017)
Obs.	710	715	690
R^2	0.018	0.069	0.047

Panel C: Insured and uninsured deposit betas

	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
Insured deposit beta	0.211	0.108	0.329
	(0.122)	(0.131)	(0.142)
Uninsured deposit beta	0.341	0.370	0.581
	(0.122)	(0.131)	(0.142)
Obs.	711	715	690

Table 3: **Deposit costs**

The table presents regressions of net non-interest expense on bank characteristics, which we use to estimate deposit costs. Net non-interest expense is non-interest interest expense minus non-interest income divided by assets. Core deposits are checking, savings, and small time deposits over assets. Uninsured zero-maturity (ZM) deposits are uninsured checking and savings deposits. Insured zero-maturity (ZM) deposits are insured checking and savings deposits. Size controls and interactions use quartile splits. All columns control for time fixed effects and the asset shares of loans, foreign deposits, other borrowed money, equity, trading assets, trading liabilities, other assets (assets net of cash, reverse repo, securities, loans, and trading assets), and other liabilities (assets net of deposits, repo, trading liabilities, other borrowed money, and equity). The omitted categories are large time deposits, fed funds and repo on the liabilities side and cash and securities on the asset side. The sample is from 2015q4 to 2019q4.

Panel A: Deposit cost estimation

	Net non-interest expense %					
	(1)		(2)		(3)	
Core dep %	1.311***	(0.425)				
Uninsured ZM dep %			1.130**	(0.502)	1.061**	(0.489)
Insured ZM dep %			1.558***	(0.439)		
Small time dep %			1.535**	(0.750)		
Insured ZM dep % × Size						
1					1.602***	(0.521)
2					1.407***	(0.531)
3					1.770***	(0.537)
4					1.250**	(0.532)
Small time dep % × Size						
1					1.840**	(0.781)
2					1.659	(1.134)
3					1.208*	(0.713)
4					0.829	(0.712)
Size						
1	−0.044	(0.365)	−0.121	(0.403)	−0.175	(0.428)
2	−0.080	(0.049)	−0.084*	(0.048)	0.031	(0.236)
3	−0.272***	(0.054)	−0.269***	(0.055)	−0.241	(0.356)
4	−0.415***	(0.062)	−0.384***	(0.068)	−0.103	(0.240)
Controls	Yes		Yes		Yes	
Time FE	Yes		Yes		Yes	
Obs.	12.023		12.023		12.023	
R^2	0.199		0.204		0.207	

Table 3: **Deposit costs (cont.)**

Panel B: Insured and uninsured deposit costs

	Insured	Uninsured	Overall
	(1)	(2)	(3)
All Banks	1.497	0.933	1.296
	(0.198)	(0.152)	(0.155)
Size			
1	1.647	0.926	1.397
	(0.030)	(0.132)	(0.092)
2	1.452	0.898	1.261
	(0.034)	(0.205)	(0.084)
3	1.687	0.923	1.415
	(0.065)	(0.140)	(0.129)
4	1.202	0.985	1.109
	(0.044)	(0.095)	(0.053)

Table 4: **Mark-to-market asset losses**

The table presents summary statistics for the mark-to-market asset losses for all banks and large banks. Asset losses are calculated using matched Bloomberg indices by asset class and repricing maturity. They are reported as a percentage of December 2021 asset values. Standard deviations in parentheses.

	All banks			Large banks		
	Dec 2021	Feb 2023	Feb 2024	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)	(4)	(5)	(6)
Asset loss	0.00	8.22	7.36	0.00	6.75	5.98
	(0.00)	(2.41)	(2.38)	(0.00)	(1.84)	(1.42)
Obs.	717	715	690	17	17	14

Table 5: **Deposit franchise values**

The table reports our estimates of deposit franchise values. Panel A is for all banks in our sample and Panel B is for large banks. Deposit franchise values are calculated using the formula in Proposition 1 and our empirical estimates of deposit betas, costs, and the exogenous outflow rate (see Tables 2 and 3). We report the values of the insured and uninsured deposit franchise separately, as well as their sum at each of the three dates, December 2021, February 2023, and February 2024. Deposit franchise values are scaled relative to assets. Standard deviations in parentheses.

Panel A: All banks

	All banks		
Deposit Franchise Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
DF_I (Insured)	-1.42	7.67	5.20
	(1.30)	(2.82)	(2.52)
DF_U (Uninsured)	0.13	3.48	1.91
	(0.62)	(1.96)	(1.48)
$DF_I + DF_U$ (Total)	-1.29	11.14	7.10
	(1.60)	(3.26)	(3.45)
Obs.	717	715	690

Panel B: Large banks

	Large banks		
Deposit Franchise Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
DF_I (Insured)	-0.02	5.64	5.18
	(0.29)	(2.75)	(1.74)
DF_U (Uninsured)	-0.02	3.85	1.94
	(0.59)	(1.34)	(0.83)
$DF_I + DF_U$ (Total)	-0.04	9.49	7.12
	(0.81)	(3.39)	(2.44)
Obs.	17	17	14

Table 6: **Bank values**

The table reports our estimates of bank values. Panel A is for all banks and Panel B is for large banks. The first row is without the deposit franchise. Assets are marked to market using matched Bloomberg indices by asset class and repricing maturity. The second row is the bank value if a deposit franchise run occurs, $V(0,r) = A - D + DF_I$. The third value is if there is no run, $V(1,r) = A - D + DF_I + DF_U$. Deposit franchise values are calculated using the formula in Proposition 1 and our empirical estimates of deposit betas, costs, and the exogenous outflow rate (see Tables 2 and 3). Bank values are reported on three dates, Dec 2021, Feb 2023, and Feb 2024. Bank values are scaled relative to assets. Standard deviations in parentheses; % and # ≤ 0 are the percentage and number of banks with non-positive value, respectively.

Panel A: All banks

	All banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	10.26	2.03	2.91
	(2.08)	(3.22)	(3.22)
% ≤ 0	0.00	26.43	17.10
$V(0,r) = A - D + DF_I$ (Run)	8.84	9.70	8.10
	(2.40)	(3.78)	(3.57)
% ≤ 0	0.00	0.70	1.16
$V(1,r) = A - D + DF_I + DF_U$ (No run)	8.97	13.18	10.01
	(2.52)	(4.01)	(4.02)
% ≤ 0	0.00	0.14	0.72
Obs.	717	715	690

Panel B: Large banks

	Large banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	9.96	2.95	4.20
	(1.68)	(2.57)	(1.83)
# ≤ 0	0	2	0
$V(0,r) = A - D + DF_I$ (Run)	9.94	8.60	9.38
	(1.66)	(4.31)	(2.37)
# ≤ 0	0	1	0
$V(1,r) = A - D + DF_I + DF_U$ (No run)	9.92	12.45	11.32
	(1.65)	(4.51)	(2.88)
# ≤ 0	0	0	0
Obs.	17	17	14

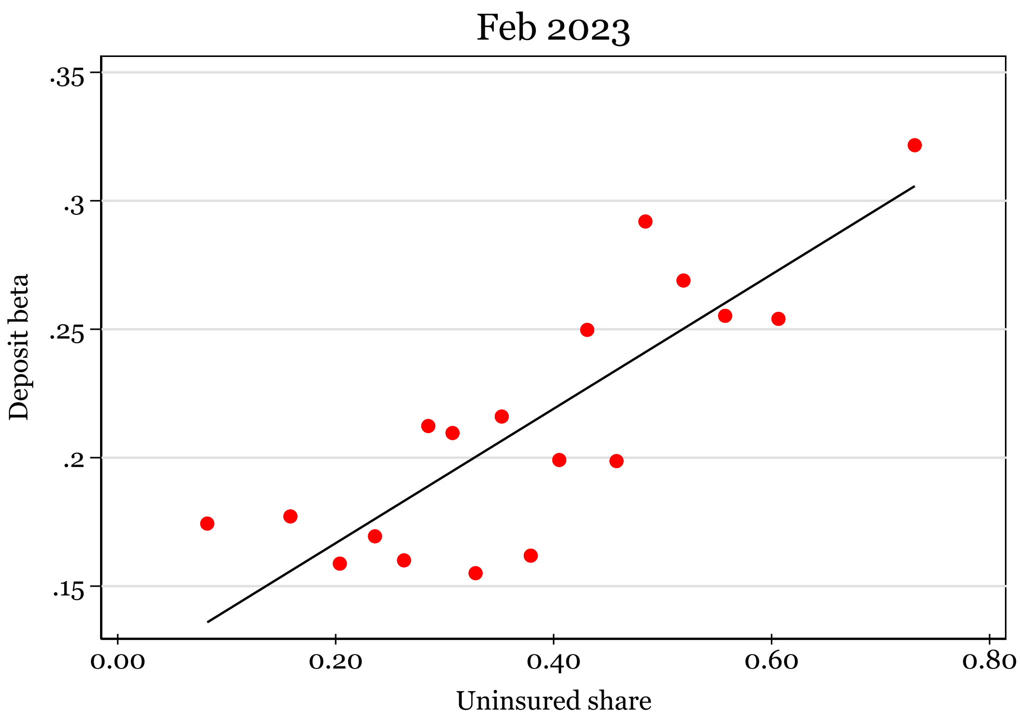
Table 7: **Regional Bank Crisis event study**

The table shows regression results of SVB betas (a bank's SVB beta is its stock return during the SVB crisis, from March 6 to March 13, 2023) on uninsured deposits shares, uninsured deposit betas, and deposit franchise values. The uninsured deposit beta is measured during the previous cycle from 2015 to 2019. Column 3 replaces the variables with the product of the uninsured deposit share and one minus the uninsured deposit beta, as implied by Proposition 4. Column 4 replaces the variables with the uninsured deposit franchise in February 2023, scaled by the total bank value. Column 5 adds the insured deposit franchise in February 2023, also scaled by total bank value.

