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ABSTRACT

We develop a framework to estimate bank franchise value. Contrary to existing models, sticky deposits and low deposit rate betas do not imply negative duration. While operating costs could generate negative duration, they are offset by fixed interest rate spreads from lending activity. Consequently, franchise value declines as interest rates rise, further exacerbating losses on banks' securities holdings. Banks with less responsive deposit rates tend to invest more in long-term securities, aiming to hedge cash flows rather than market value. Despite significant recent rate hike losses, most U.S. banks still retain sufficient franchise value to remain solvent, justifying forbearance.

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1 Introduction

The turmoil in the banking system in the spring of 2023, punctuated by the failure of SVB and the government's actions to stabilize other mid-sized banks, raises a number of important questions. Were SVB and other affected banks solvent as a going concern, with the stress primarily due to liquidity problems? Were these banking stresses isolated to the few banks that required intervention, or were they the tip of the iceberg? Should we expect that large movements in interest rates will systematically lead to stress in the banking system, or was this a one-off event?

Addressing these questions is crucial for informing both banking policy and practice. The justification for intervention often hinges on distinguishing between solvency and liquidity issues. Therefore, a comprehensive understanding of bank solvency in 2023 is essential for assessing the impact of recent government actions. Evaluating bank solvency necessitates an analysis of the interest rate risk faced by the banking sector, specifically the *duration* of bank assets and liabilities. This metric is vital for guiding the risk management strategies of banks as well as their prudential regulation.

This paper develops and estimates a model of a bank's franchise value and the duration of this franchise. The model has elements in common with prior work (Hutchison and Pennacchi, 1996; Drechsler et al., 2023a; Jiang et al., 2023). We contribute to the literature by providing estimates of the components of franchise value for the entire cross-section of banks.[1] These estimates drive our conclusions regarding the solvency and duration risk of the banking system.

We model a bank with a portfolio of loans with varying maturities, funded primarily by short-term demand deposits. The value of a bank stems from its ability to discriminate among borrowers and earn a spread on its loan portfolio. The value of a bank also arises from the money-services that its deposits provide to customers, which allow the bank to earn

[1] In this regard, our objectives are similar to Egan et al. (2022) that measures the productivity of different bank business lines and translates these to franchise value estimates. There is also a literature that estimates bank production functions, which can inform value estimates. See Berger and Mester (1997).

a convenience yield on issuing deposits. Finally, banks incur operating costs to provide these screening, monitoring, and convenience services, as well as to acquire new borrowers and depositors. Together, these loan and deposit spreads, net of operating costs, determine the bank's "franchise value" — that is, its value in excess of the market value of its portfolio of assets and liabilities.

After presenting the model, we estimate the components of the loan and deposit spreads that contribute to franchise value, both at the aggregate and individual bank level. We use call report data to assess each bank's interest income, interest expense, and franchise costs. We use this data, along with interest rate movements, to characterize a bank as portfolio of fixed and floating rate bonds. On the deposit side, we show that the typical bank earns a spread that is proportional to the overnight interest rate. This profit stream is equivalent to a floating rate bond. We also show that the typical bank earns an additional fixed spread from its deposit and lending business; this fixed spread, net of the bank's operating costs, generates cash flows equivalent to a fixed rate bond. Finally, we estimate the implicit maturities of loans and deposits from movements in the term structure of interest rates and show they can be mapped to a portfolio of interest rate swaps. Together, these estimates enable us to evaluate the bank's franchise value as the value of this replicating portfolio.

As a check on our model and our empirical estimates, we compute model-implied market to book ratios for a set of publicly traded banks and compare this to the stock market's assessed market to book in 2021. We show that our estimates are in line with the market valuation. We also compare our model-implied change in values from 2021 to 2023 to that of the market. These comparisons validate our model-based exercise, and allow us to extrapolate our results to non-public banks.

The first question we tackle is whether the typical bank franchise has a positive or negative duration. While many bank deposits are contractually short-term, they are de-facto longer term because depositors are slow to withdraw deposits from low yielding accounts. A further implication of the sticky deposit behavior is that banks only partially adjust offered deposit rates, which move far less than one-for-one with money market interest rates – the "low deposit β" in the literature. This low deposit beta implies that the spread the bank earns on its deposits rises along with interest rates.

There are several papers in the literature which associate a low deposit beta with a negative duration of the deposit franchise. First, and most prominently, Drechsler et al. (2021) present a model where a bank has a deposit base that generates a flow of income of $r_t^* \times (1 - \beta)$, where r_t is the federal funds rate. Many researchers draw on the work of Drechsler et al. (2021) and conclude – misleadingly – that the sticky deposit rate (low β) of a bank leads to a negative duration for bank franchise value. Academic and central bank researchers such as Hoffmann et al. (2019); Luck et al. (2023); Greenwald et al. (2023); Paul (2023); Metrick (2024), and Bolton et al. (2023) note that the low β implies that as rates rise banks earn a higher spread between the rate they pay on deposits and the rate they can receive on investing those deposits in riskless bonds. This increase in profits, it is argued, raises the value of deposits as rates rise, implying that low β banks have a more negative duration.

This intuition is, however, incorrect. As stated earlier, the cash flow stream from the deposit spread $r_t^* \times (1 - \beta)$ is equivalent to an investment of $1 - \beta$ in a floating rate bond, which trades at par, and therefore has a value that is independent of interest rates. So, even though the deposit spread that banks earn rises with interest rates, its value does not. The source of the negative duration in Drechsler et al. (2021) does not derive from the low deposit beta, but is instead due to the fixed stream of the bank's operating costs. This fixed liability is equivalent to a short position in a fixed-rate bond, which declines in value as interest rates rise.

But although fixed operating costs are a *potential* source of negative duration, in our empirical estimates most banks generate a positive fixed spread from their lending portfolio that exceeds their operating costs. Taken together, this positive fixed spread net of operating costs is leads to a positive, not negative, duration.

An alternative means to generate a negative duration from the deposit franchise is to treat deposits as though they have an effective maturity based on their stickiness (or "runoff rate"). This approach is advocated by regulators (BCBS, 2016; Abdymomunov et al., 2023) and is also present in the analysis of Drechsler et al. (2023b). Implicitly, this approach assumes that the bank will lose its deposits in the future. Because the present cost of this future loss declines with interest rates, this assumption leads to a negative duration for low β banks.

This regulatory guidance of assuming a runoff on deposits may be relevant when assessing potential liquidity concerns, and can be motivated as a "conservative" estimate of franchise value. But it is incorrect for the purpose of measuring duration. Deposits in the banking system grow (with GDP) on average, rather than shrink. Hence for most banks, the deposit franchise represents a claim to a *growing* income stream. Replacing a runoff rate with future deposit growth again leads to a positive, not negative, duration.

To summarize, from our estimates, the median bank has a franchise value that can be viewed essentially as a zero-duration floating-rate bond (from the low deposit beta), and a positive duration fixed-rate bond (from the fixed lending spread net of operating costs). This result implies that the recent increase in interest rates caused the bank's franchise value to fall, further exacerbating the mark-to-market losses on their securities portfolio.

In addition to characterizing the median bank, we also explore the patterns apparent in the cross section. Empirically, we document an inverse relation between the β of a bank and the total duration contributed by the bank's securities portfolio (consistent with Drechsler et al. (2021)). The regulatory guidance banks receive is one rationale for this finding. As noted, regulators suggest that banks treat a low-β deposit as if it is a long duration fixed-rate liability. Thus, a bank with a low β may choose to hold positive duration securities to offset this regulator-prescribed negative duration of the deposit base. Alternatively, banks may be acting to stabilize their net interest margins (NIM). By purchasing long duration securities, their net, after funding-cost, income from their assets is negatively related to r_t^* thus acting as a hedge against their deposit income which is positively related to r_t^*. However, as we have argued, such hedging behavior does not stabilize the market value of a bank, and instead increases duration risk for most banks. In the last two years these actions have led to increased fragility of the banking system. SVB is a manifestation of the fragility induced by taking on duration risk. Our result that banks' actions have increased duration risk exposure are in line with the findings of Begenau et al. (2015), but our calculations also include the duration of banks' franchise value.

The second question we address is whether the banking system is currently solvent on a long-run basis. From 2021 Q2 to 2023 Q1 the Fed raised the overnight money market rate from 0.25% to 4.75%. Long-term interest rates rose by over 2%, leading to reductions in the value of long-term Treasurys and mortgage-backed securities. Jiang et al. (2023) estimate that the banking sector lost over $2 trillion on their holdings of long-term securities.[2] These market losses reduced solvency and have been identified as an important factor in the turmoil in the banking system in spring 2023, and the failure of SVB (Barr, 2023). But these losses are not determinate for solvency. As Jiang et al. (2023) and Drechsler et al. (2023b) emphasize, the franchise value of the bank can buffer these losses. Indeed, Drechsler et al. (2023b) estimate that the deposit franchise has a negative duration, and compute that the value of the deposit franchise *rose* by $1.6 trillion as rates have risen.[3]

Unlike Drechsler et al. (2023b), we show that franchise value did *not* increase when interest rates rose in 2022. Rather, franchise value declined by approximately 2.2% of assets for the median bank, exacerbating mark to market losses of approximately 3.6% of assets on their securities holdings. Nevertheless, we estimate that the remaining franchise value for the typical bank is substantial and supports the long-term solvency of most banks. Indeed, in the cross-section of banks, we estimate that the ones that lost the most money on their

[2]Flannery and Sorescu (2023) perform a related analysis, accounting for the impact of loan and security losses due to the rise in interest rates on Tier 1 equity capital, and concluding that a substantial number of banks are insolvent if these losses are booked.

[3]Jiang et al. (2023), Drechsler et al. (2023a) and Haddad et al. (2023) further show that when the deposit franchise itself is runnable, even liquid banks could be exposed to a "solvency" run as exiting depositors erode the future franchise value of the bank. Our analysis is focused on the bank's ongoing franchise value absent a run.

securities portfolio also had the highest franchise value in 2021. As a result, we estimate a smaller fraction of insolvent banks than Jiang et al. (2023). Nevertheless a robust conclusion of our work is that the franchise value did not rise as interest rates rose. That is, franchise value has not been a hedge against the rise in interest rates in contrast to regulatory guidance as well as the analysis of Drechsler et al. (2023b).

Finally, we note that our finding that banks' franchise value has positive duration is also in sharp contrast to banks' own estimates of the impact of future interest-rate hikes that they reported in their 10k filings. In their 2021 filings, most banks in our sample, including those with high exposure to long-duration securities, estimated that upward shifts in the yield curve would *raise* the market value of their equity. These estimates, however, were based on the flawed regulatory guidance on the treatment of deposits discussed earlier, and are inconsistent with the actual market value impact of subsequent interest-rate hikes and with the economic logic of our valuation model.

There is a large literature that estimates the interest rate risk of banks. This literature has two branches: one that examines the sensitivity of *cash flows* to interest rate fluctuations, and one that is interested in the sensitivity of bank *value* to interest rate fluctuations. As our analysis is about the solvency of banks, we orient our paper around the latter literature. In the conclusion, we discuss whether and when banks and regulators should be more concerned with the interest rate risk of bank value versus bank cash-flows.

In the first branch, Flannery (1981) measures the earnings sensitivity of 15 large banks to fluctuations in short-term rates, finding that they are quite low. English et al. (2002) presents international evidence, examining the earnings sensitivity of banks to both long and short-term rates, and generally finds a low sensitivity. Drechsler et al. (2021) study a much larger cross-section of U.S. banks and report similar results. They moreover show a cross-sectional hedging pattern that underlies this finding: banks with low interest rate sensitivity in deposit costs, also have low interest rate sensitivity on the asset side. Consistent with this literature, we find that banks choose their security holdings in a manner that stabilizes their

NIM with respect to interest rate shocks.

Stabilizing cash-flows is not the same as stabilizing value with respect to interest rate risk. Begenau and Stafford (2019) show that it is not possible to reject the null that banks' value is exposed to duration risk based on tests that examine the stability of NIM with respect to interest rate shocks. Flannery and James (1984) examine the comovement between interest rates on bank stock returns, showing a relation that is negative and more so in the duration mismatch between assets and liabilities. English et al. (2018) provide well-identified evidence, examining the impact of surprise movements in interest rates due to FOMC announcements on bank stock prices, showing that bank stock prices fall when rates rise. Begenau et al. (2015) consider reported position data on banks' fixed income and derivatives positions, and applying a statistical approach that tracks these reported positions and values and the history of interest rates, estimates banks' interest rate exposures. A central finding is that banks are net long duration risk. Consistent with this literature, we estimate that the median bank portfolio is net long duration. Additionally, we examine the change in bank values during the large interest rate increase from 2021 to 2023, finding that this rate rise lead to losses in bank value, consistent with this literature.

2 Valuation Framework

In this section we develop a basic theoretical model of bank franchise value. There are two potential sources of this franchise value. First, the bank provides transaction services that allow it to pay below market rates on its deposits. Second, the bank may perform screening or monitoring functions that allow it to charge a premium on its loans. These activities are positive NPV as long as the combined deposit and lending spreads exceed the operating cost of the franchise. After laying out the basic model, we then develop the empirical strategy to estimate it.

2.1 Balance Sheet Model

We begin with the following balance sheet model of a bank. The bank raises funds through deposits, external borrowing by issuing bonds or other forms of debt, and issuing equity. These funds are used to make loans or hold tradeable securities. Table 1 illustrates a simple bank balance sheet.

ASSETS	**LIABILITIES**
Loans (L)	Deposits (D)
Tradeable Securities (T)	External Borrowing (B)
	(Book) Equity
Tangible Assets (A)	Liabilities and Equity

TABLE 1

We assume that the bank's tradeable security purchases (T), along with its external borrowing (B) and equity issuance, are all market-based transactions with zero NPV at the time of trade.

On the other hand, the bank can create value via its deposit-taking (D) and loan-making (L) activities. This value results from the interest rate spread the bank offers on deposits, and charges on loans, relative to the equivalent market rate. These spreads can exist because of the bank's market power, informational advantages, provision of transaction services, etc.

Specifically, we define the interest rate spread on deposits and loans, relative to the short-term funding rate, as follows:

$$\text{Deposit rate spread} \equiv r^* - r^D, \quad \text{Loan rate spread} \equiv r^L - r^* \tag{1}$$

where r^D is the average rate paid on deposits, r^L is the average rate earned on loans, and r^* is the short-term risk-free interest rate.

Letting D be the total amount of deposits, and L the total amount of loans, the total cash flow generated by these rate spreads is given by:

$$S \equiv \underbrace{D(r^* - r^D)}_{S^D} + \underbrace{L(r^L - r^*)}_{S^L} \tag{2}$$

To normalize for bank size, we also define spreads scaled by tangible assets:

$$s^D \equiv \frac{S^D}{A}, \quad s^L = \frac{S^L}{A}. \tag{3}$$

We refer to $s = s^D + s^L$ as the total spread earned by the bank, and s^D and s^L as the deposit and loan spread, respectively, per dollar of assets.

To generate these spreads, the bank incurs operating costs C that includes rent, salaries, trading costs, loan losses, etc. We define the bank's franchise value as the present value of these spreads net of costs:

$$\text{Franchise Value} = PV(S - C). \tag{4}$$

The primary goal of our analysis is to provide an empirical estimation of this franchise value and its sensitivity to changes in market interest rates. Understanding this franchise value is essential to determining the solvency of the bank as an ongoing enterprise.

Long-term Solvency: While we have assumed that security purchases and debt issuances have zero NPV initially, ex post the value of these assets and liabilities will fluctuate with market interest rates. To determine solvency, we must incorporate these mark-to-market gains or losses. Define the notation MTM_p to be the current mark-to-market gains or losses for some portfolio of securities p. Specifically, MTM_{T-B} represents the mark-to-market gains on the bank's tradeable securities net of any increase in value of its external borrowing. Then the bank is solvent as an ongoing enterprise if and only if

$$\text{pretax Market Equity} = \underbrace{\text{Book Equity} + MTM_{T-B}}_{\text{Portfolio Value}} + \underbrace{PV(S-C)}_{\text{Franchise Value}} \geq 0. \tag{5}$$

Note that the present value of the spread incorporates changes in the value of bank's deposit and lending portfolio. This solvency condition (5) makes clear that to insure against potential insolvency, the bank's position in tradeable securities and borrowings should hedge potential losses to franchise value.

Short-term Solvency: The ongoing solvency condition (4) is distinct from the condition determining the short-term solvency in the event of a potential bank run. Uninsured creditors will suffer losses in the event of liquidation unless

$$\text{Book Equity} + MTM_T - \theta L \geq 0, \tag{6}$$

where θ represents the "haircut" on the bank's loan portfolio if acquired by another lender, encompassing costs associated with illiquidity, asymmetric information, and mark-to-market adjustments. When condition (6) fails, then in the event of liquidation the bank will be unable to pay the face value of its liabilities. Importantly, there is likely to be significant gap between the left-hand side of (5) and (6). The relevant case for regulators is when this gap is positive and the bank remains solvent from an ongoing perspective yet may be subject to short-term illiquidity, in which case forbearance may be warranted.[4]

In our valuation exercise, we measure the continuation value of the bank and assume that the short-term solvency condition is either always met or the regulator steps in to provide sufficient liquidity support to avoid a run. In a stochastic model, it is possible that realizations of shocks push down the market value of a bank so that the long-term solvency condition,

[4] We note that the evaluation of (6) is the primary emphasis of Jiang et al. (2023).The existence of multiple equilibria in this case will be relevant when evaluating the market value of equity, and will depend in part on regulators' decision rule regarding when to shut down the bank.

(5), is met, but that the short-term solvency condition is violated. In this case, there is the possibility that a bank is liquidated and the ex-ante franchise value of the bank will be affected, as in the analysis of Haddad et al. (2023). As we are interested in the franchise value the bank could achieve if it has sufficient liquidity support to continue as an ongoing concern, we set aside this possibility in our exercise.

2.2 Franchise Value Estimation

In this section we outline the theory behind our approach for estimating franchise value. We begin with a simple (and standard) model of deposit spreads and evaluate its consequences for deposit franchise valuation and duration. We then extend the model to allow for term deposits and loans, and finally summarize our empirical strategy.

A Simple Model of Franchise Value: We start with a standard model of deposit rates and the implications for deposit franchise value. Suppose the deposit rate adjusts linearly to the short-term interest rate:

$$r_t^D = -\alpha^D + \beta_r^D r_t^* \tag{7}$$

Here, β_r^D is referred to as the "deposit beta" and captures the sensitivity of the deposit rate to short rate and is generally estimated to be significantly less than 1. The constant α^D represents an additional fixed discount plus any fee income on deposits.

Consider a bank with assets A , and let d be the fraction funded by deposits such that $D = dA$. Letting c^D be the operating costs per dollar of deposits, the net spread earned by the deposit franchise can be expressed in terms of a return on the bank's assets:

$$S_t^D - c^D D = D(r_t^* - r_t^D) - c^D D = A \left[\underbrace{d(\alpha^d - c^D)}_{\text{Net Fixed Spread}} + \underbrace{d(1 - \beta_r^D) r_t^*}_{\text{Floating Spread}} \right] \tag{8}$$

Equation (8) decomposes the deposit franchise earnings into fixed and floating return components. Consider first the floating component of the franchise value. Because the present value of receiving the floating rate r_t^* in perpetuity is simply \$1 (the same cash flow stream can be created by rolling over a \$1 investment in short-term instruments), the floating franchise value is equal to a constant percentage of the bank's deposits:

$$\text{Floating Franchise Value} = PV\left(D(1-\beta_r^D)r_t^*\right) = D(1-\beta_r^D). \tag{9}$$

This floating component arises solely from the fact that the deposit beta is less than 1. A lower deposit beta increases the value of the deposit spread. Note, however, that a low deposit beta does not imply that the value of the deposit franchise increases when interest rates rise. Although the size of the deposit spread in (8) increases when interest rates rise, so does the implied cost of capital, fully offsetting this increase.

Next, the fixed component of the franchise value can be evaluated as a perpetuity using the current long-term interest rate r_t^∞ as,

$$\text{Fixed Franchise Value} = PV\left(D(\alpha^D - c^D)\right) = D\left(\frac{\alpha^D - c^D}{r_t^\infty}\right). \tag{10}$$

Note that this component of the franchise value can be either an asset or a liability depending on the sign of $\alpha^D - c^D$. If $\alpha^D > c^D$, so that the fixed spread or fee income exceeds operating costs, then the value of the deposit franchise declines when interest rates rise.

Negative Franchise Duration: In order for the value of the deposit franchise to have negative duration and thereby increase with interest rates, there are two possible mechanisms: operating costs in excess of fixed spreads, or negative deposit growth (deposit attrition).

First, suppose operating costs exceed fixed spreads ($c^D > \alpha^D$). Then the fixed component in (9) is a perpetual liability. The present value of this liability decreases as interest rates rise. This mechanism is emphasized, for example, in Drechsler et al. (2017, 2021).

An alternative way to generate negative duration is to assume deposits have a finite expected "maturity" after which their associated income stream disappears. This deposit attrition is equivalent to assuming a negative expected growth rate of deposits. To see the effect on franchise value, consider a setting with a flat yield curve and a constant risk-neutral expected growth rate $g < 0$ for deposits. The deposit franchise value then becomes a declining perpetuity, with present value given by,

$$PV(S^D - c^D D) = D \underbrace{\left[\frac{\alpha^D - c^D}{r_t^\infty} + (1 - \beta_r^D)\right]}_{\text{dur=sign}(\alpha^D - c^D)} \underbrace{\left(\frac{r_t^\infty}{r_t^\infty - g}\right)}_{\text{dur=sign}(g)}. \tag{11}$$

Again, if g is negative, higher interest rates will reduce the present value of the cost of future attrition, which has a positive effect on franchise value. This approach is the one advocated in bank regulatory guidelines (BCBS, 2016) (which indicates using a long maturity for deposits based on expected runoff rates) as well as by Drechsler et al. (2023a,b) (which assumes an expected deposit "life" of ten years).

2.2.1 Term Deposits and Lagged Adjustment

The model of deposit rates in (7) ignores term deposits. Term deposits will cause changes in the average deposit rate to lag changes in current short-term rates, which is evident empirically.

To extend the model to allow for term deposits, let y_t^T be the T-period market interest rate on date t. Suppose a fraction λ of total deposits are short-term demand deposits, with the remaining fraction $1 - \lambda$ held as T-period term deposits. These term deposits earn a constant yield equal to a fraction β_T^D of the market yield on the date invested. Any constant spread between market yields and term deposit rates is absorbed in the constant α^D. In this case we can model the average deposit rate as follows:

$$
\begin{aligned}
r_t^D &= -\alpha^D + \lambda\beta_r^D r_t^* + (1-\lambda) \overbrace{\left[\frac{1}{T}\sum_{j=1}^{T}\beta_T^D y_{t-j}^T\right]}^{\text{Avg. rate on term deposits}} \\
&= -\alpha^D + \underbrace{\left[\lambda\beta_r^D + (1-\lambda)\,\beta_T^D\right]}_{\hat{\beta}_r^D = \text{ Avg. deposit beta}} r_t^* + (1-\lambda)\,\beta_T^D \underbrace{\left[\frac{1}{T}\sum_{j=1}^{T} y_{t-j}^T - r_t^*\right]}_{\ell_t^T = \text{ swap ladder payment}} \qquad (12) \\
&= -\alpha^D + \hat{\beta}_r^D r_t^* + (1-\lambda)\,\beta_T^D \ell_t^T.
\end{aligned}
$$

Here, $\hat{\beta}_r^D$ is the average deposit beta across demand and term deposits, and ℓ_t^T represents the average payment on a ladder of $T-$period fixed-for-floating interest rate swaps. We compute the deposit spread as a ratio to assets as s_t^D:[5]

$$
s_t^D \equiv \frac{S_t^D}{A_t} = \left[\underbrace{d\alpha^D}_{\phi_0^D} + \underbrace{d(1-\hat{\beta}_r^D)}_{\phi_r^D}\ r_t^*\ \underbrace{-d(1-\lambda)\beta_T^D}_{\phi_T^D}\ \ell_t^T\right] \qquad (13)
$$

In other words, we can decompose the deposit spread into fixed (ϕ_0^D), floating (ϕ_r^D), and term swap (ϕ_T^D) exposures.

Given these exposures, we can compute the present value of the deposit franchise as in (11) with an additional term capturing the present value arising from the term swap exposure. Because fixed-for-floating swaps have zero value at initiation, their only contribution to the value of the deposit spread comes from the mark-to-market value of the currently held swaps,

[5]For brevity we include only a single swap term T here; we could include multiple terms to represent different term horizons T, and we do so in our empirical analysis.

which can be approximated as follows,[6]

$$PV(\ell_t^T) \approx \frac{1}{T}\sum_{j=1}^{T}(y_{t-j}^T - y_t^{T-j})(T-j) \tag{14}$$

In our empirical analysis, the relevant term length T is between one and five years. While this term swap component provides a lagging variable that significantly improves our ability to match the movement in spreads, its impact on bank franchise value is minor. Given the relatively short term-length, typical changes in interest rates, and measured sensitivities ϕ_T^D well below one, its value contribution for the median bank is generally less than 1% of bank assets.

Term-swap exposures can also arise from delayed adjustment of deposit rates to federal funds rate changes. Diebold and Sharpe (1990), Hannan and Berger (1991), Neumark and Sharpe (1992) and Driscoll and Judson (2013) present evidence of delayed adjustment in deposit rates, with delays ranging from several weeks to months. The inclusion of term-swap factors in our model can account for the valuation consequences such delayed adjustment.