	SVB beta				
	(1)	(2)	(3)	(4)	(5)
Uninsured share	−0.449***	−1.097***			
	(0.055)	(0.157)			
Uninsured beta 2019		−0.740***			
		(0.199)			
Unins beta × Unins share		1.834***			
		(0.422)			
(1 − Unins beta) × Unins share			−0.636***		
			(0.077)		
Uninsured deposit franchise				−0.415***	−0.393***
				(0.059)	(0.060)
Insured deposit franchise					0.105**
					(0.049)
Constant	0.001	0.260***	−0.015	−0.081***	−0.144***
	(0.025)	(0.072)	(0.023)	(0.018)	(0.034)
Obs.	171	171	171	171	171
R^2	0.280	0.356	0.286	0.225	0.246

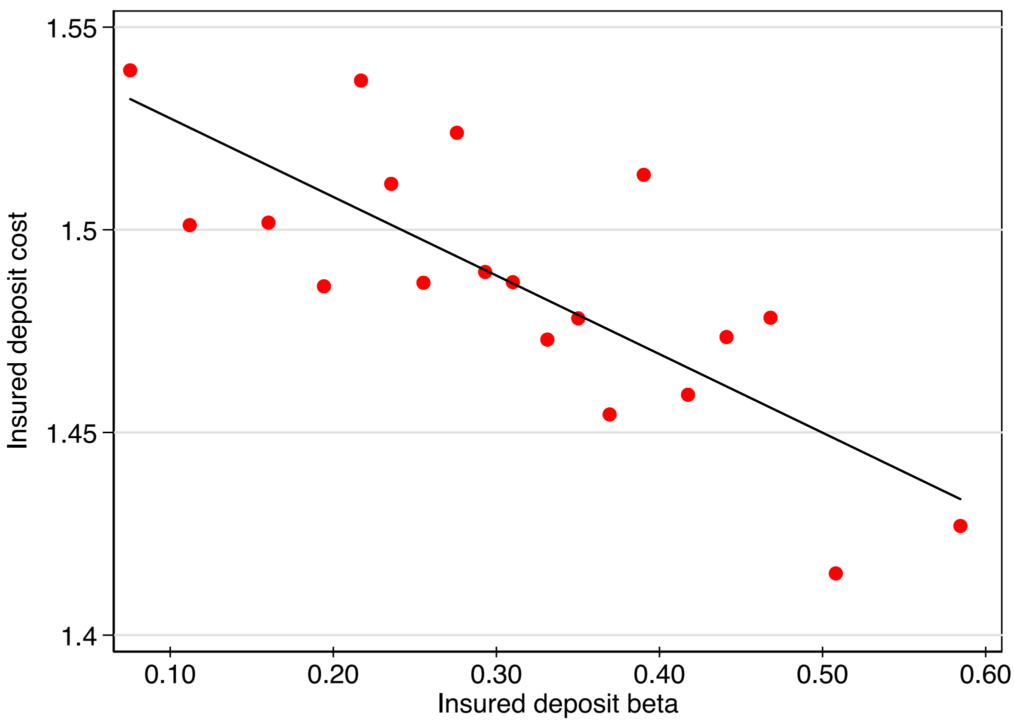
8 Figures

Figure 7: Deposit beta and the uninsured deposit share



The figure shows a binscatter plot of the relationship between deposit betas and the uninsured share of deposits as of February 2023.

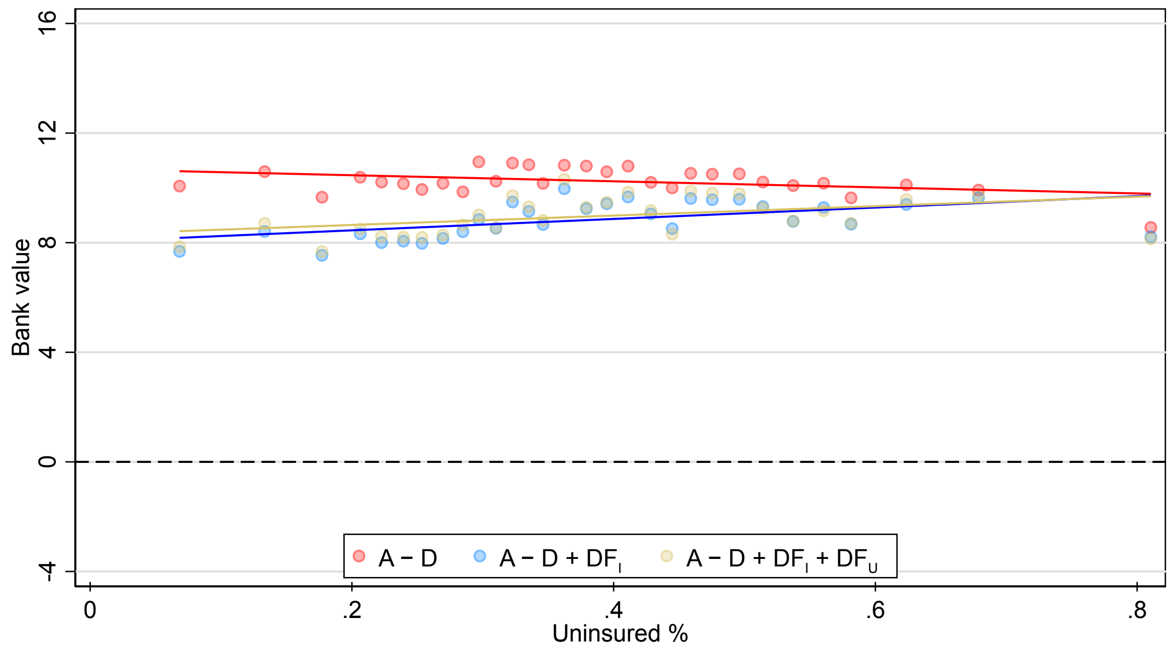
Figure 8: **Deposit costs and betas**



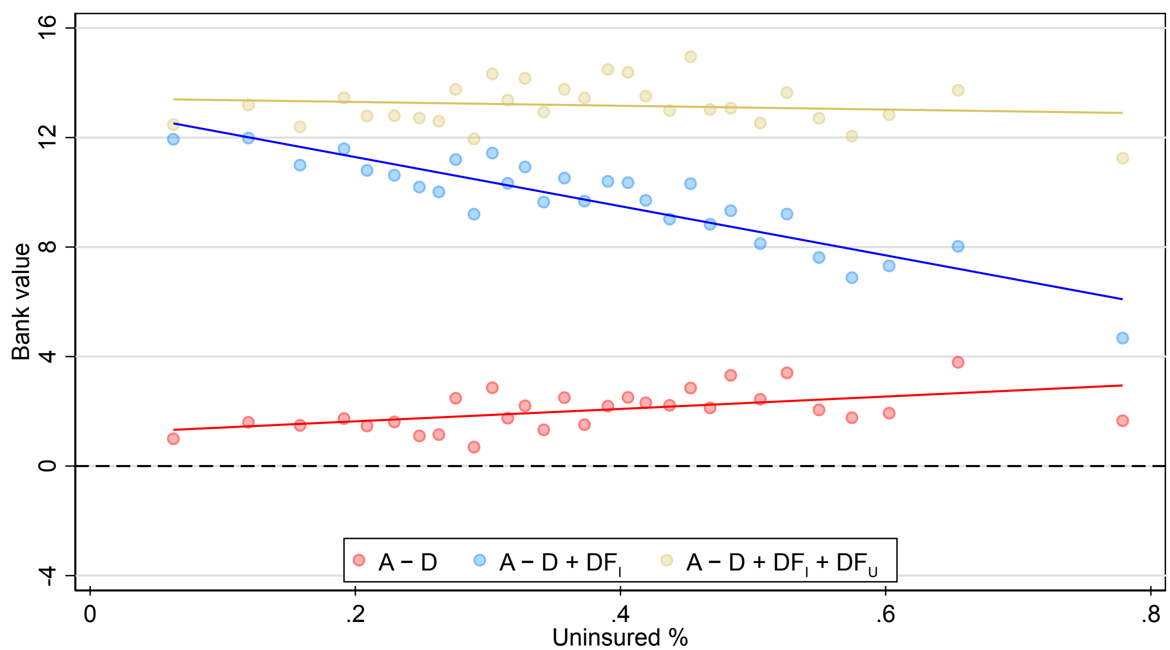
This figure shows a binscatter plot of the cost of insured deposits against the insured deposit beta (estimated over the same period). The deposit costs and betas are estimated following the methodology in Section 4.2. The plot is shown for the end of our sample, in December 2023, but other dates look similar.

Figure 9: Bank values and the uninsured share of deposits

Panel A: December 2021



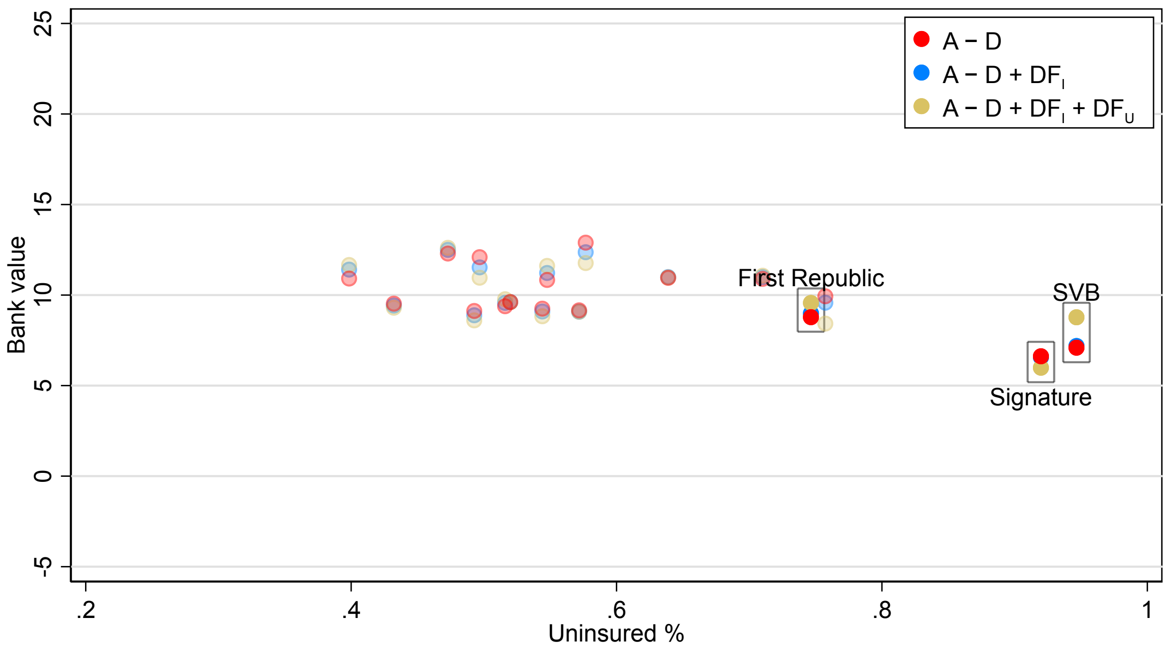
Panel B: February 2023



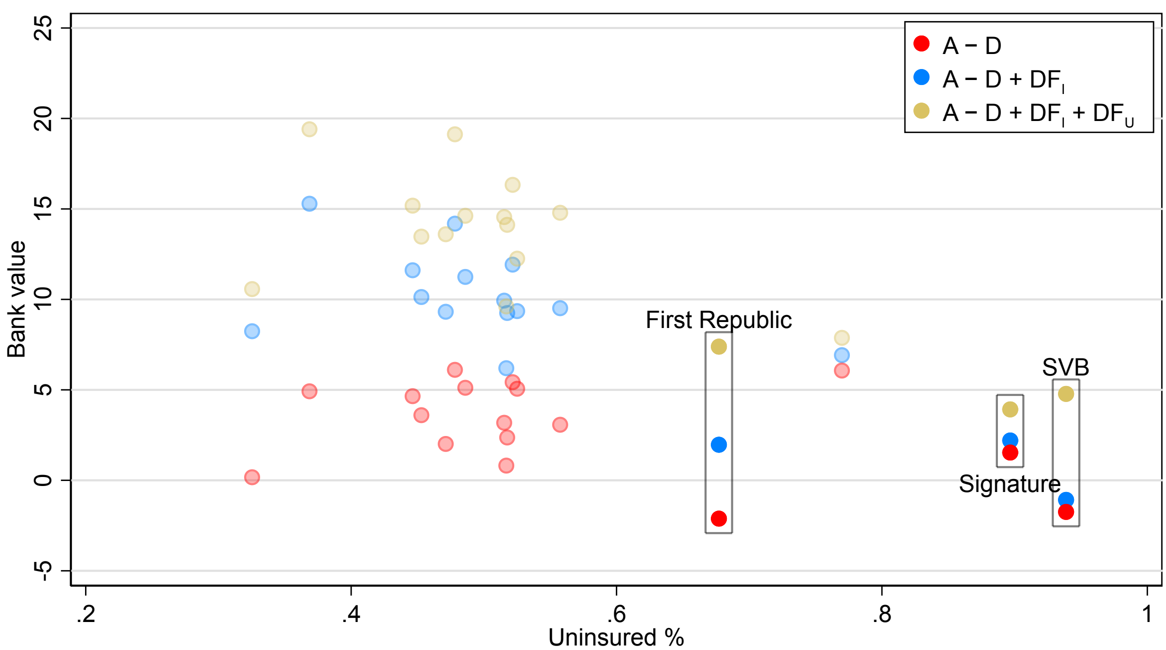
This figure plots bank values against the uninsured share of deposits as of December 2021 (Panel A) and February 2023 (Panel B). (February 2024 looks similar to February 2023.) The red circles show bank values without the deposit franchise, $A - D$. Blue circles show the value in a run, $V(0, r) = A - D + DF_I$. Yellow circles show the value without a run, $V(1, r) = A - D + DF_I + DF_U$. All values are scaled by assets.

Figure 10: Large bank values

Panel A: December 2021



Panel B: February 2023



This figure plots bank values against the uninsured share of deposits, for the 17 large banks in our sample as of December 2021 (Panel A) and February 2023 (Panel B). The red circles show bank values without the deposit franchise, $A - D$, the blue circles show the value in a run, $V(0, r) = A - D + DF_I$, and the yellow circles show the value without a run, $V(1, r) = A - D + DF_I + DF_U$. All values are scaled by assets.

Appendix

A Proofs

A.1 Proof of Proposition 1

From (12) and using $D_{t-1} = (1-\delta)^{t-1} D$ we have

$$\begin{aligned} L &= \sum_{t=1}^{\infty} \frac{\delta D_{t-1}}{(1+r')^t} + \sum_{t=1}^{\infty} \frac{(\beta r' + c)\, D_{t-1}}{(1+r')^t} \\ &= D \left[\sum_{t=1}^{\infty} \frac{(1-\delta)^{t-1}}{(1+r')^t} \right] (\delta + \beta r' + c) \\ &= D \left[\frac{(\delta + \beta r' + c)}{r' + \delta} \right]. \end{aligned}$$

Therefore

$$DF \;=\; D - L \;=\; D \left[1 - \frac{(\delta + \beta r' + c)}{r' + \delta} \right] \;=\; D \left[\frac{(1-\beta) r' - c}{r' + \delta} \right]$$

and

$$\frac{\partial DF\,(r)}{\partial r} = D \left[\frac{(1-\beta)\delta + c}{(r+\delta)^2} \right]$$

Thus, the dollar duration evaluated at r is

$$T_{DF} \;\equiv\; -\frac{\partial DF\,(r)}{\partial r} \;=\; -\frac{c + (1-\beta)\,\delta}{(r+\delta)^2} D \leq 0. \tag{44}$$

A.2 Proof of Proposition 2

Recall that an equilibrium requires the fixed-point condition (24)

$$\Lambda(v(\lambda(r'), r')) = \lambda(r'),$$

where Λ is given by the step function (11). Since r' is given we can simply denote $\lambda = \lambda(r')$, omitting the r' argument to ease notation.

- If $v(0,r') \geq \underline{v}$ then $\lambda = 1$ is an equilibrium since

$$\Lambda(v(1,r')) = 1.$$

Conversely, consider any $\lambda \in [0,1)$. Since $\left(1-\beta^U\right) r' > c^U$ we have $v(\lambda,r') > v(0,r')$ hence

$$\Lambda(v(\lambda,r')) \geq \Lambda(v(0,r')) = 1 > \lambda,$$

hence λ cannot be an equilibrium.

- If $v(1,r') < \underline{v}$ then $\lambda = 0$ is an equilibrium. Since $\left(1-\beta^U\right) r' > c^U$ we have $v(0,r') < v(1,r')$ hence $\Lambda(v(0,r')) \leq \Lambda(v(1,r')) = 0$, therefore

$$\Lambda(v(0,r')) = 0.$$

Conversely, consider any $\lambda \in (0,1]$. Then $v(\lambda,r') < v(1,r')$ hence $\Lambda(v(\lambda,r')) \leq \Lambda(v(1,r')) = 0$, therefore $\Lambda(v(\lambda,r')) = 0 < \lambda$ and λ cannot be an equilibrium.

- If $v(0,r') < \underline{v} \leq v(1,r')$ then:
  - $\lambda = 0$ is an equilibrium since $\Lambda(v(0,r')) = 0$;
  - $\lambda = 1$ is an equilibrium since $\Lambda(v(1,r')) = 1$.

Given a no-run bank value $v(1,r')$, the solvency ratio under a run is

$$v(0,r') = v(1,r') - u \times \frac{\left(1-\beta^U\right) r' - c^U}{r'+\delta}.$$

Therefore the condition $v(0,r') < \underline{v}$ is more likely to be satisfied if u is higher, if β^U or c^U is lower, and when r' is higher.