2.2.2 Total Spreads

We have thus far focused on deposit spreads. We can apply a similar decomposition to lending spreads. The average rate charged on floating rate loan may include a fixed spread and a

[6]To see this, note that the value on date t of a T-period swap initiated at time $t-j$ can be approximated by

$$PV(y_{t-j}^T - r_{t+s}^*|s=0\ldots T-j) = PV(y_{t-j}^T - y_t^{T-j}|s=0\ldots T-j) \approx (y_{t-j}^T - y_t^{T-j})(T-j)$$

by first swapping the floating side to the current $(T-j)$-period fixed rate (which is zero NPV) and then ignoring the minor discounting of these payments over the remaining life of the swap. Averaging over the current swaps gives (14). Given the relatively short time horizon, these approximations are second order and not consequential for our analysis. By ignoring the correlation between j and $(y_{t-j}^T - y_t^{T-j})$ one could further approximate the average in (14) as

$$PV(\ell_t^T) \approx (\overleftarrow{y}_t^T - \overrightarrow{y}_t^T)\left(\frac{T}{2}\right),$$

where $\overleftarrow{y}_t^T$ and $\overrightarrow{y}_t^T$ are an average of past and current yields, respectively:

$$\overleftarrow{y}_t^T \equiv \frac{1}{T}\sum_{j=1}^{T} y_{t-j}^T \quad \text{and} \quad \overrightarrow{y}_t^T \equiv \frac{1}{T}\sum_{j=1}^{T} y_t^{T-j}.$$

spread that is proportional to the current level of interest rates. The bank may also issue fixed-rate term loans (with spread to longer term yields that also includes both fixed and proportional components). Representing the loan rate similarly to (12),

$$r_t^L = \alpha^L + \lambda^L \hat{\beta}_r^L r_t^* + (1 - \lambda^L)\beta_T^L \ell_t^T \tag{15}$$

we find a similar ultimate representation to (14) for the bank's loan spread income:

$$s_t^L = \phi_0^L + \phi_r^L r_t^* + \phi_T^L \ell_t^T . \tag{16}$$

Here, for example, $\phi_0^L = \alpha^L L/A$ with a similar mapping to (13) for the other coefficients.

Loan and Deposit Franchise: Equations (13) and (16) form the basis of our empirical strategy: we will consider both the deposit and loan spreads for individual banks and evaluate their fixed, floating, and term swap exposures. If we let $\phi = \phi^D + \phi^L$ and $c = C/A$ be total operating costs per dollar of assets, this leads to the following generalization of (11) for the estimation of the bank's franchise value:

$$PV(S - C) = A \underbrace{\left[\frac{\phi_0 - c}{r_t^\infty} + \phi_r + \phi_T PV(l^T)\right]}_{\text{dur}\approx\text{sign}(\phi_0 - c)} \underbrace{\left(\frac{r_t^\infty}{r_t^\infty - g}\right)}_{\text{dur}=\text{sign}(g)} . \tag{17}$$

Growth and Risk: The g in equation (17) represents growth/attrition in the bank. As noted earlier, a typical assumption of regulators (BCBS, 2016) as well as some researchers (Drechsler et al., 2023b) is that $g < 0$. This regulatory guidance of assuming a runoff on deposits may be relevant when assessing potential liquidity concerns, and can be motivated as a "conservative" estimate of franchise value. But it is incorrect for the purpose of measuring duration.

A negative g for valuation means that a bank's value stems only from its current cohort of customers, who moreover will exit the bank at rate g. However, deposits in the banking system grow (with GDP) on average, rather than shrink, indicating that $g > 0$. That is, we would expect that with growth of the economy, the current depositors' income will grow and hence their deposits in banks will also grow. With respect to new depositors, banks may pay a cost to attract new deposits and receive some profits associated with the new customers. In our valuation exercise we measure the total franchise costs of running the bank, which will include costs of servicing current customers and costs of acquiring new customers. If the bank is able to collect a quasi-rent on its customers, then growth in both profits and costs is the appropriate benchmark for valuation. Hence for most banks, the deposit franchise represents a claim to a *growing* income stream. From (17), we note duration is increasing in g.

A second consideration that is implicit in equation (17) is risk to growth. Consider our characterization of the value stemming from the deposit franchise as equivalent to the value attached to $D(1 - \beta)$ floating rate bonds. It is possible that as the economy grows/slows, the growth in D will change. The quantity of floating rate bonds in the deposit franchise then grows at a stochastic rate. In this case, standard finance arguments dictate that one should model g as the risk-adjusted growth rate,[7] which will typically be lower than the mean growth rate of the economy.

In our empirical implementation, we will set $g = 0$. As noted, setting $g > 0$ is appropriate given growth in the economy. However, given that growth is risky, the risk-adjusted growth rate may be lower than that of the economy. As a benchmark, we assume that these two effects offset each other and thereby set $g = 0$ (which we view as conservative).

3 Data

Our commercial bank data are from the Call Reports of U.S. banks provided by Wharton Research Data Services. We use data from 1984Q1 to 2021Q2.[8] The data contain quarterly observations of the income statements and balance sheets of all U.S. commercial banks. We

[7] That is, the expected growth rate when weighted according to the risk-neutral probability measure.

[8] We process the raw data with a modified version of the program code developed by Drechsler et al. (2021). We thank Philipp Schnabl for providing the code on his website.

annualize the quarterly income and expense numbers. We exclude banks that have the majority of their deposit liabilities in foreign offices. We also exclude banks that obtain more than 30% of their interest income from credit card business. The highly fee-driven credit card business is not represented well by our model of a deposit and lending franchise. For this reason, we exclude this type of bank. Finally, we exclude banks in the bottom percentile by assets. For banks that are publicly traded, we match the Call Report bank data to equity prices obtained from CRSP.

For the subset of publicly traded banks, we obtain bank holding company data from WRDS that we merge with market capitalization and returns data from CRSP using a link provided by the Federal Reserve Bank of New York.[9] In the part of our analysis where we compare market valuations with our valuation estimates, we aggregate bank-level data at the bank-holding company level.

Table 2 provides summary statistics. Panel A shows statistics for the full sample from 1984Q1 to 2021Q2 that we use to construct and analyze the time series of aggregate banking sector cash flows. On average, we have about 8,500 banks in each of the 150 quarters. Panel B looks at the single cross-section of banks in 2021Q2 that we use to estimate franchise values. Due to mergers and consolidation during the previous decades, the 3,846 banks in this cross-section are substantially fewer than in the earlier part of the full sample.

In terms of balance sheet composition, the median bank in 2021Q2 looks very similar to the full sample: The loans/assets ratio is around 60% and the deposits/assets ratio slightly above 85%. Only for the securities holdings we see a more substantial change with a decline of securities/assets from a median of around 25% to around 18% in 2021Q2.

3.1 Franchise cost

Franchise costs are the operating costs of the banking business. To calculate the operating costs of the lending and deposit-taking franchise, we begin by computing Tangible Non-

[9] See `https://www.newyorkfed.org/research/banking_research/datasets.html`

Table 2
Summary Statistics

The sample in Panel A includes all U.S. commercial banks from 1984Q4 to 2021Q2. In Panel B, the sample is restricted to 2021Q2. All ratios to assets use tangible assets in the denominator. Tangible assets are reported in thousands of dollars.

	Mean	S.d.	p10	Median	p90
Panel A: Full sample 1984Q1 to 2021Q2					
Tangible Assets	829,196	2,1286,833	17,106	72,767	473,614
Securities/Assets	0.2641	0.1572	0.0718	0.2460	0.4793
Loans/Assets	0.5723	0.1608	0.3551	0.5891	0.7658
Deposits/Assets	0.8560	0.0858	0.7796	0.8767	0.9178
Other bus. inc./Assets	0.0069	0.2740	0.0005	0.0023	0.0087
Loan losses/Assets	0.0043	0.0163	0.0000	0.0014	0.0088
Franchise cost/Assets	0.0313	0.3182	0.0180	0.0267	0.0416
Deposit spread	0.0087	0.0176	-0.0066	0.0088	0.0249
Lending spread	0.0132	0.0442	-0.0006	0.0131	0.0279
Total spread	0.0219	0.0443	0.0085	0.0220	0.0354
Obs.	1,288,342				
Panel B: Sample restricted to 2021Q2					
Tangible Assets	4,152,234	712,53,964	75,252	290,949	1,953,962
Securities/Assets	0.2280	0.1602	0.0375	0.2012	0.4538
Loans/Assets	0.5725	0.1525	0.3686	0.5833	0.7603
Deposits/Assets	0.8595	0.0535	0.8017	0.8712	0.9076
Other bus. inc./Assets	0.0072	0.0253	0.0009	0.0039	0.0122
Loan losses/Assets	0.0005	0.0024	0.0000	0.0000	0.0020
Franchise cost/Assets	0.0240	0.0179	0.0151	0.0220	0.0311
Deposit spread	-0.0022	0.0017	-0.0044	-0.0019	-0.0003
Lending spread	0.0220	0.0095	0.0116	0.0213	0.0327
Total spread	0.0198	0.0092	0.0096	0.0192	0.0299
Obs.	3,846				

Interest Expense ($TNIE$) as the sum of salaries, expenses on premises, and other non-interest expenses (largely technology and marketing expenses). We then subtract deposit service charges (DSC) as this fee income partly offsets the operating costs.

We make two further adjustments to costs, described in more detail in Appendix A. First, some banks have substantial other lines of business outside of deposit-taking and lending that do not fit our valuation model, such as brokerage or investment advising fees, underwriting fees etc. We exclude these sources of other business income from our valuation, and so should exclude an estimate of their corresponding expenses (OBX) from the franchise costs.

Second, even though we have excluded banks with a large share of credit card business, there are still banks in the sample with substantial activity in this line of business. Indeed, business credit cards may be an important component of small business lending (Benetton, 2022). While we include credit card interest in our lending spread, a substantial part of revenue in this line of business is fee income that we do not observe directly. Because our franchise costs measure includes the entire cost of the credit card business, this missing fee income creates a mismatch. We correct by deducting estimated credit card fees (CCF) from the franchise cost.

Together, we therefore have the following definition of franchise costs for the banks deposit and lending business:

$$\text{Franchise Cost} = TNIE - \widehat{OBX} - DSC - \widehat{CCF}. \tag{18}$$

The first two terms capture the total non-interest expenses excluding other businesses, while the second two terms are different types of fee income that offset these expenses. Note that neither $\widehat{OBX}$ nor $\widehat{CCF}$ are directly reported by banks. In the appendix we estimate these components based on the magnitude of the bank's other business income and credit card interest earnings. We also test and show that these franchise costs do not appear to be sensitive to changes in interest rates.

Panel B of Table 2 shows that the mean and median of the franchise cost to tangible assets ratio is close to 2% for the median bank in the 2021Q2 cross section that we use for our franchise valuation calculations and the mean is similar.

In Appendix A.1, we present a robustness check where we do these cost adjustments in a simpler fashion. We drop banks with more than 30% of total income from other business income. This screen drops about 7.5% of banks, including some of the largest banks. We then compute Franchise Cost $= TNIE - OBI - DSC$. That is, we do not follow a regression procedure to estimate $\widehat{OBX}$ and $\widehat{CCF}$ as in the main text. We instead include all other business income, which includes credit card fee income, and reduce the franchise costs with such income (note that other business income does not comove with interest rates in a statistically significant fashion). In other words, we are in essence capturing all income and costs, but using our screen to eliminate banks where the magnitude of total income coming from non-deposit and lending activity is large. We then revisit our main result on franchise value duration and show that our main conclusions continue to hold up.

3.2 Deposit and lending spread

To understand the interest-rate risk of banks' deposit and lending franchise, we calculate spreads that banks earn from deposit-taking and lending. These spread calculations are based on the assumption that banks earn spreads only in lending, not on securities holdings, and only in deposit-taking, not in other types of funding. As stated in Section 2.1, we assume that other types of funding or investing are zero NPV transactions.

For bank b at time t, we measure the average deposit and lending rate as

$$r^D_{t,b} = \frac{\text{Interest Expense on Deposits}_{t,b}}{D_{t,b}}, \quad \text{and} \quad r^L_{t,b} = \frac{\text{Interest Income on Loans}_{t,b}}{L_{t,b}} - \rho_b. \quad (19)$$

In the expression for the lending rate, ρ_b adjusts for credit losses as follows. We estimate a bank's expected credit loss under the physical measure as the bank's sample average of credit loss provisions as a percentage of loans outstanding. We then convert these expected credit losses into risk-neutral expected credit losses by using the mapping from physical to risk-neutral expected credit losses for corporate bonds in different ratings categories provided in Table III of Berndt et al. (2018). Formally, the expected loss for bank i is,

$$\rho_b = \frac{\text{Historical Credit Loss Provisions}}{L_b} \times \frac{Q(\text{Loss})}{P(\text{Loss})}. \tag{20}$$

We then define the deposit and loan spread income as in Section 2.1 as follows:

$$s_{t,b}^D = \frac{D_{t,b}}{A_{t,b}}(r_t^* - r_{t,b}^D), \quad s_{t,b}^L = \frac{L_{t,b}}{A_{t,b}}(r_{t,b}^L - r_t^*), \quad \text{and} \quad s_{t,b} = s_{t,b}^D + s_{t,b}^L, \tag{21}$$

where $A_{t,b}$ is tangible assets, $D_{t,b}$ is total deposits, and $L_{t,b}$ is total loans and r_t^* is the federal funds rate.

A total spread of zero would arise, for example, for a bank that earns r_t^* on lending and faces r_t^* as a deposit funding cost. If this bank had no other business lines, it would then also earn r_t^* on its equity.