A.3 Proof of Proposition 3

An equilibrium with $\lambda = 0$ exists when $v\left(0,r'\right) < \underline{v}$. From (8) and (**??**)

$$\frac{T_A}{D} = \frac{l\,(1+e)}{(r+\delta)}. \tag{45}$$

We have

$$v\left(0,r'\right) = \frac{A\left(r'\right)}{D} - 1 + \frac{DF_I\left(r'\right)}{D}. \tag{46}$$

The value of the assets is equal to the sum of short term assets, $(1-l)\,A$, whose value is independent of the interest rate, and long-term assets. Long-term assets represent a fraction l of the value A of assets at r. If their initial cash flow is C, we have $lA = C/\,(r+\delta)$, which gives $C = (r+\delta)\,lA$. Therefore, at r', the value of the long-term assets is $\frac{r+\delta}{r'+\delta}lA$. Thus,

$$A(r') \;=\; (1-l)\,A + \frac{r+\delta}{r'+\delta}lA. \tag{47}$$

Therefore

$$\begin{aligned} v(0,r') &= (1-l)\,\frac{A}{D} + \frac{r+\delta}{r'+\delta}l\frac{A}{D} - 1 + \frac{(1-\beta^I)r' - c^I}{r'+\delta}\frac{D_I}{D} \\ &= (1-l)\,(1+e) - 1 + (1-u)(1-\beta^I) + \frac{l(1+e)(r+\delta) - (1-u)\left[(1-\beta^I)\delta + c^I\right]}{r'+\delta}. \end{aligned}$$

This shows that $v\,(0,r')$ is monotone in r'. The existence of a threshold r^{Run} therefore depends on whether $\lim_{r'\to\infty} v\,(0,r') < \underline{v}$. This limit is

$$\lim_{r'\to\infty} v\left(0,r'\right) \;=\; (1+e)\,(1-l) - 1 + \left(1-\beta^I\right)(1-u)\,. \tag{48}$$

Note that this limit is decreasing in l. Thus, the threshold T_A^{Run} is where l is high enough that

$$(1+e)\,(1-l) - 1 + \left(1-\beta^I\right)(1-u) = \underline{v}. \tag{49}$$

Re-arranging to match the expression in (45),

$$T_A^{Run} \;= D\;\; \frac{e - \underline{v} + \left(1-\beta^I\right)(1-u)}{r+\delta}. \tag{50}$$

Therefore when l is high enough so that $T_A > T_A^{Run}$ or

$$l > \frac{e - \underline{v} + \left(1-\beta^I\right)(1-u)}{1+e},$$

then $\lim_{r'\to\infty} v\,(0,r') < \underline{v}$, and since $v\,(0,r')$ is monotone in r', it must be weakly below $\underline{v}$ at some $r' = r^{Run}$ and remain below after, hence $\lambda = 0$ is an equilibrium for all $r' > r^{Run}$, where

$$r^{Run} = \frac{l(1+e)r - (1-u)c^I + \delta(e-\underline{v})}{l\,(1+e) - (e-\underline{v}) - (1-u)\left(1-\beta^I\right)}.$$

An equilibrium with $\lambda = 1$ fails to exist when $v(1, r') < \underline{v}$. We have

$$v\left(1, r'\right) = \frac{A(r')}{D} - 1 + \frac{DF(r')}{D}. \tag{51}$$

Plugging in,

$$v\left(1, r'\right) = (1-l)(1+e) - \beta + \frac{l(1+e)(r+\delta) - [(1-\beta)\delta + c]}{r' + \delta} \tag{52}$$

Like $v(0, r')$, $v(1, r')$ is also monotone in r'. Note that $\lim_{r' \to -\delta} v(1, r') = \pm\infty$, hence the $\lambda = 1$ equilibrium disappears for low enough r' when $\lim_{r' \to -\delta} v(1, r') = -\infty$. This requires $v(1, r')$ to be increasing in r', that is

$$l < \frac{(1-\beta)\delta + c}{(1+e)(r+\delta)}. \tag{53}$$

Therefore, the threshold asset duration below which $\lambda = 1$ is not an equilibrium for sufficiently low r' is

$$T_A^{Insolv} = D \frac{(1-\beta)\delta + c}{(r+\delta)^2} = -T_{DF}(r). \tag{54}$$

When T_A is below T_A^{Insolv}, the value of the bank falls toward $-\infty$ as $r' \to -\delta$. Since it is monotone in r', it must fall below the threshold $\underline{v}$ for sufficiently low $r' \leq r^{Insolv}$, where

$$r^{Insolv} = \frac{l(1+e)r - c + \delta(e - \underline{v})}{l(1+e) - (e - \underline{v}) - (1-\beta)}.$$

A.4 Proof of Proposition 4

We wish to know when $T_A^{Insolv} \leq T_A^{Run}$ so that the bank can rule out both runs at high interest rates and insolvency at low interest rates. Plugging in, this requires

$$T_A^{Insolv} \leq T_A^{Run} \tag{55}$$

$$\frac{(1-\beta)\delta + c}{(r+\delta)^2} \leq \frac{e - \underline{v} + \left(1-\beta^I\right)(1-u)}{r+\delta} \tag{56}$$

$$(1-\beta) - \frac{(1-\beta)r - c}{r+\delta} \leq e - \underline{v} + \left(1-\beta^I\right)(1-u). \tag{57}$$

Re-arranging and using $v(r) = \frac{A(r)}{D} - 1 + DF(r) = e + \frac{(1-\beta)r-c}{r+\delta}$ and $1-\beta = u\left(1-\beta^U\right) + (1-u)\left(1-\beta^I\right)$, the condition becomes

$$v(r) \;\; \geq \;\; \underline{v} + \left(1-\beta^U\right)u. \tag{58}$$

More generally, suppose that r' is bounded above by $\bar{r}$. Then T_A^{Insolv} is unchanged but T_A^{Run} is higher, such that

$$\underline{v} \;\; = \;\; (1-l)(1+e) - 1 + (1-u)(1-\beta^I) + \frac{l(1+e)(r+\delta) - (1-u)\left[(1-\beta^I)\delta + c^I\right]}{\bar{r}+\delta} \tag{59}$$

$$l(1+e) \;\; = \;\; \frac{\bar{r}+\delta}{\bar{r}-r}\left\{e - \underline{v} + (1-u)\left[\frac{(1-\beta^I)\bar{r} - c^I}{\bar{r}+\delta}\right]\right\} \tag{60}$$

hence

$$T_A^{Run} = D\frac{e - \underline{v} + \left(1-\beta^I\right)(1-u)}{r+\delta} \times \frac{\bar{r}+\delta}{\bar{r}-r}.$$

Relative to the case with $\bar{r} \to \infty$, T_A^{Run} is simply multiplied by a factor $\frac{\bar{r}+\delta}{\bar{r}-r} > 1$. As a result the condition $T_A^{Insolv} \leq T_A^{Run}$ becomes

$$v(r) \geq \underline{v} + u\frac{\left(1-\beta^U\right)\bar{r} - c^U}{\bar{r}+\delta}.$$

A.5 Proof of Proposition 6

The proof of (40) follows the proof of Proposition 1 with the new deposit base $D\left[1 - w(r')\right]$ replacing D.

The proof of (41) follows by differentiating (40) with respect to r' and substituting $r' = r$ and the expressions for T_{DF} and $DF(r)$ from Proposition 1.

A.6 Proof of Proposition 7

Substituting the expressions for $T_{DF}(r)$ and $DF(r)$ from Proposition 1 back into (41),

$$T_{DF} = -\frac{(1-\beta)\,\delta + c}{(r+\delta)^2} + w'(r)\left[\frac{(1-\beta)\,r - c}{r+\delta}\right] \tag{61}$$

$$= -\frac{\left[1-\left(\beta + w'(r)\left[(1-\beta)\,r - c\right](1 + r/\delta)\right]\right)\delta + c}{(r+\delta)^2} \tag{62}$$

$$= -\frac{\left(1-\tilde{\beta}\right)\delta + c}{(r+\delta)^2}. \tag{63}$$

This expression is the same as (17) but with $\tilde{beta}$ replacing β.

B Data appendix

Call reports. The call reports are accessible through the Federal Financial Institutions Examination Council and Wharton Research Data Services. The data contain quarterly income statements and balance sheets. We use the CRSP-FRB crosswalk provided by the New York Federal Reserve to merge in the stock returns of publicly traded bank holding companies from CRSP.

Macro data. We collect interest rate data from FRED. We use the quarterly average effective Fed funds rate (FEDFUNDS) for the estimation of deposit betas. We use the daily 10-year Treasury yield (DGS10) for the estimation of deposit franchise values as of December 31, 2021 (1.52%), February 28, 2023 (3.92%), and February 29, 2024 (4.25%).

Bloomberg indices. We collect data on the prices (with reinvested coupons) of Treasury and mortgage-backed security (MBS) indices by maturity from Bloomberg on the same dates as the Treasury yields. The specific indices and how we map them to banks' balance sheets from the call reports are listed in Table A.1. The mapping uses the same asset class whenever possible, and closest available remaining maturity. In some cases we use more than one index to match the average remaining maturity of a call report item. Since call report items give a range of remaining maturities, we approximate the average remaining maturity of an item under the assumption that remaining maturities are uniformly distributed (i.e., staggered).

Expected betas. The Fed began surveying banks about their expected deposit betas starting with the November 2022 Senior Financial Officer Survey (SFOS, available through the Board of Governors website). This was done separately for retail and wholesale betas; we use the retail betas as they are closest to the call reports.

Banks were asked to report their current realized beta and their expected beta in six months. We use the ratio of these two values (expected over current) as the scaling factor for each partial-cycle beta (February 2023 and 2024). For the February 2023 date, we use the November 2022 survey (the most recent at the time), which gives us a scaling factor of $0.31/0.23 = 1.35$. For the February 2024 date, we use the September 2023 survey, which gives a scaling factor of $0.41/0.35 = 1.17$. It remains possible that even these betas are incomplete; they are also uncertain. This is an intrinsic problem in valuing an intangible asset such as the deposit franchise.