We also highlight a few points of definition in our approach that are useful to keep in mind. We are interested in the variation of the *deposit spread* with respect to r_t^*, a variable we call the bank's "floating exposure" ϕ_r^D. Much of the literature is interested in the variation of the *deposit rate* with respect to r_t^*, which is the "deposit beta" β_r^D in the literature. From equation (13) we have that $\phi_r^D = d(1 - \hat{\beta}_r^D)$. Additionally, we note that these spreads are not in units of interest rates, but rather are expressed in terms of returns on total tangible assets.

As Panel B of Table 2 shows, with interest rates near zero in 2021Q2, deposit spreads were mostly slightly negative. Nevertheless, the mean and median of total spread is about 1.9% due to a mean and median lending spread of around 2.2%.

4 Aggregate analysis

We start with an analysis based on aggregates. We aggregate balance sheet and income variables across all banks in our data. Based on aggregate data, we then calculate the spreads in (21).

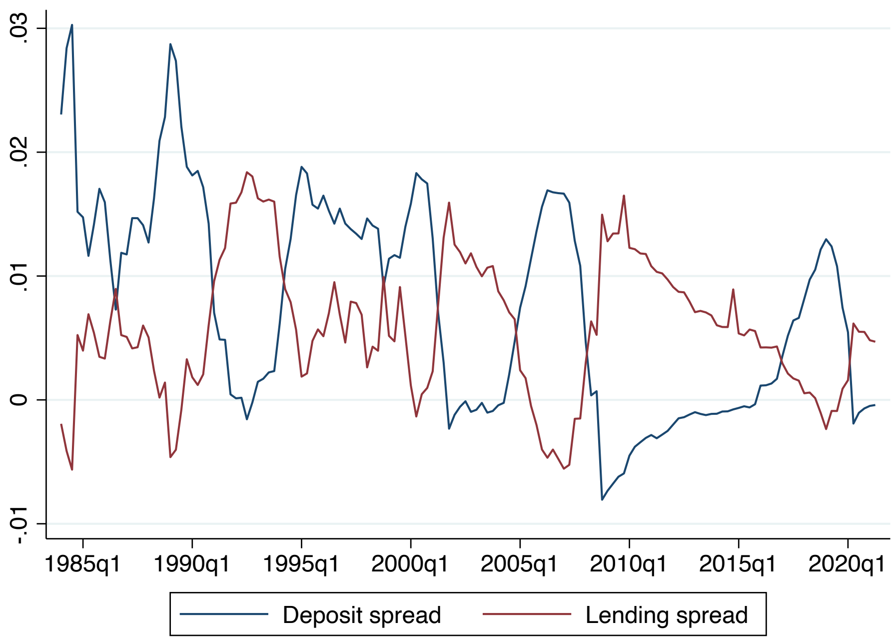
Comparing the deposit and lending spreads in Figure 1a with the fed funds rate shown in Figure 1b, it is evident that deposit and lending spreads move in offsetting directions when the fed funds rate changes. This is related to the observation by Drechsler et al. (2021) that interest income and expenses are strongly positively correlated. As a consequence, the total spread shown in Figure 1b is much more stable than its deposit and lending components. Nevertheless, there is still a clearly visible positive correlation in Figure 1b between the total spread and the federal funds rate.

Figure 1b also shows the time series of the aggregate franchise cost. These costs do not vary with the federal funds rate. The franchise cost is occasionally above the total spread, and after the Great Financial Crisis persistently so. However, as the total spread has a component that floats with the level of interest rates, this does not mean that present value of the franchise cost flow is also above the present value of the total spread flow. To evaluate this, we will need to value the fixed and floating components of the spread separately.

Table 3 examines the dynamics of aggregate spreads with time-series regressions. The first and third column in Panel A show a regression of deposit and lending spreads on the federal funds rate. In line with the impression from Figure 1a, these two spreads load on the federal funds rate with opposite signs. A rise in r_t^* of 100bp is associated with a rise in the deposit spread of 26bp and drop in the lending spread of 8bp. The positive loading of the deposit spread reflects the well-known fact that the deposit beta of deposit interest rates is smaller than one.[10] The negative loading of the lending spread suggests that lending rates

[10]Existing assessments of the interest-rate risks of cash flows from the deposit business often focus on the loading of deposit yields or deposit rates on the federal funds rate, rather than the loading of the deposit spread on the federal funds rate (ϕ_r^D). Drechsler et al. (2021) measure the deposit yield as the ratio of deposit expense to total assets ($d\beta^D$), and estimate an average of 0.37. We have that $\phi_r^D = d(1-\beta^D)$. In aggregate, banks have $d \approx 0.75$ and we estimate that $\phi_r^D = 0.26$, which yields an implied $d\beta^D$ of 0.49 and β^D of 0.65.

(A) Aggregate deposit and lending spreads



(B) Total spread and franchise costs

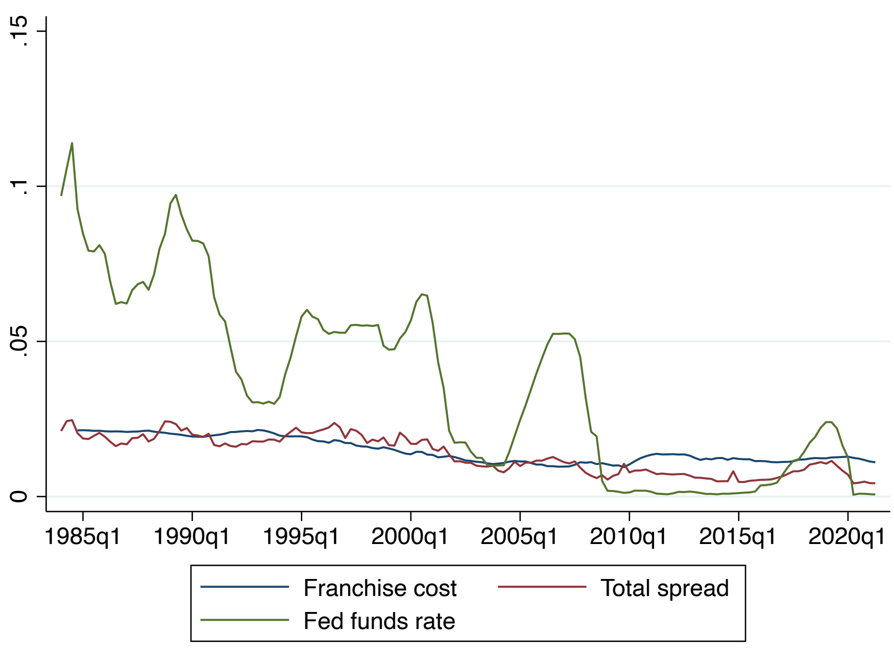


FIGURE 1
Deposit spreads, lending spreads, and franchise costs (4-qtr moving averages)

Table 3
Dynamics of spreads at the aggregate level

The sample includes U.S. commercial banks from 1984Q1 to 2021Q2. In Panel A, the dependent variables are levelas of spreads and in Panel B, the dependent variables are is the quarterly changes in spreads. The term swap variables are for 1-year and 5-year term swaps. The t-statistics shown in parentheses are based on Newey-West standard errors with 8 lags.

	(1) Deposits	(2) Deposits	(3) Lending	(4) Lending	(5) Total
Panel A: Regression in levels					
r_t^*	0.257	0.241	-0.076	-0.055	0.186
	(12.97)	(18.41)	(-3.46)	(-2.53)	(11.93)
ℓ_t^1		-0.238		0.165	-0.073
		(-4.66)		(2.36)	(-1.32)
ℓ_t^5		-0.122		0.197	0.075
		(-4.68)		(4.49)	(1.86)
Intercept	-0.002	0.002	0.009	0.004	0.006
	(-1.56)	(2.27)	(5.85)	(2.96)	(5.94)
R^2	79.16	95.28	17.03	74.07	82.41
Obs.	150	150	150	150	150
Panel B: Regression in changes					
Δr_t^*	0.506	0.312	-0.361	-0.181	0.131
	(18.42)	(4.61)	(-15.76)	(-2.14)	(1.93)
$\Delta \ell_t^1$		-0.247		0.144	-0.104
		(-12.03)		(5.24)	(-4.07)
$\Delta \ell_t^5$		-0.035		0.086	0.051
		(-0.53)		(1.01)	(0.76)
Intercept	0.000	0.000	-0.000	-0.000	-0.000
	(1.45)	(0.57)	(-1.97)	(-1.05)	(-0.31)
R^2	80.33	87.75	48.70	52.02	28.68
Obs.	149	149	149	149	149

adjust less than one-for-one with the federal funds rate.

Note that our estimate for the lending spread differs markedly from a pure "maturity transformation" benchmark model in which the bank uses short-term deposits to fund fixed-rate long-term loans. In that model the lending spread would fall one-for-one with r_t^*. Our estimate for the coefficient ϕ_r^L on r_t^* is far away from -1. Perhaps in part via floating-rate loans and in part by adjusting rates of new loans, banks are able to raise their income from lending when the federal funds rate rises. This finding is broadly consistent with Drechsler et al. (2021).

To allow for term deposits and term loans, as well as delayed adjustment of interest rates, columns (2) and (4) add the term swap cash flows ℓ_t^1 and ℓ_t^5. For example, ℓ_t^1 is the average of one-year Treasury bond yields during the past 4 quarters minus the federal funds rate. This is the cash flow from a long-short portfolio that rolls over positions in one-year Treasury bonds acquired at par and held to maturity, financed by borrowing at the federal funds rate. Hence, the portfolio cash flows approximate the cash flows net of funding costs that one gets from medium-duration fixed-rate assets that are rolled over upon maturity. See equation (12).

Since yield changes across the term structure are largely explained by three factors (level, slope, and curvature), our results are not sensitive to the choice of maturity of the swap ladders. The interest rate spreads in our analysis already take out the level factor. The remaining two factors can be spanned by any two swap factors as long as they are not too close in terms of maturity.

Deposit spreads load negatively on the term swap factors, especially at the one-year horizon, consistent with a significant share of term deposits and possibly also some slow adjustment of deposit rates. For example, when the federal funds rate has recently fallen but long yields remain high, $\ell_t^1 = \frac{1}{4}\sum_{j=1}^{4} y_{t-j}^1 - r_t^*$ increases and in this situation deposit spreads

Koont et al. (2023) report a β^D for the interest rates on deposit savings accounts of 0.54. Greenwald et al. (2023) examine deposit interest rate betas as reported by banks from the Fed's Senior Financial Officer Survey. Based on the survey of May 2022, they compute an average beta on retail deposit rates of 0.28, on wholesale operational deposits of 0.45, and on wholesale non-operational deposits of 0.57.

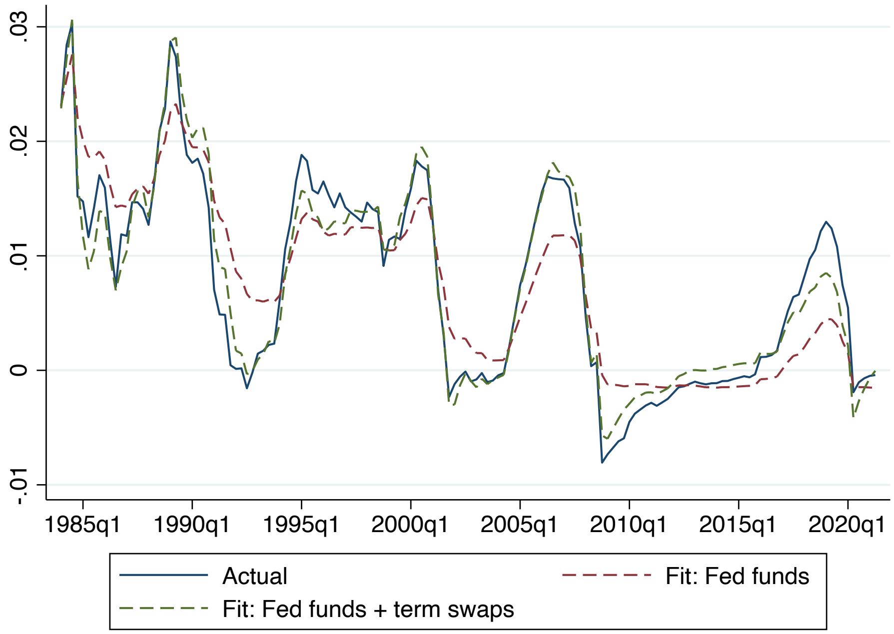
shrink. The opposite is true for lending spreads, which is consistent with slow adjustment of lending spreads via rolling over of fixed-rate loans. For example, when the federal funds rate has recently fallen but long yields remain high, lending rates are still somewhat anchored to the level of long yields, which results in an increase in lending spreads. Lending spreads load positively on both the one- and five-year term swap factors, with the loading on the one-year smaller in magnitude for the lending spread than than that of the deposit spread, while the loading on the five-year is larger in magnitude for the lending spread than that of the deposit spread.