Figure A.3 plots our call report betas against the current and expected betas from the SFOS at each point in time. There are some differences but the overall pattern is that the betas evolve consistently across the two datasets.

C Deposit franchise value with a general yield curve

We show that our valuation formulas generalize to the case when the yield curve is not flat. The appropriate interest rate that enters our formulas becomes the yield of an amortizing perpetuity at rate δ.

We use continuous time to simplify the notation but nothing changes with discrete time. Total interest expense and costs normalized by initial deposits has a value

$$\int_0^\infty \underbrace{e^{-\delta t}}_{=D_t/D} (\beta r_t + c)\, e^{-\int_0^t r_s ds} dt = \int_0^\infty (\beta r_t + c)\, e^{-\int_0^t (r_s+\delta) ds} dt \tag{64}$$

$$= \int_0^\infty (\beta (r_t + \delta) + c - \beta\delta)\, e^{-\int_0^t (r_s+\delta) ds} dt \tag{65}$$

$$= \beta + (c - \beta\delta) \underbrace{\int_0^\infty e^{-\int_0^t (r_s+\delta) ds} dt}_{=P_0(\boldsymbol{r},\delta)}, \tag{66}$$

where $P_0(\boldsymbol{r}, \delta)$ is the date-0 price of the geometrically declining (amortized) perpetuity as a function of the path of interest rates $\boldsymbol{r} = \{r_t\}_{t=0}^{\infty}$. It is just a portfolio of zero-coupon bonds of maturity t with weight $e^{-\delta t}$. The last line uses the identity

$$\int_0^\infty (r_t + \delta) e^{-\int_0^t (r_s+\delta) ds} dt = 1 \tag{67}$$

which follows from integration by parts; the same identity holds in discrete time by Abel transformation.

Defining the deposit franchise DF as a reduction in total interest expense and costs relative to $\beta = 1$ and $c = 0$, we have

$$\frac{DF}{D} = \underbrace{[1 - \delta P_0(\boldsymbol{r}, \delta)]}_{\text{without deposit franchise}} - [\beta + (c - \beta\delta)\, P_0(\boldsymbol{r}, \delta)] \tag{68}$$

$$= 1 - \beta - [c + (1-\beta)\delta]\, P_0(\boldsymbol{r}, \delta). \tag{69}$$

In the special case of a flat yield curve with constant rate r, this specializes to

$$\frac{DF}{D} = 1 - \beta - \frac{[c + (1-\beta)\delta]}{r + \delta} = \frac{(1-\beta)r - c}{r + \delta}, \tag{70}$$

as in Proposition 1.

Since the geometrically declining perpetuity has duration $1/\delta$, when computing its sensitivity to interest rates we can approximate

$$P_0(\boldsymbol{r}, \delta) \approx Z_0(\boldsymbol{r}, 1/\delta), \tag{71}$$

where $Z_0(\boldsymbol{r}, T)$ is the price of a zero-coupon bond with maturity T. In our case this corresponds to using the 10-year rate since $\delta = 0.1$.

D Higher exogenous outflow rate δ

Our baseline rate of exogenous outflows is $\delta = 0.1$, implying an average deposit life of 10 years. This is consistent with Sheehan (2013) but higher than the average deposit life estimates in the OCC's "Interest Rate Statistics Report." The latest OCC report shows an average life of about six years for zero-maturity deposits. To see what impact this has, we re-run our estimates with $\delta = 1/6 = 0.167$.

Table A.2 reproduces our main Table 6 with $\delta = 1/6$. The results are broadly similar. The main difference is that bank values decline. The average bank value in a run in February 2023 falls from 9.70% to 7.22%. The fraction of banks with negative run values rise from 0.70% to 1.54%. For large banks, run values decline from 8.60% to 6.77%. The number of large banks with a negative run value remains the same (one).

The impact is larger on bank values if there is no run. For all banks they fall from 13.18% to 9.57% and for large banks from 12.45% to 9.37%. A higher exogenous outflow rate lowers deposit franchise values. This has a larger impact on no-run values because they include the uninsured deposit franchise value.

Figure A.4 similarly reproduces Figure 10. As in Table A.2, the impact is concentrated in the no-run values (yellow dots), which decrease substantially. Run values fall too but, importantly, they do not fall appreciably for the vulnerable banks (First Republic, Signature, and SVB). The reason is that these banks do not have a significant insured deposit franchise, so raising outflow rates does not hurt their run values much. Our results are therefore robust to using a different exogenous outflow rate.

E Partial runs by insured depositors

Our main empirical results assume that the bank retains (or is able to sell) its entire insured deposit franchise in a run. This assumption is supported by the experience of the Regional Bank Crisis. Nevertheless, it is also plausible that some share of insured depositors would leave in a run so that the insured deposit franchise is partly lost.

Table A.3 re-estimates Table 6 under the assumption that 15% insured depositors leave. This implies that only a fraction $\lambda^I = 85\%$ of the insured deposit franchise is retained in a run. Bank values without the deposit franchise ($A - D$) and without a run ($V(1, r)$) are unaffected, while bank values in a run ($V(0, r)$) decline due to the partial loss of the insured deposit franchise.

For all banks in February 2023, the average value in a run drops from 9.70% to 8.55%. For large banks, it drops from 8.60% to 7.75%. While adding to the stress of the banking system, these values are still only slightly below the values in December 2021. Interestingly, for the most exposed banks (SBV, First Republic, Signature), insured depositor outflows have almost no impact because these banks had very few insured deposits.

F Partial retention of uninsured depositors

Our main empirical results assume that all uninsured depositors leave in a run. It is plausible that some remain, especially since the FDIC's preferred resolution process is a sale to another bank. We can easily implement this by adjusting the run value of the bank, $V(0, r)$ to include a fraction of the uninsured deposit franchise.

Table A.4 re-estimates Table 6 under the assumption that 15% of the uninsured deposit franchise is retained in a run. Bank values in a run increase, as expected.

The interesting effect of this policy is that it benefits precisely those banks most at risk of a deposit franchise run. To illustrate, we also re-estimate Figure 10 and present the results in Figure A.5. The main difference is that SVB now has a run value of -0.20%, which is only marginally negative. First Republic and Signature bank are in the green with 2.78% and 2.46%, respectively.

G Further extensions

G.1 Fixed and variable operating costs

Recall that in the main model we assume that c is a cost per dollar of remaining deposits hence the franchise value is

$$DF\left(r'\right) \quad = \quad D\left[1-w\left(r'\right)\right]\frac{\left(1-\beta\right)r'-c}{r'+\delta}. \tag{72}$$

In practice operating costs are a combination of pre-determined costs that do not fully respond to withdrawals, and costs that scale with the amount of deposits in each period. Here we extend the model by allowing the bank to decide the scale of the branch network and services offered before the interest rate shock, which corresponds to costs κD that must be paid even if deposits are withdrawn at $t = 0$.

For simplicity we assume that the costs κ stop being paid on the exogenous withdrawals at rate δ (otherwise nothing substantial changes except that expressions are slightly more complex because the last term is $-D\kappa/r'$ instead). Define the total cost

$$C \quad = \quad c+\kappa. \tag{73}$$

Results are mostly unchanged under this formulation except for two points:

First, since outflows do not help to economize on the fixed operating costs κ, if all costs are fixed ($C = \kappa, c = 0$) then outflows always hurt the franchise value, even when $DF < 0$. We can generalize Proposition 6 to:

Proposition 8 (Deposit Franchise Valuation with Fixed Costs)**.** *If there are no runs, then the value of the deposit franchise with fixed costs after the interest rate shock is*

$$DF\left(r'\right) \quad = \quad \left[1-w\left(r'\right)\right]\left[\frac{\left(1-\beta\right)r'-c}{r'+\delta}\right]D-\frac{\kappa}{r'+\delta}. \tag{74}$$

The dollar duration of the deposit franchise with fixed costs before the interest rate shock is

$$T_{DF} \;\equiv\; -\left.\frac{\partial DF\left(r'\right)}{\partial r'}\right|_{r'=r} \quad = \quad -\frac{\left(1-\beta\right)\delta+C}{\left(r+\delta\right)^{2}}+w'\left(r\right)\left[\frac{\left(1-\beta\right)r-c}{r+\delta}\right]. \tag{75}$$

Proof: Equation (74) comes from the fact that outflows do not affect the fixed cost κ. Equation (75) comes from differentiating it with respect to r' and evaluating at $r' = r$.

Proposition (8) shows that, holding total costs $C = c + \kappa$ fixed, higher fixed costs (lower c) make the duration of the deposit franchise less negative. The reason is that fixed costs are not recouped due to rate-driven outflows. This makes their present value decrease less when interest rates go up, so the deposit franchise appreciates less. All else equal, the bank needs a lower asset duration to hedge interest rate risk.