Figure 2 shows the fitted value from the regressions. The figure shows that if the regressions include the federal funds rate only, there is a substantial unexplained component, especially for lending spreads. However, when the two term swap variables at one- and five-year maturity are included, the fit improves markedly and is close to perfect for the deposit spread. The tight fit suggests that there is little room left for further improvements in explanatory power, e.g., by incorporating nonlinearities that are missed in our linear model, as suggested by the evidence for convexity in Greenwald et al. (2023). Begenau and Stafford (2019) presents a similar finding that the loan rates and deposit interest rate are well tracked by the cash flows on a portfolio of US Treasury securities of different maturities.

Column (5) of Table 3 examines the total spread. The high loadings of the deposit spread on r_t^* dominates relative to the negative loading of the lending spread, and hence the total spread has a substantial positive loading on r_t^*. The total spread's positive loading on the federal funds rate suggests that there is a substantial floating-rate component to the franchise value as well. This coefficient ϕ_r would be an important input to a franchise value calculation. In contrast, the loadings ϕ_1^D ϕ_5^D and ϕ_1^L, ϕ_5^L on the term swap variables roughly offset, which leaves the total spread almost unexposed to these factors. To a first approximation, the fixed rate exposure of the bank loan portfolio captured by the term swap factors matches the slow adjustment of deposit rates.

The intercept ϕ_0 in column (5) is important for our analysis. The estimate of 0.006

(A) Aggregate deposit spread



(B) Aggregate lending spread

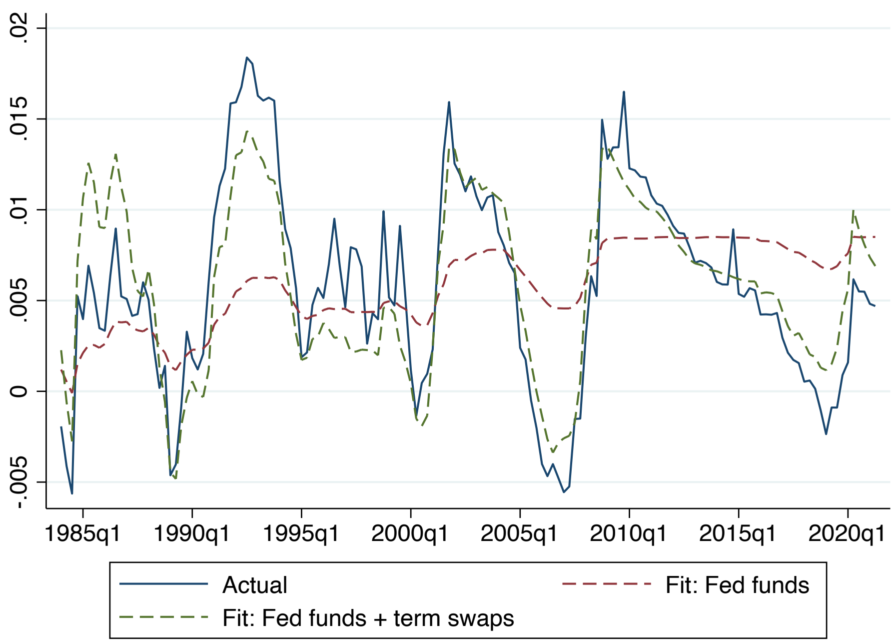


FIGURE 2

Deposit spreads, lending spreads, and fitted values from time-series regressions suggests that banks' aggregate lending spread has a fixed component of 0.6% that accrues irrespective of the level of the federal funds rate. In a franchise valuation of banks in aggregate, this fixed spread component would contribute to the fixed-rate component of the franchise value. It can originate from two sources. First, banks may have assets or deposit liabilities with duration much longer than what we capture with the two term swap factors. The regression effectively approximates these very long duration exposures with a consol bond yield represented as a component of the intercept. Second, if banks charge a fixed spread above market rates in their loan business, this spread will show up as component of the intercept.

To check whether spurious correlations induced by trends could distort the regression in levels, Panel B runs the same regression in quarterly changes. The fed funds rate coefficient for the deposit spread is substantially higher than in Panel A, but in the total spread this is more than offset by an also much lower coefficient on the fed funds rate in the lending spread regression. The net effect is that the total spread coefficient on the fed funds rate is about two thirds the magnitude of the coefficient in Panel A. However, the standard error for this coefficient in Panel B is about four times as large as in Panel A, due to the much lower signal-to-noise ratio in differenced regressions, with the consequence that the point estimate in Panel A is still within about one standard error of the point estimate in Panel B. Statistically, there is therefore little evidence that the regressions in changes deliver substantially different results from the levels regressions.

5 Bank-level analysis

We now turn to a bank-level analysis. We estimate the same regressions as in Table 3, but now at the individual bank level, using data from 2001Q1 to 2021Q2. We start in 2001 to capture the properties of banks' business after deregulation in the 1990s. That said, our bank-level estimates are broadly consistent with the estimates from aggregate data that used the full 1984Q1 to 2021Q2 sample.

Table 4
Summary Statistics of Bank-level Spread ϕ Estimates

The sample includes U.S. commercial banks from 2001Q1 to 2021Q2. The term swap variables are for 1-year and 5-year term swaps.

	(1) Intercept ϕ_0	(2) Fed Funds ϕ_r	(3) Term Swap ϕ_1	(4) Term Swap ϕ_5
		Panel A: Regression in levels		
		Deposit spread		
mean	0.002	0.26	-0.31	-0.27
p50	0.003	0.25	-0.31	-0.27
sd	0.003	0.13	0.12	0.12
		Loan spread		
mean	0.018	-0.11	0.13	0.30
p50	0.018	-0.10	0.13	0.31
sd	0.009	0.19	0.21	0.22
		Total spread		
mean	0.020	0.15	-0.18	0.031
p50	0.020	0.15	-0.17	0.034
sd	0.009	0.23	0.22	0.22
		Panel B: Regression in changes		
		Deposit spread		
mean		0.26	-0.25	-0.25
p50		0.27	-0.25	-0.25
sd		0.16	0.089	0.15
		Loan spread		
mean		-0.13	0.14	0.26
p50		-0.11	0.14	0.27
sd		0.36	0.17	0.37
		Total spread		
mean		0.13	-0.11	0.00
p50		0.15	-0.11	0.02
sd		0.38	0.18	0.37

Table 4 presents summary statistics of the bank-level regression results. Focusing on the means of the estimates, we obtain results that are similar to the earlier estimates from aggregate data. In particular, for the total spread in Panel A we find an an average positive loading on the federal funds rate and loadings with opposite signs on the term swap variables. Hence, the bank-level analysis confirms that the typical bank is able to raise lending income when the federal funds rate rises to largely insulate the lending spread from exposure to the federal funds rate. We also note that the fit in the bank-level regression is quite good. The regression of the deposit spread on the fed funds rate, the term swap variables, and a bank fixed effect gives an R^2 of 94.4%. As in the aggregate data, the term swap variables are important to capture the slow adjustment of the deposit spread to changes in the level of interest rates, and once this accounted for, there is little further room to improve the fit beyond our linear model.

We find a substantially positive intercept. The mean of the bank-level intercept is 2.0%, which is higher than the 0.6% estimate from the aggregate analysis. This indicates that smaller banks (which obtain a higher weight in the average of bank-level estimates than in the aggregate analysis) appear to have a higher fixed spread component. The higher fixed spread for the median bank comes predominantly from the loan side.

Panel B presents results for regression specifications in changes. At the bank level, the differences between the level and changes regressions are minor. Regressions in levels are possibly subject to contamination by trends in dependent and explanatory variables unrelated to the mechanisms that we are trying to capture. However, regressions in changes are more sensitive to bias due to inertia effects and noise. Moreover, at the bank-level, the analysis of changes can be distorted by mergers and other corporate actions. For the remainder of the analysis, we focus on the regression in levels. We winsorize betas at the 5% level and we recalculate intercepts based on these winsorized betas.

5.1 Franchise value in 2021

We now calculate banks' franchise value in 2021Q2 following the valuation framework in (17). We set $g = 0$ in our computations. Note that some approaches to valuation set $g < 0$ based on the assumption of deposit attrition. Since banks on average grow, a negative g is inconsistent with the data. On the other hand, g in our valuation framework is a risk-neutral growth rate. We opt to set $g = 0$ which assumes that the positive growth is equal to the negative risk adjustment required.

The source of the franchise value is the total spread that we analyzed in the regressions reported in Table 4. The total spread represents the cash flow (as a proportion of tangible assets) that the bank earns from lending and deposit taking. Based on the regression estimates, these cash flows, and their associated present value (PV), can be decomposed into the following three components:

- Fixed component: The PV of the constant cash flow component represented by the intercept ϕ_0 net of franchise costs c, valued as a perpetuity.

- Floating component: The PV of the cash flow component represented by floating exposure, which is given by ϕ_r (that is, the sensitivity and PV are the same, since a floating exposure trades at par).

- Term inertia component: The PV of the cash flow component represented by the exposures ϕ_1 and ϕ_5 to the term swap factors ℓ_t^1 and ℓ_t^5, as approximated by (14)

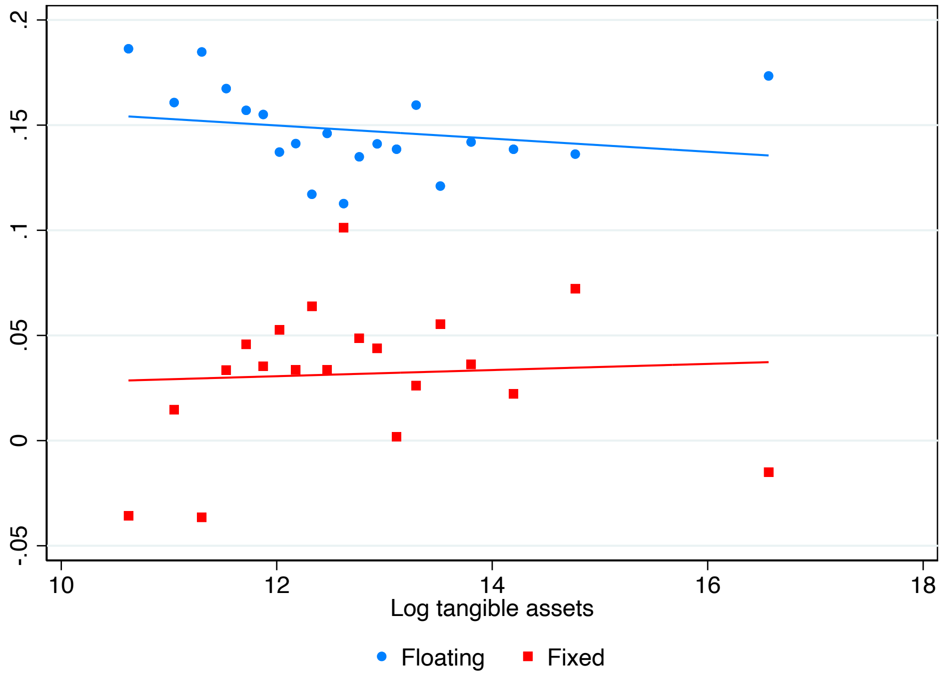
The first component is akin to a perpetual bond. We take the intercept, after subtracting franchise costs, as an annual cash flow that we discount as a perpetuity. As an approximation for a perpetual bond yield we use the 30-year forward rate extracted from Treasury yields at the end of 2021Q2. The second component is a floating rate bond whose value is ϕ_r. The PV of the third component should be relatively small. It may deviate from zero depending on recent changes in the slope of the yield curve, but its unconditional PV is zero.

Beta estimates used in these calculations are those from Table 4, Panel A, but now winsorized at a 5% level. In addition, we exclude banks in the bottom percentile by assets in 2021Q2.

Figure 3a presents the fixed and floating components of franchise value for banks that are binned by size. For the median bank, the franchise value of the bank is attributable more to the floating component (which mostly represents the present value of future deposit spreads) than the fixed component (which mostly arises from the present value of future loan spreads). Egan et al. (2022) using a different methodology estimate that the median bank earns 60-70% of value from the deposit side while the loan side contributes 30-40%. We cannot directly compare our numbers to theirs, as we do not attempt a split franchise costs into deposit business and lending business components, but the substantial value contribution of the floating component in our analysis is broadly consistent with their estimates. The high value of the floating component is also consistent with data from the sale prices of bank branches that show higher prices for banks with a larger core deposit business (Sheehan, 2013; Cyree, 2010). For smaller banks, the floating component plays a particularly significant role. That is, small banks have a deposit base on which they are able to pay a deposit rate that is substantially below market rates. There is evidence that larger banks have a higher deposit beta than smaller banks (Drechsler et al., 2021) and evidence that digital banks, which likely have a more sophisticated depositor base, have a higher beta than non-digital banks (Koont et al., 2023). Interestingly, the banks in the very largest size bin look similar to the small banks in that the franchise value originates entirely from the floating component. This could be a consequence of the perceived too-big-to-fail status of these banking giants that gives them an advantage in the deposit market. These very large banks in the highest size bin also drive the results in our earlier aggregate analysis.

Figure 3b shows the fixed and floating components, binned by franchise costs. High cost banks have a negative fixed component of the franchise value, which means that the duration of the franchise value is negative. This can provide a motive for holding long-

(A) Binned by size



(B) Binned by franchise value cost

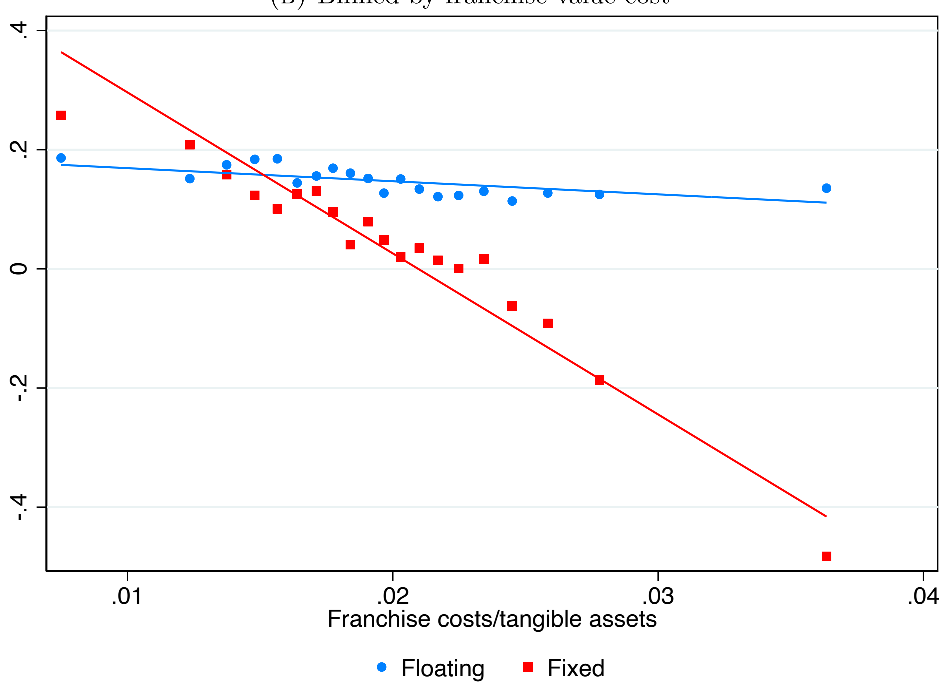


FIGURE 3
Fixed and floating components of franchise value

TABLE 5
Franchise Value Statistics

Beta estimates used in this analysis are those from Table 4, Panel A, but now winsorized at a 5% level. In addition, we exclude banks in the bottom percentile by assets in 2021Q2.

	(1) Mean	(2) Median	(3) S.E. of Mean
Panel A: Franchise value inputs			
ϕ_0	0.0206	0.0207	0.0001
ϕ_r	0.1475	0.1449	0.0029
Franchise cost/Assets	0.0198	0.0194	0.0001
Panel B: Franchise value components			
Floating FV	0.1475	0.1449	0.0029
Fixed FV	0.0317	0.0468	0.0055
Term inertia component	0.0022	0.0024	0.0003

duration securities to hedge the negative duration of the franchise value.

We conclude from this analysis that most banks' franchise value in 2021 is exposed to risk from a rise in interest rates. For the typical bank, the fixed spread component of the total spread exceeds fixed franchise costs, which renders the duration of the franchise value positive. Panel B in Table 5 shows that the mean fixed component of the franchise value is positive and close to 3.2% of tangible assets.

Panel B also reports a standard error for this mean of the fixed franchise value component, as well as for floating component, and, in Panel A, the key inputs to the franchise value calculations. To calculate these standard errors, we make two assumptions. First, all between-bank heterogeneity in the estimated regression coefficients ϕ_0, ϕ_r, and the other inputs of the franchise value calculation, is due to estimation error. This assumption likely substantially overstates the standard error, as there is presumably some between-bank heterogeneity in the true values of these inputs. Second, we assume that the residuals in the bank-level regressions are uncorrelated across banks. This likely understates the standard error to some extent, as there may be some commonality in residuals. Based on these assumptions, we can estimate the standard error consistently as $1/\sqrt{N}$ times the cross-sectional standard deviation of the franchise valuation calculation inputs.[11] Given the likely large upward bias in the standard error from ignoring true heterogeneity in these input variables, we regard these standard error estimates as an upper bound. Based on the standard error estimate for the mean fixed franchise value component, the estimated mean is more than five standard errors above zero. Hence, the inference that the typical bank has a franchise value with positive duration can be made with a high degree of statistical confidence.

Panel B also shows that the present value of the term inertia component is very small, less than a basis point of tangible assets for the median bank. This is why we do not include the term inertia component in the earlier plots.

5.1.1 Robustness checks

In Appendix B, we report a number of robustness checks. We first show that that the risk exposure estimates are similar when we use four-quarter moving averages of dependent and explanatory variables in levels regressions, and multiple lags of explanatory variables in differences regressions. We then address the concern that banks' interest rate risk exposures could be time-varying. We find similar results when we use a shorter, more recent subsample 2011 to 2021 to estimate factor loadings. We further obtain similar franchise value estimates when we use factor loadings estimated in differences regressions instead of levels. Next, we check the assumption we made in our valuation approach that franchise costs and loan loss provisions are not interest rate sensitive. Supporting our assumptions, we find quantitatively small sensitivities. We also assumed in our valuation that asset levels are not sensitive to interest rates. We find support for this assumption as well. Therefore, regressing the deposit and loan spreads, expressed as a fraction of assets, on the interest rate factors gives an accurate assessment of the interest rate risk exposure of banks' cash flows. This exposure can come from sensitivity of the ratio of deposits or loans to assets to interest rates, or from deposit and

[11] This approach is in analogy to Fama-MacBeth regressions in asset pricing research where $1/\sqrt{T}$ times the time-series standard deviation of date-by-date cross-sectional regression coefficients consistently estimates the standard error if errors are uncorrelated across time and the true regression coefficients are time-invariant.

loan rate variation with interest rates. We find that both components contribute. Finally, we provide some checks on the specification of interest rate factors. Inclusion of factors that can capture an asymmetric response of deposit and loan rates to interest rates has little impact on our results. Similarly, replacing the swap factors based on lagged long-term yields with factors based on lagged federal funds rate observations, which would be better suited than our baseline swap factors to capture delayed adjustments to past federal funds rate changes, has very little effect on our results.

5.1.2 Implied and actual market-to-book ratio in 2021

As a check of our valuation framework and the franchise value estimates, we compare the market-to-book ratio implied by these calculations to the actual market-to-book for banks with publicly traded equity. For these comparisons, we look at the banking subsidiaries aggregated at the bank holding company level for publicly traded bank holding companies. We measure the actual market-to-book ratio at the end of 2021Q2 using market equity, plus book assets minus common equity, divided by tangible assets.

To map to available market data, we can use our valuation model to estimate the market value of the firm's equity (conditional on its long-run survival). Because returns to equity holders are subject to taxes, given tax rate τ, we must adjust the pretax market equity by the factor $(1-\tau)$ to determine the post-tax market equity value:

$$\begin{aligned} \text{Market Equity} &= (1-\tau)\text{Pre-tax Market Equity} \\ &= (1-\tau)\left(\text{Book Equity} + \text{MTM}_{T-B} + PV(S-C)\right) \qquad (22) \end{aligned}$$

Finally, to abstract from differences in leverage, it will be useful to assess and compare banks based on the market value of their assets (relative to their book value). For this computation we adjust for the difference between the market and book value of equity:

$$\text{Asset } M/B = 1 + \frac{\overbrace{(1-\tau)\left(\text{MTM}_{T-B} + PV(S-C)\right) - \tau \text{ Book Equity}}^{\text{Market Equity - Book Equity}}}{\text{Book Assets}} \tag{23}$$

Equation (23) highlights the tax disadvantage associated with bank equity; for banks to add value to their investors, the franchise value associated with deposit and lending activity must overcome this additional cost. We set $\tau = 0.25$ in our computations.

If q_i is the true market-to-book ratio of bank i and our estimates of the franchise value are noisy but unbiased, then $\hat{q}_i = q_i + e_i$ where e_i is mean-zero noise uncorrelated with q_i. In this case, averaging $\hat{q}_i$ of many banks in a neighborhood of q_i should yield a value approximately equal to q_i. Figure 4 shows that our model estimates, $\hat{q}_i$ are in line with the market estimate q_i. In this figure observations are binned by the equity market measure of M/B and we can see that the the average model-estimated M/B in each bin is quite close to the equity market's M/B. It is also noteworthy that the actual M/B of banks in 2021Q2 are generally greater than unity. This is not consistent with the analysis of Begenau and Stafford (2019) that argues that banks' earnings track a traded portfolio of capital market assets, and that banks do not provide an "edge" beyond this portfolio. In their analysis the M/B ratio will be at most one.[12]

5.2 Securities holdings as hedges?

We have shown so far that the typical bank has a franchise value (FV) with positive duration. The typical bank therefore has no duration-hedging motive for holding long-duration securities. However, in the cross-section of banks, some banks have FV with negative duration. For this reason, we now investigate whether the cross-sectional variation in banks' securities holdings is consistent with a duration-hedging motive.

[12]The main differences between our analysis and theirs are that our cost estimates are around 1.4% lower for the median bank and our risk-neutral loan loss estimates are much lower than the corporate bond credit spreads and mortgage spreads they use in their analysis.

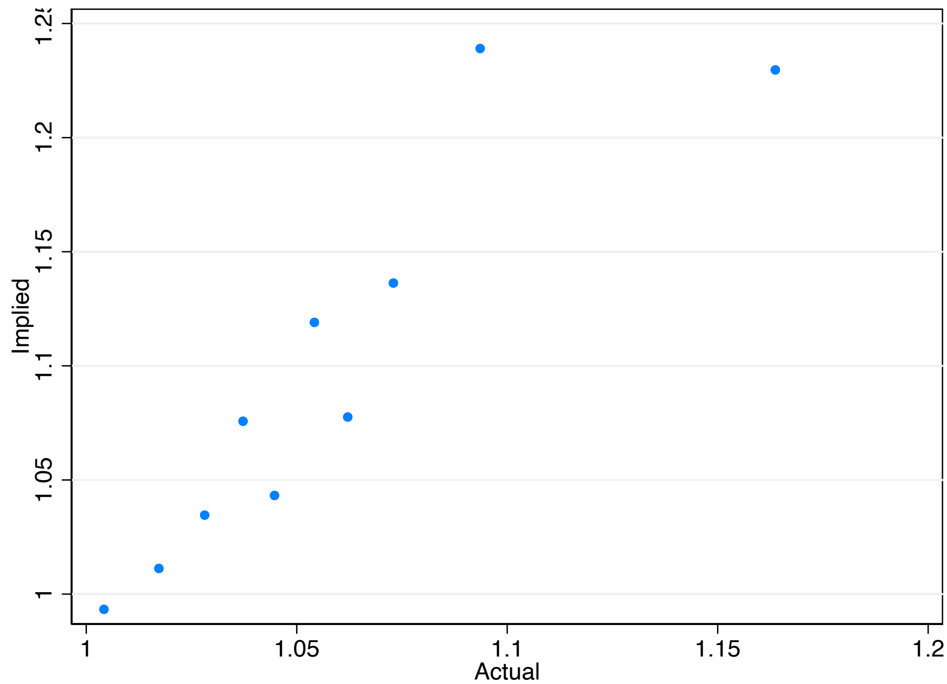


FIGURE 4
Actual and model-implied market-to-book in 2021Q2

Table 6 shows regressions of banks' securities holdings (securities share × duration of securities) in 2021Q2 on the fixed FV and floating FV. Column (1) shows that banks with a low fixed FV hold more duration. While this is consistent with duration-hedging motive, the R^2 is very low.

In column (2) we include both fixed and floating FV as independent variables. Now we see that the R^2 rises substantially and the explanatory power of the fixed FV falls considerably. In column (3) we add log tangible assets as a control for size, and doing so has no appreciable effect on the results. In column (4), we split the floating FV component into its deposit and lending parts. Both are positively related to securities duration exposure, but with a larger coefficient for the floating FV from the lending business. We will come back to this point.

Figure 5 presents the result graphically. We sort the banks into 25 equally sized bins on the basis of 5 bins of each of fixed and floating FV. We then plot the average securities duration in each bin. We see that securities duration is largely driven by variation in floating

Table 6
Determinants of Long-Duration Securities Exposure

The sample includes all U.S. commercial banks in 2021Q2. The dependent variable is the duration of securities held by each bank times the ratio of securities holdings to tangible assets. t-statistics are reported in parentheses.

	(1)	(2)	(3)	(4)
Fixed FV component	-0.718	-0.201	-0.202	-0.094
	(-6.74)	(-2.19)	(-2.20)	(-1.04)
Floating FV component		3.036	3.025	
		(16.28)	(16.21)	
Floating FV deposits				1.709
				(6.21)
Floating FV lending				3.929
				(17.33)
Log tangible assets			-0.047	
			(-2.49)	
Intercept	2.183	1.714	2.311	2.140
	(69.95)	(52.13)	(9.42)	(29.17)
R^2	0.02	0.09	0.09	0.11
Obs.	3772	3772	3772	3772

FV, with the highest duration in the highest floating FV bin. The variation across the fixed FV bins is far smaller in magnitude.