Second, the analysis of uninsured depositor runs is unchanged, except that in a run ($\lambda = 0$) the uninsured deposit franchise can become negative instead of zero, since the fixed costs κ still need to be paid. This only affects the expressions for v and Λ as follows. The solvency ratio of the bank after the interest rate shock as a function of λ is still

$$v\left(\lambda, r'\right) \quad = \quad v\left(0, r'\right) + u\lambda \frac{\left(1-\beta^{U}\right) r' - c}{r' + \delta} \tag{76}$$

as in (22), but the solvency ratio when all uninsured depositors run ($\lambda = 0$) is

$$v\left(0, r'\right) \quad = \quad \frac{A\left(r'\right) - D + DF_{I}\left(r'\right)}{D} - u\frac{\kappa}{r' + \delta} \tag{77}$$

instead of (23). The cost κ implies that the bank should hold some long-term assets to cover κ per period even to hedge liquidity risk, i.e., to stabilize $v(0, r')$. However, the dilemma between hedging interest rate and liquidity risk persists for two reasons: first, a bank hedging interest rate risk in the no-run equilibrium must account for total operating costs $C = c + \kappa$, and second, the term $\frac{(1-\beta^{U})r'-c}{r'+\delta}$ increases with r' even if $c = 0$, hence the uninsured deposit franchise still drives a wedge between $v\left(0, r'\right)$ and $v\left(1, r'\right)$ that is increasing in r'.

G.2 Endogenous deposit pricing

Our results take advantage of the fact that the endogenous variables β and w' can be used as "sufficient statistics" for the bank's hedging problem. Here we discuss how they are related in a more micro-founded setting.

Let $\omega(s'_d, r')$ be the household deposit withdrawal rate, where $s'_d = r' - r'_d$ is the deposit spread. The bank is thus left with deposits

$$D_0 \quad = \quad \left[1 - \omega\left(s'_d, r'\right)\right] D \tag{78}$$

after the interest rate shock. Let the withdrawal rate ω be increasing in the deposit spread s'_d and, holding s'_d fixed, decreasing in r'. The two arguments capture the "deposits channel" of monetary policy (Drechsler et al., 2017): depositors withdraw if the deposit spread widens. The dependence on r' captures the fact that deposit demand becomes less elastic at higher rates as the opportunity cost of cash rises. The lower elasticity allows banks to charge a higher spread s'_d, as we see in practice. Given the assumption that the deposit rate is proportional to the market interest rate (see (3)), the date-0 withdrawal rate can be rewritten as a function of r' only:

$$w\left(r'\right) \;\equiv\; \omega\left(\left(1-\beta\right)r', r'\right). \tag{79}$$

This is the reduced-form withdrawal rate in our main model.

While β depends on w' through the bank's profit maximization problem, and w' depends on β through the deposit demand function, in general neither is fully pinned down by the other, which is why we treat them as separate. Indeed, without additional restrictions on the deposit demand function $\omega\left(s_d, r\right)$, the correlation between β and $w'\left(r\right)$ can take any sign, as w' is given by

$$w' = (1-\beta)\omega_s + \omega_r,$$

where $\omega_s = \partial\omega/\partial s_d$ and $\omega_r = \partial\omega/\partial r$. Banks facing relatively inelastic depositors (low ω_s) have more market power, which allows them to set a low β. But given their low β, these banks could see more or less outflows when rates go up, as w' depends on the product $(1-\beta)\omega_s$. Empirically, Drechsler et al. (2017) find a negative correlation between β and w': low β banks face stronger rate-driven outflows w'.

G.3 Variable deposit beta

We can easily extend the model to allow for non-linear deposit pricing with a deposit beta $\beta(r)$ that depends on r. In that case, the optimal modified duration is

$$T_{DF} \;=\; T_{DF}^{\beta'(r)=0} - \beta'(r)\frac{r}{r+\delta}, \tag{80}$$

where $T_{DF}^{\beta'(r)=0}$ is given by Proposition 1. Betas tend to increase with rates: as rates rise the composition of deposits shifts from low-beta checking and savings accounts to higher-beta time deposits (Drechsler et al., 2017; Greenwald et al., 2023); betas also increase for given products (Wang, 2022). An increasing beta, $\beta'(r) > 0$, makes the duration of the deposit franchise less negative and hence calls for a shorter asset duration. Unlike for outflows, this duration-shortening effect is present at both low and high rates because an increase in β always hurts the deposit franchise value, even if it is negative.

G.4 Quantifying Rate-Driven Outflows

Figures A.1 and A.2 show the deposit franchise duration and effective beta $\tilde{\beta}$ as functions of w' for three values of the deposit beta.

The average correction $\tilde{\beta} - \beta$ is not negligible. There is also substantial heterogeneity across banks. Most importantly, equation (43) shows that the correction $\tilde{\beta} - \beta$ is higher for low-β banks (as they earn higher deposit spreads hence stand to lose more from outflows) and high w' banks, which also tend to be the low-β banks (Drechsler et al., 2017). For instance, their estimates imply that going from $\beta = 0.2$ (high market power) to $\beta = 0.4$ (low market power), outflow betas decline from $w' = 3.5$ to $w' = 2.5$. Therefore, the effective betas for hedging are

$$\beta = 0.2 \quad \rightarrow \quad \tilde{\beta} = 0.28 \quad \text{(high market power)} \tag{81}$$

$$\beta = 0.4 \quad \rightarrow \quad \tilde{\beta} = 0.43 \quad \text{(low market power)} \tag{82}$$

Thus, correcting for outflows has a modest effect for competitive banks, but a strong effect for banks with high deposit market power.[40]

G.5 Lender of Last Resort

We end by showing how a lender of last resort can eliminate the run equilibrium ex post and thus avoid the risk management dilemma ex ante. We caution, however, that in a richer model this could lead to moral hazard or adverse selection.

Suppose that the central bank (henceforth, the Fed) gives a long-term loan to the bank

$$B(\lambda, r')$$

contingent on the extent of the run $1-\lambda$, with $B(1, r') = 0$. After borrowing from the Fed the solvency ratio entering uninsured depositors' run function $\lambda(v)$ is $v = \frac{A(r')+\lambda DF_U(1,r')+B(\lambda,r')}{D} - 1$. Importantly the denominator is given by deposits D hence does not take into account the long-term loan from the Fed, which is not runnable and effectively junior to current uninsured deposits. This is why the long-term loan improves v. More generally, it is enough if the denominator includes the government loan B discounted by a "runnability" factor $\alpha < 1$.

By setting

$$B(\lambda, r') = (1-\lambda) DF_U(1, r')$$

[40] Interestingly, Drechsler et al. (2021) show that banks' income is slightly more interest-sensitive than their deposits. This is consistent with banks setting asset duration using an effective beta that is slightly higher than their deposit beta, as in Proposition 7.

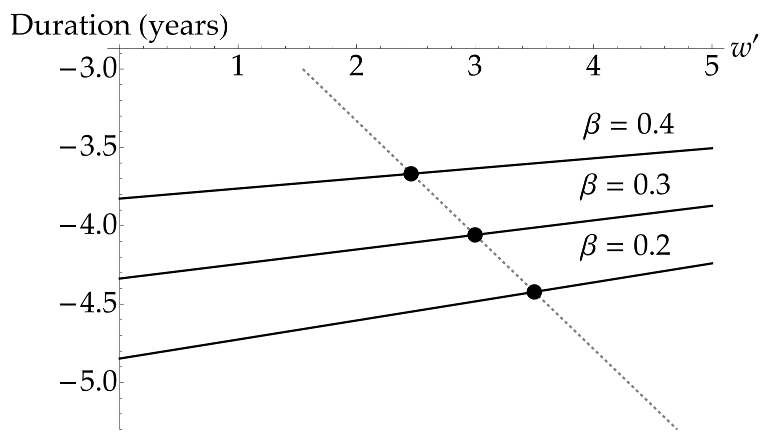


Figure A.1: Deposit franchise duration T_{DF}/D as a function of the outflow elasticity w' for three values of the deposit beta $\beta = 0.2, 0.3, 0.4$. The dotted gray line captures the negative correlation between β and w' estimated by Drechsler et al. (2017).

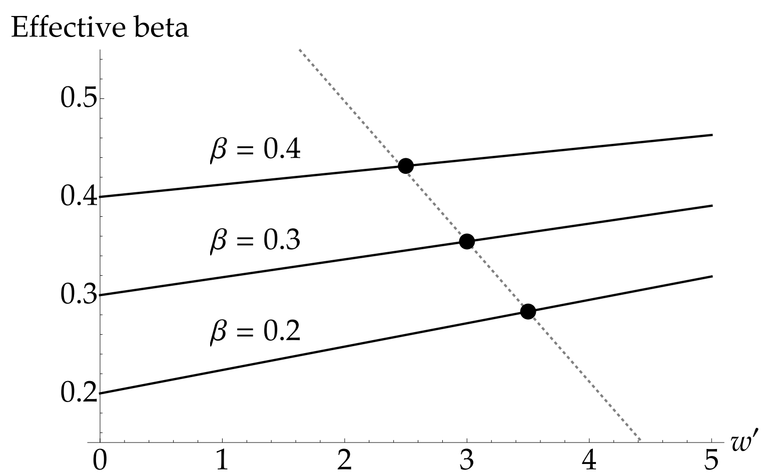


Figure A.2: Effective beta as a function of outflow elasticity w' for three values of rate beta $\beta = 0.2, 0.3, 0.4$. The dotted gray line captures the negative correlation between β and w' estimated by Drechsler et al. (2017).

the Fed can ensure that

$$v(\lambda, r') = v(1, r')$$

for any λ. Therefore, the Fed policy eliminates the run equilibrium, in the sense that if the bank is hedged against interest rate risk in the good, run-free, equilibrium, then there is no run equilibrium. Moreover, since there is no run, the intervention ends up costless in equilibrium.