Overall, the evidence does not support the notion that banks are using securities to hedge the duration of FV. The strong relationship between the floating component of FV and banks' holding of positive duration securities cannot be explained by duration-hedging motives. Then what could explain the empirical patterns in securities holdings?

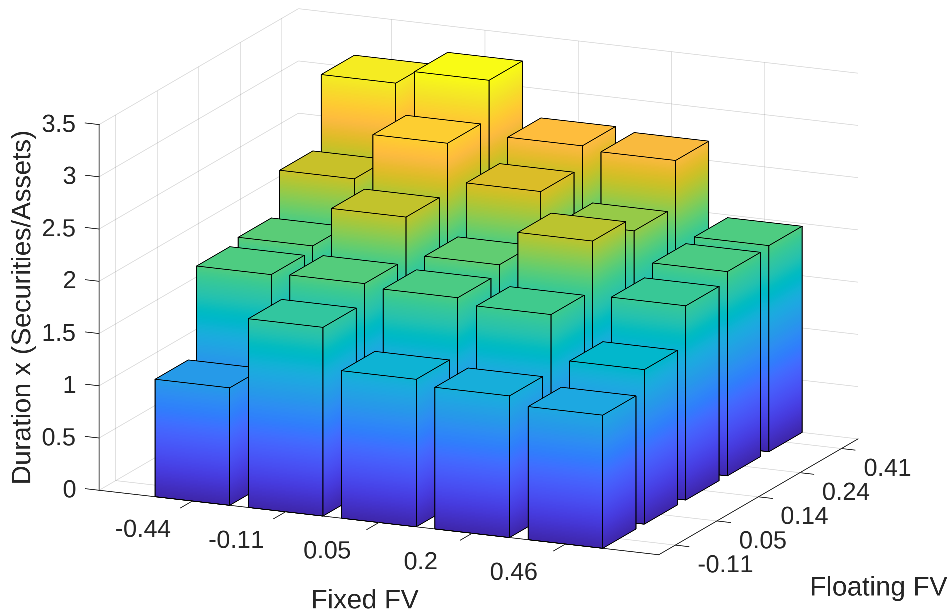


FIGURE 5
Long-Duration Securities Exposure as Function of Fixed and Floating Components of Franchise value

5.2.1 Cash flow hedging?

One possible rationale for securities holdings is that banks aim to stabilize their net interest margins (NIM). Take a bank with a high ϕ_r and negligible loadings on the swap factors so that the total spread it earns from lending and deposits is increasing in r_t^*. The cash flow from a long-term security that is funded with short-term debt at r_t^* is decreasing in r_t^*. Thus, by holding long-term securities, this bank is effectively stabilizing the sum of lending-minus-deposit income and the securities-minus-funding cost income. We would then expect banks with a higher exposure of lending-minus-deposit income to r_t^* to have a higher securities share. Moreover, securities holdings should contribute to lowering the sensitivity of the NIM to r_t^*.

Drechsler et al. (2021) find that banks do indeed largely neutralize the exposure of NIM to short-term interest rate movements, consistent with a cash flow hedging motive. Here we examine the NIM exposure in our multi-factor interest rate risk framework. Let B denote the amount of securities held, and let

$$s_t^B = \frac{B}{A}(r_t^B - r_t^*) \tag{24}$$

denote the spread to the federal funds rate earned from securities holdings as a share of assets. Then the NIM as a share of assets is

$$NIM = s_t^D + s_t^L + s_t^B + (1-d)r_t^*. \tag{25}$$

Implicitly, this calculation of NIM also includes the spread on cash holdings (e.g., repo, reserves) with the assumption that this spread is approximately zero. The last term on the right-hand side is the portion of the balance sheet that comprises assets funded by equity. Expressing the spread earned on securities holdings in terms of its exposure to interest rate factors,

$$s_t^B = \phi_0^B + \phi_r^B r_t^* + \phi_T^B \ell_t^T, \tag{26}$$

and doing the same for $s_t^L + s_t^B$ as well, equation (25) implies NIM exposures to the interest rate factors of

$$\begin{aligned} \phi_r^{NIM} &= 1 - d + \phi_r + \phi_r^B, \\ \phi_T^{NIM} &= \phi_T + \phi_T^B. \end{aligned} \tag{27}$$

To apply this to our empirical setting, we make the approximation that the contribution of the one-year swap factor to cash flow risk is negligible as it involves differences in yields at very close maturities and timing. With the remaining swap factor having $T = 5$, and breaking up the swap factor into its two components, the average past yields and r_t^*, this then gives

$$NIM \approx \phi_0^{NIM} + \underbrace{(\phi_r^{NIM} - \phi_5^{NIM})}_{\text{NIM sensitivity}} r_t^* + \phi_5^{NIM}\left(\frac{1}{5}\sum_{j=1}^{5} y_{t-j}^5\right) \tag{28}$$

To illustrate how securities holdings affect the NIM sensitivity, it is useful to consider two cases:

- Floating-rate securities: If all securities are floating-rate, then $\phi_r^B = 0$ and $\phi_5^B = 0$, and so $\phi_r^{NIM} = 1 - d + \phi_r$ and $\phi_5^{NIM} = \phi_5$. The NIM sensitivity is

$$\phi_r^{NIM} - \phi_5^{NIM} = 1 - d + \phi_r - \phi_5. \tag{29}$$

  In this case, securities holdings do not hedge the exposure of NIM to short-term interest rates.

- Fixed-rate securities: If all securities are fixed-rate with maturity $T = 5$ at time of purchase, and rolled over in a laddered portfolio, then $\phi_r^B = 0$ and $\phi_5^B = B/A$, and hence $\phi_r^{NIM} = 1 - d + \phi_r$ and $\phi_5^{NIM} = \phi_5 + B/A$. The NIM sensitivity is

$$\phi_r^{NIM} - \phi_5^{NIM} = 1 - d + \phi_r - \phi_5 - B/A. \tag{30}$$

  So, B/A can be chosen to set this term to zero. The bank has then completely swapped all short-rate exposure into 5-year exposure. If the securities have maturity $T > 5$, then the expression for the NIM sensitivity is approximately still the same, but ϕ_5^B would not be equal to B/A.[13]

To illustrate the cash flow hedging effect of securities holdings, Panel (A) of Figure 6 compares banks' hypothetical NIM sensitivity without cash flow hedging, calculated as on the right-hand side of (29), on the horizontal axis to the actual NIM sensitivity on the vertical axis. While the binned no-hedging sensitivities on the horizontal axis range from 0 to 0.6, the actual NIM sensitivity estimates for banks in these bins range from only -0.15 to 0.15. That

[13]Suppose $T = 10$. In time-series data from 1984Q1 to 2021Q2, $\ell_t^{10} \approx 0.02 + 0.83 \times \ell_t^5$ with R^2 of 92%. Adding r_t^* as an explanatory variable to the regression yields an insignificant coefficient and negligible increase in R^2. Hence, a laddered securities portfolio with $T = 10$ would yield $\phi_r^B \approx 0$, as in the case $T = 5$, and $\phi_5^B \approx 0.83 \times (B/A)$. Since $\phi_r^B \approx 0$, we still get $\phi_r^{NIM} - \phi_5^{NIM} = 1 - d + \phi_r - \phi_5 - B/A$. as in (30).

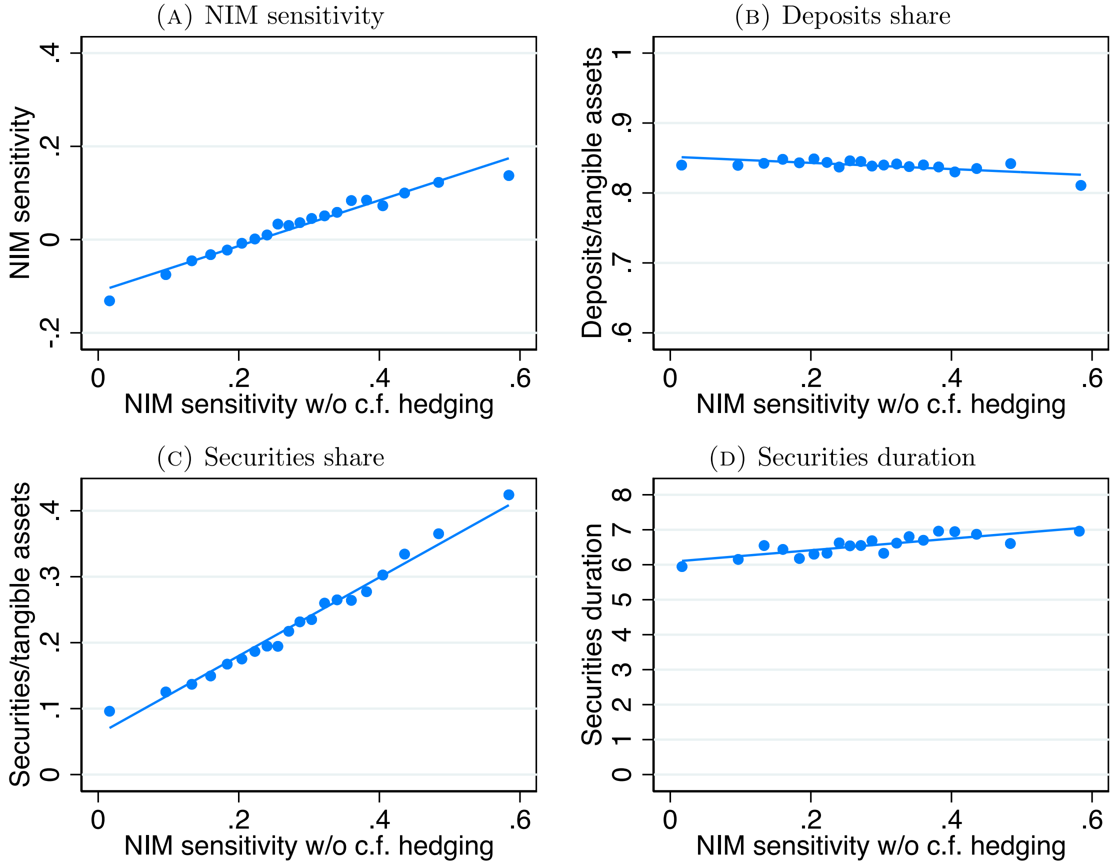


Figure 6
Do Securities Hedge Cash Flow Risk?

is, the figure shows that banks' actual NIM sensitivities are indeed substantially closer to zero than those that would prevail without cash flow hedging. Panel (B) displays the average ratio of deposits to tangible assets for banks over the same 2001–2021 sample period used to estimate spread betas. The deposit share varies very little across bins, indicating that most of the variation in the no-hedging sensitivities on the horizontal axis comes from spread beta differences, not differences in deposit share. Panel (C) shows the banks' average securities share B/A during 2001-2021. The share varies strongly with the no-hedging sensitivities. Furthermore, the observed B/A closely aligns with the difference between the sensitivities on the horizontal and vertical axes in Panel (A), as predicted by comparing (29) and (30). For example, for the median bank, the difference in Panel (A) is slightly above 0.20 and the securities share in Panel (C) is about 0.20. Panel (D) illustrates that these securities typically have long durations, ranging from 6 to 7 years. This indicates that securities holdings transform the short-term interest rate exposure of cash flows into lower-frequency exposure to long-term rates. These results show that securities holdings of banks hedge to a substantial extent the exposure of cash flows to short-term interest rates. Our findings are broadly consistent with the empirical findings in Drechsler et al. (2021).

However, Drechsler et al. (2021) argue that holding securities for cash-flow hedging purposes also provides a duration hedge for value. In their model this happens because a free-entry assumption forces a negative correlation of deposit betas and franchise costs. Put in our terminology, their model implies that when the floating FV is high, fixed FV is strongly negative, and hence FV duration is negative. Securities holdings then simultaneously hedge the cash flow risk of the floating FV component while also duration-hedging the fixed FV. However, this coincidence of cash-flow and duration-hedging is not borne out in the data. As we showed earlier in Table 5, the typical bank has a positive franchise value duration, and hence no duration-hedging motive for holding securities in the first place. Moreover, Table 6 shows that in the cross-section, the securities share varies predominantly with the floating component of FV, not with the fixed component, inconsistent with a duration-hedging role of securities.