Proposition 9. *Suppose that for any λ, a bank facing an uninsured deposit run $1-\lambda$ can borrow*

$$B(\lambda, r') = (1-\lambda) DF_U(1, r') \tag{83}$$

long-term from the Fed. Then $\lambda = 1$ is the unique equilibrium and the equilibrium cost of the Fed intervention is zero.

One particular implementation resembles the Bank Term Funding Program (BTFP) introduced by the Federal Reserve in March 2023 allowing banks to borrow from the Fed at par, that is against a collateral value $A(r)$ instead of $A(r')$. Starting from an interest rate r such that $DF_U(1, r) = 0$, this corresponds to a loan size

$$B(\lambda, r') = (1-\lambda)\left[A(r) - A(r')\right],$$

which is exactly (83).

In principle complete private insurance markets could also implement this allocation: banks would buy insurance contracts contingent on their idiosyncratic realization of λ and not just on the aggregate interest rate r'. In the model featuring only interest rate risk and purely idiosyncratic runs, these contracts would prevent runs from happening in the first place hence the equilibrium price of such insurance would be zero. However, in a richer setting featuring contagion and widespread runs, or in the presence of other aggregate shocks s as in Section 5.2, such private insurance markets would be insufficient, which is why we focus on government-provided insurance.

There are two main drawbacks of the Fed policy we describe: moral hazard and adverse selection, both of which are outside the model. The equilibrium cost for the Fed is zero because banks hold high-quality liquid assets such as agency MBS and Treasuries whose value depends only on r. Banks therefore have no "bad" assets to offload on the Fed. In a model with more complex bank incentives and assets, the intervention may lead to excessive risk-taking and adverse selection in asset purchases, in particular because it is targeted at the ex post weakest institutions instead of favoring the healthiest ones.[41]

[41] See, e.g., Philippon and Skreta (2012) and Tirole (2012) for an analysis of the cost of intervention with

The expectation of ex-post Fed intervention may also reduce private incentives to buy swaptions ex ante.

adverse selection, and Philippon and Schnabl (2013) and Philippon and Wang (2022) for the design of ex post interventions that mitigate moral hazard.

Table A.1: **Bloomberg indices matched to call reports**

This table provides the Bloomberg indices matched to each call report asset class and maturity bucket.

Asset class	**Repricing maturity bucket**	**Matched Bloomberg Index Price Change (Name)**	**Matched Bloomberg Index Price Change (Ticker)**
Non mortgage loans and securities	Less than 3m	Treasury index 0y-1y	I22917US
	3m-1y	Treasury index 0y-1y	I22917US
	1y-3y	Treasury index 1y-3y	LT01TRUU
	3y-5y	Treasury index 3y-5y	LT02TRUU
	5y-15y	4/15*(Treasury index 5y-7y) + 2/5*(Treasury index 7y-10y) + 1/3*Treasury index 10y-20y	4/15*LT03TRUU + 2/5*LT09TRUU + 1/3*I00059US
	Over 15y	Treasury index 10y-20y	I00059US
Mortgage loans and RMBS	Less than 3m	Treasury index 0y-1y	I22917US
	3m-1y	Treasury index 0y-1y	I22917US
	1y-3y	US Aggregate MBS 1y-5y	I27402US
	3y-5y	US Aggregate MBS 1y-5y	I27402US
	5y-15y	FNMA MBS 15y	I00854US
	Over 15y	2/3*FNMA MBS 15y + 1/3*Fixed Rate Conventional MBS 30y	2/3*I00854US + 1/3*I00109US
Other MBS	Less than 3y	As matched for mortgage loans and RMBS less than 3y, weighted by bank's holding of each asset class	-
	Over 3y	As matched for mortgage loans and RMBS over 3y, weighted by bank's holding of each asset class	-

Table A.2: **Bank values with a higher exogenous outflow rate**

The table reports our estimates of bank values under the alternative assumption that the deposit decay rate $\delta = 1/6 = 0.167$, indicating an average maturity of 6 years, instead of 0.1. Panel A is for all banks and Panel B is for large banks. The first row is without the deposit franchise. Assets are marked to market using matched Bloomberg indices by asset class and repricing maturity. The second row is the bank value if a deposit franchise run occurs, $V(0,r) = A - D + DF_I + DF_U$. The third value is if there is no run, $V(1,r) = A - D + DF_I + DF_U$. Deposit franchise values are calculated using the formula in Proposition 1 and our empirical estimates of deposit betas, costs, and the exogenous outflow rate (see Tables 2 and 3). Bank values are reported on three dates, December 2021, February 2023, and February 2024. Bank values are scaled relative to assets. Standard deviations in parentheses; % and # ≤ 0 are the percentage and number of banks with non-positive value, respectively.

Panel A: All banks

	All banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	10.26	2.03	2.91
	(2.08)	(3.22)	(3.22)
% ≤ 0	0.00	26.43	17.10
$V(0,r) = A - D + DF_I$ (Run)	9.36	7.22	6.45
	(2.20)	(3.36)	(3.26)
% ≤ 0	0.00	1.54	1.30
$V(1,r) = A - D + DF_I + DF_U$ (No run)	9.44	9.57	7.74
	(2.24)	(3.45)	(3.42)
% ≤ 0	0.00	0.42	1.16
Obs.	717	715	690

Panel B: Large banks

	Large banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	9.96	2.95	4.20
	(1.68)	(2.57)	(1.83)
# ≤ 0	0	2	0
$V(0,r) = A - D + DF_I$ (Run)	9.95	6.77	7.73
	(1.66)	(3.61)	(2.06)
# ≤ 0	0	1	0
$V(1,r) = A - D + DF_I + DF_U$ (No run)	9.93	9.37	9.05
	(1.61)	(3.65)	(2.33)
# ≤ 0	0	0	0
Obs.	17	17	14

Table A.3: **Bank values with a partial run by insured depositors**

The table reports our estimates of bank values under the alternative assumption that $1 - \lambda^I = 15\%$ of insured depositors leave in a run. Note that relative to the main results in Table 6, this only affects run values, $V(0, r)$. Panel A is for all banks and Panel B is for large banks. The first row is without the deposit franchise. Assets are marked to market using matched Bloomberg indices by asset class and repricing maturity. The second row is the bank value if a deposit franchise run occurs, $V(0, r) = A - D + \lambda^I DF_I$. The third value is if there is no run, $V(1, r) = A - D + DF_I + DF_U$. Deposit franchise values are calculated using the formula in Proposition 1 and our empirical estimates of deposit betas, costs, and the exogenous outflow rate (see Tables 2 and 3). Bank values are reported on three dates, December 2021, February 2023, and February 2024. Bank values are scaled relative to assets. Standard deviations in parentheses; % and # ≤ 0 are the percentage and number of banks with non-positive value, respectively.

Panel A: All banks

Bank Value	All banks		
	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	10.26	2.03	2.91
	(2.08)	(3.22)	(3.22)
% ≤ 0	0.00	26.43	17.10
$V(0, r) = A - D + \lambda^I DF_I$ (Run)	9.05	8.55	7.32
	(2.31)	(3.56)	(3.41)
% ≤ 0	0.00	0.98	1.30
$V(1, r) = A - D + DF_I + DF_U$ (No run)	8.97	13.18	10.01
	(2.52)	(4.01)	(4.02)
% ≤ 0	0.00	0.14	0.72
Obs.	717	715	690

Panel B: Large banks

Bank Value	Large banks		
	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	9.96	2.95	4.20
	(1.68)	(2.57)	(1.83)
# ≤ 0	0	2	0
$V(0, r) = A - D + \lambda^I DF_I$ (Run)	9.94	7.75	8.60
	(1.66)	(3.97)	(2.21)
# ≤ 0	0	1	0
$V(1, r) = A - D + DF_I + DF_U$ (No run)	9.92	12.45	11.32
	(1.65)	(4.51)	(2.88)
# ≤ 0	0	0	0
Obs.	17	17	14

Table A.4: **Bank values with a partial retention of uninsured depositors**

The table reports our estimates of bank values under the alternative assumption that $\lambda = 15\%$ of uninsured depositors remain in a run. Note that relative to the main results in Table 6, this only affects run values, $V(0,r)$. Panel A is for all banks and Panel B is for large banks. The first row is without the deposit franchise. Assets are marked to market using matched Bloomberg indices by asset class and repricing maturity. The second row is the bank value if a deposit franchise run occurs, $V(0,r) = A - D + DF_I + \lambda DF_U$. The third value is if there is no run, $V(1,r) = A - D + DF_I + DF_U$. Deposit franchise values are calculated using the formula in Proposition 1 and our empirical estimates of deposit betas, costs, and the exogenous outflow rate (see Tables 2 and 3). Bank values are reported on three dates, December 2021, February 2023, and February 2024. Bank values are scaled relative to assets. Standard deviations in parentheses; % and # ≤ 0 are the percentage and number of banks with non-positive value, respectively.

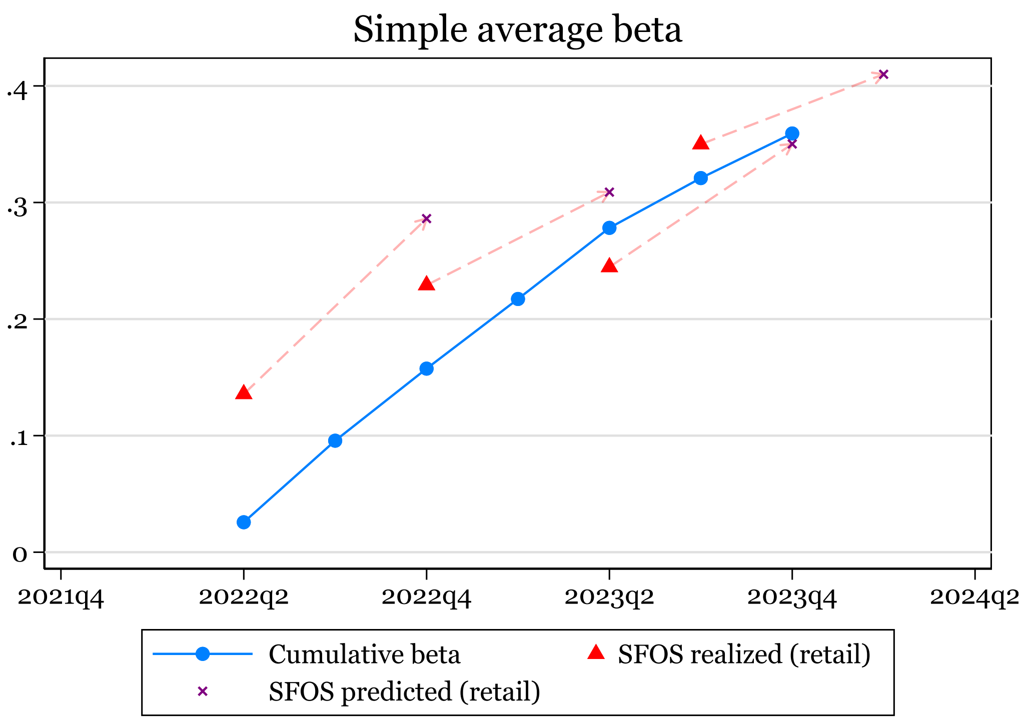
Panel A: All banks

	All banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	10.26	2.03	2.91
	(2.08)	(3.22)	(3.22)
% ≤ 0	0.00	26.43	17.10
$V(0,r) = A - D + \lambda DF_I$ (Run)	8.86	10.22	8.39
	(2.41)	(3.75)	(3.60)
% ≤ 0	0.00	0.70	1.01
$V(1,r) = A - D + DF_I + DF_U$ (No run)	8.97	13.18	10.01
	(2.52)	(4.01)	(4.02)
% ≤ 0	0.00	0.14	0.72
Obs.	717	715	690

Panel B: Large banks

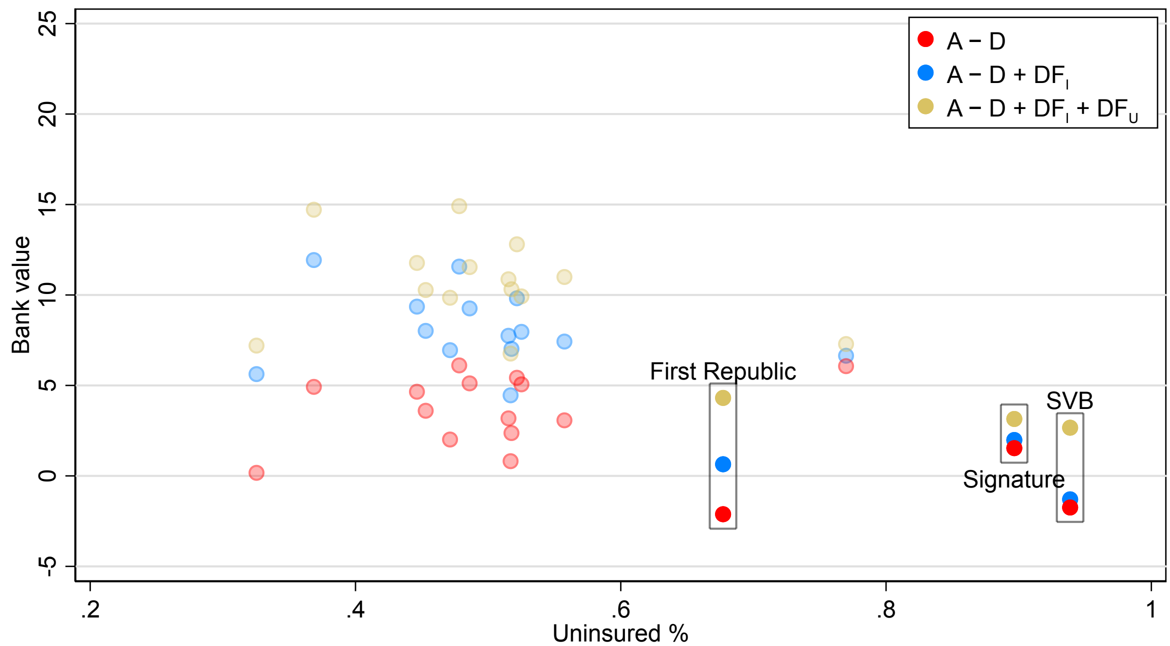
	Large banks		
Bank Value	Dec 2021	Feb 2023	Feb 2024
	(1)	(2)	(3)
$A - D$ (No DF)	9.96	2.95	4.20
	(1.68)	(2.57)	(1.83)
# ≤ 0	0	2	0
$V(0,r) = A - D + \lambda DF_I$ (Run)	9.94	9.18	9.67
	(1.64)	(4.31)	(2.44)
# ≤ 0	0	1	0
$V(1,r) = A - D + DF_I + DF_U$ (No run)	9.92	12.45	11.32
	(1.65)	(4.51)	(2.88)
# ≤ 0	0	0	0
Obs.	17	17	14

Figure A.3: Call report betas and survey betas



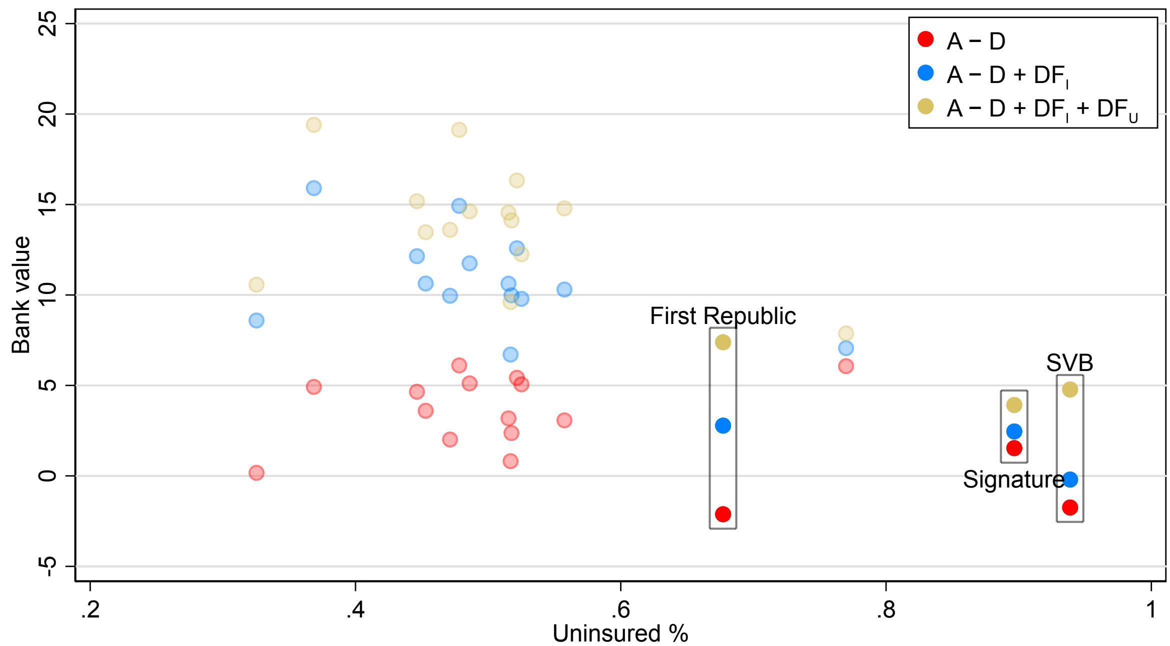
These figure plots the average beta calculated from the call reports and the realized and predicted retail betas reported in the Fed's Senior Financial Officer Surbey. The dashed lines connect the current and expected betas from each survey.

Figure A.4: Large bank values with a higher exogenous outflow rate



This figure plots bank values against the uninsured share of deposits, for the 17 large banks in our sample as of February 2023, under the alternative assumption that the deposit decay rate $\delta = 1/6 = 0.167$, indicating an average maturity of 6 years, instead of 0.1. The red circles show bank values without the deposit franchise, $A - D$, the blue circles show the value in a run, which add in the insured deposit franchise, $V(0, r) = A - D + DF_I + 0.15 \times DF_U$, and the yellow circles show the value without a run, $V(1, r) = A - D + DF_I + DF_U$. All values are scaled by assets.

Figure A.5: Large bank values with partial retention



This figure plots bank values against the uninsured share of deposits, for the 17 large banks in our sample as of February 2023, under the alternative assumption that 15% of the uninsured deposit franchise is retained in a run. The red circles show bank values without the deposit franchise, $A - D$, the blue circles show the value in a run, which add in the insured deposit franchise, $V(0, r) = A - D + DF_I + 0.15 \times DF_U$, and the yellow circles show the value without a run, $V(1, r) = A - D + DF_I + DF_U$. All values are scaled by assets.