5.2.2 Perceived duration hedging motivated by regulatory guidance?

While the evidence so far is consistent with banks engaging in cash-flow hedging, the regulatory guidance banks receive is an alternative rationale. Regulators suggest that banks treat a low-β deposit as if it is a long duration fixed rate liability. Table 2 in BCBS (2016) guides banks to slot the cash flow on core deposits, depending on type of deposit, into maturity buckets of up to 5 years. Thus, a bank with a low β (high ϕ_r) may slot many deposits as long-duration liabilities, and then choose to hold positive duration securities to offset this regulator-prescribed negative duration of the deposit base. This misperception of deposit

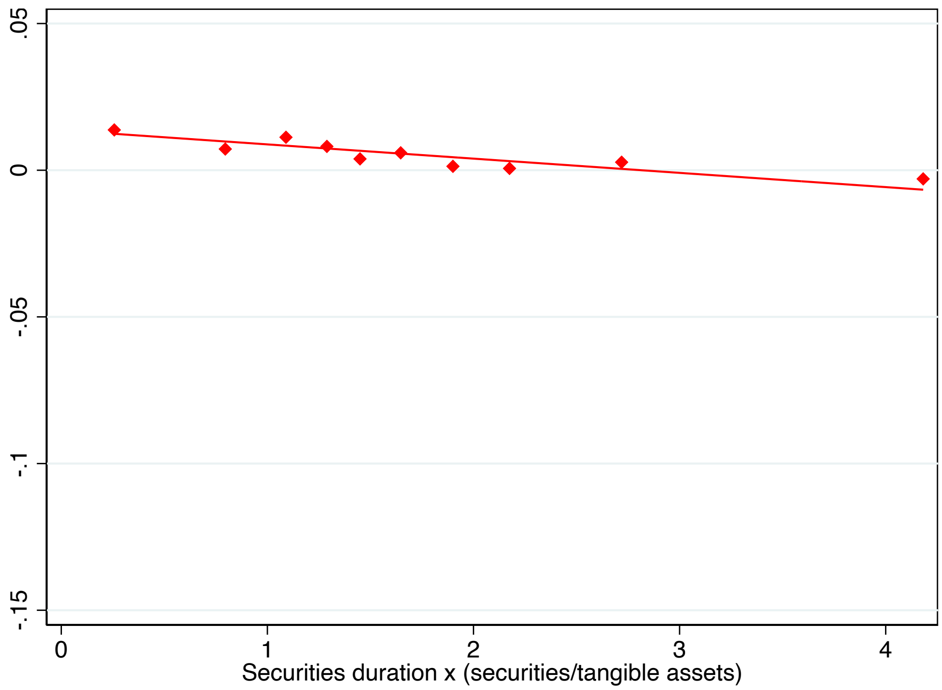


FIGURE 7
Banks' 10-K estimates in 2021 of potential losses, in units of change in market-to-book, for +100bp yield curve shift

liabilities as having negative duration may then make it seem like cash-flow hedging not only stabilizes NIM, but also has duration-hedging benefits.

For publicly traded banks, we can infer their perception of duration risk from measures of interest rate risk that they report in their annual 10-K filings. Most banks report estimates of how shifts in the yield curve of various magnitudes (e.g., 100bp, 200bp, and 400bp parallel shifts) would affect their net interest income, and some, but not all, report the estimated effect on the market value of equity. When available, we collect this information from the 2021 10-K filings of all publicly traded bank holding companies in the U.S. Figure 7 shows banks' estimates for the effect of a 100bp parallel upward shift in the yield curve, expressed as the implied change in the market-to-book assets ratio, binned by the duration contribution of securities holdings.

There are two important takeaways in this figure. First, almost all banks estimate that a rise in interest rates will raise the value of their equity, even though we find that the typical bank's franchise value has positive duration and, in addition, the typical bank holds long-duration securities. Second, even banks with the highest exposure to long-duration securities estimate to be hedged against duration risk. A likely explanation is that the framework provided by regulatory guidance encourages banks to perceive negative duration of deposit liabilities.[14]

The final piece of our analysis will now contrast these estimates provided by banks with those implied by our model and actual empirical estimates of bank losses as a result of rising interest rates from 2021 to 2023.

6 Banks' Losses in 2023

In our framework, the interest-rate hikes between 2021Q2 and 2023Q1 affect the value of bank equity through two channels. First, higher rates lead to higher discounting of the fixed-rate component of the spread that banks earn from combined lending and deposit business. This reduces the present value of the fixed component. We estimate this valuation change by keeping costs and the other inputs of the franchise value calculation as in 2021Q2, but now with the discount rate for the fixed component based on the 30-year forward rate from 2023Q1, and with the term swap valuation based on the yield history up to 2023Q1.

Second, banks can have losses outside of the lending and deposit-taking business that we have not captured in our analysis of spread dynamics. In particular, losses on securities holdings can lead to losses that could potentially push market-to-book below unity and the bank into insolvency. Jiang et al. (2023) calculate valuation losses due to higher rates on securities holdings of banks and loans. Drechsler et al. (2023a) have argued that the rest of the bank business model rises in value as interest rates rise. We assess the total effects using

[14] Golding and Lucas (2024) and Hanson et al. (2024) note that current risk-based capital requirements do not account for interest rate risk on long-duration securities such as Treasurys and mortgage-backed securities. They argue that accounting for interest rate risk in capital requirements would reduce the risk of SVB-type episodes.

our framework and estimates. We add the Jiang et al. (2023) estimates of losses on securities holdings to our estimates of changes in franchise values to obtain an estimate of the loss in banks' market value of equity. For comparison, we also look at the Jiang et al. (2023) total loss estimates which do not include the contribution of changes in banks' franchise value.

6.1 All banks

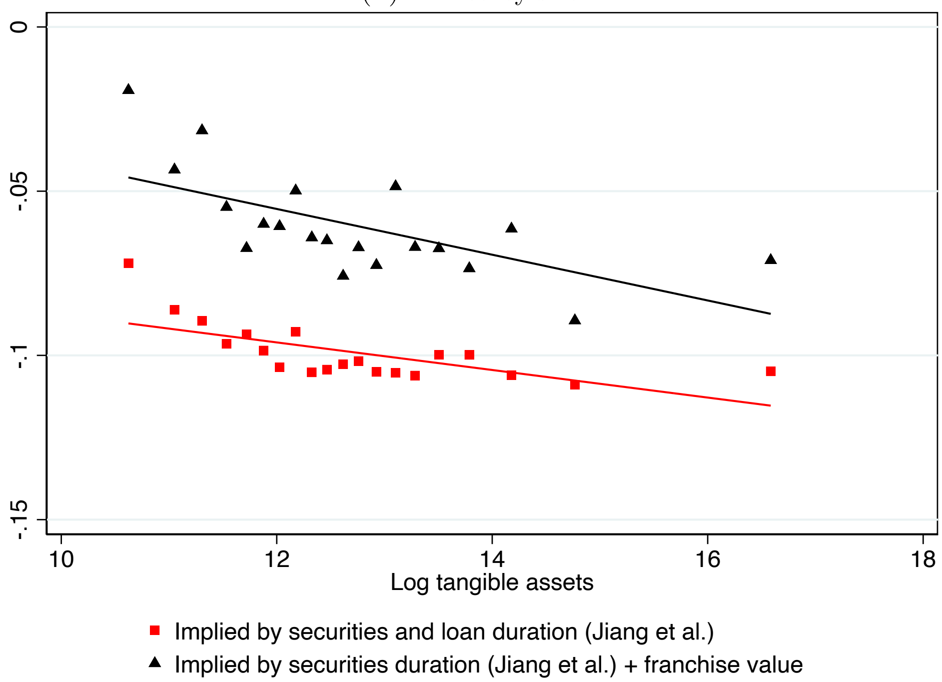
We start by examining loss estimates for all banks, including those without publicly traded equity. Figure 8a shows the loss estimates binned by size. For the average bank, the loss on franchise value and securities combined is about 6% of tangible assets. These loss estimates are much smaller than the total loss estimated by Jiang et al. (2023), which are also shown in the figure. Banks' equity has positive duration, but the duration is smaller than what it would be just based on securities and loan duration in isolation, without considering offsetting effects due to the properties of costs and spreads in the banking franchise. Across the size spectrum, medium-sized banks are particularly strongly exposed to losses.

Our earlier analysis suggested that banks most at risk from interest-rate hikes in 2021 were those with large exposure to long-duration securities. Figure 8b provides confirmation. The observations are binned by the contribution to asset duration from securities holdings, calculated as product of the duration of the securities portfolio with the securities/assets ratio. Banks with the highest exposure to long-duration securities have losses that are about twice as big as those of banks with the lowest long-duration securities exposure.

The important message coming from our analysis is that for the typical bank there was no duration-hedging motivation for holding long-duration securities because the combined lending and deposit-taking business already has positive duration. That is, the bank's ownership of long-duration securities adds risks rather than hedges risk, echoing a finding in Begenau et al. (2015).

In Figure 9 we examine whether franchise value in 2023Q1 is sufficiently positive to offset the securities losses that banks experienced. According to our estimates, even banks in the

(A) Binned by size



(B) Binned by securities duration exposure

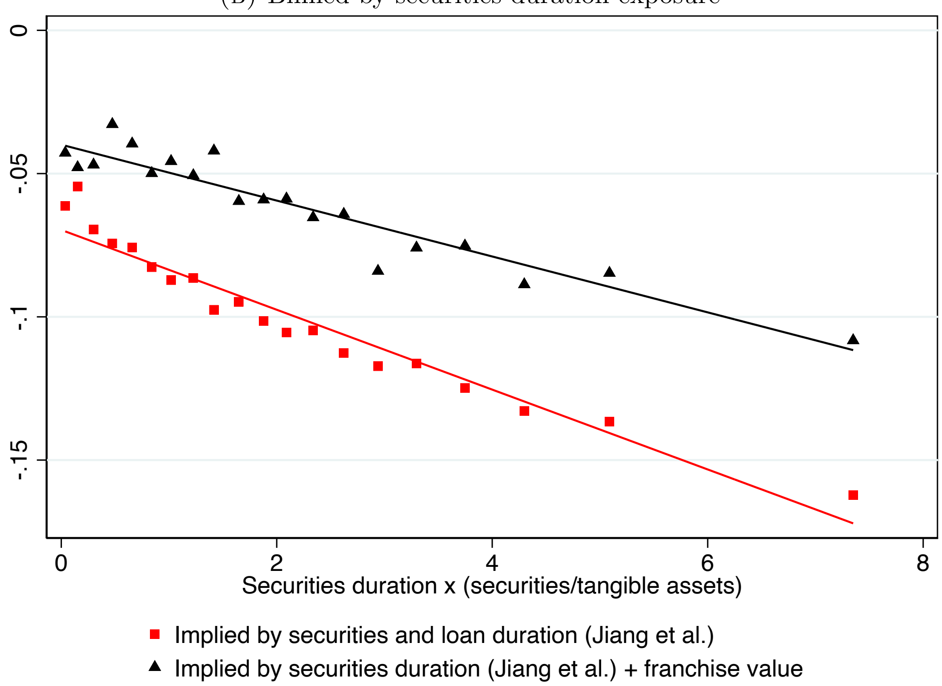


FIGURE 8
Estimates of Present Value Loss from 2021Q2 to 2023Q1

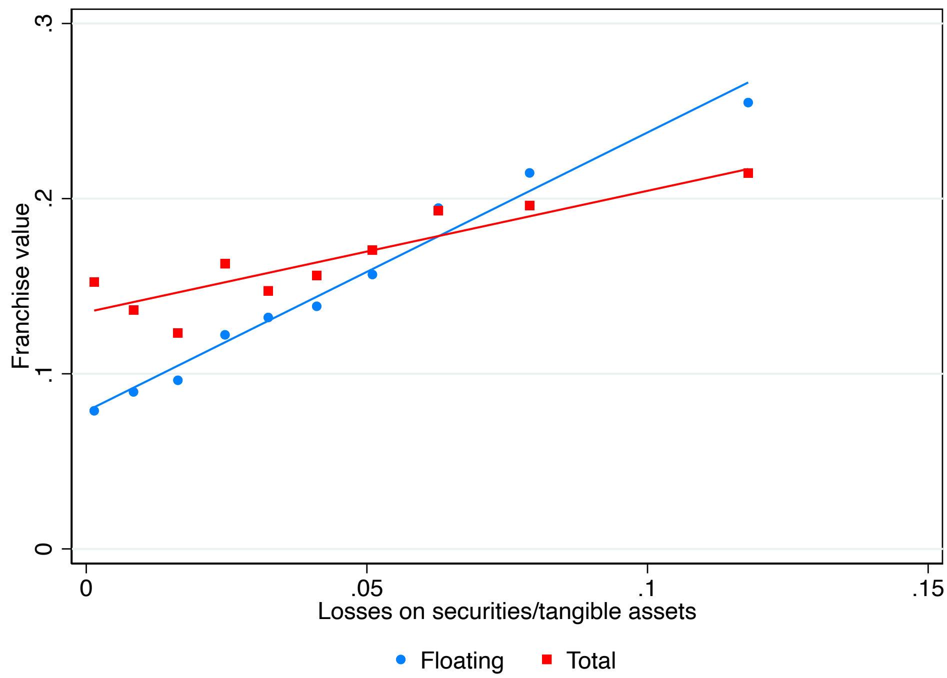


FIGURE 9
Comparison of franchise value in 2023 with losses on securities holdings

highest bin of securities losses (more than 10% of tangible assets) still have sufficient franchise value to yield a positive residual value under the assumption that the bank survives as a going concern. It may be surprising that banks lost money on their securities portfolio and on the value of their franchise, and yet remain solvent. The reason is that that in the cross-section of banks, we estimate that the ones that lost the most money on their securities portfolio also had the highest franchise value in 2021. In Appendix C, we present this result in the form of a histogram of losses along the lines of Jiang et al. (2023). We estimate a smaller fraction of insolvent banks than Jiang et al. (2023).

6.2 Publicly traded banks

We now turn to publicly traded banks. For this subset of banks, we can express our loss estimates in terms of the implied change in M/B. We can then compare this implied change in M/B with the actual M/B based on observed stock prices.

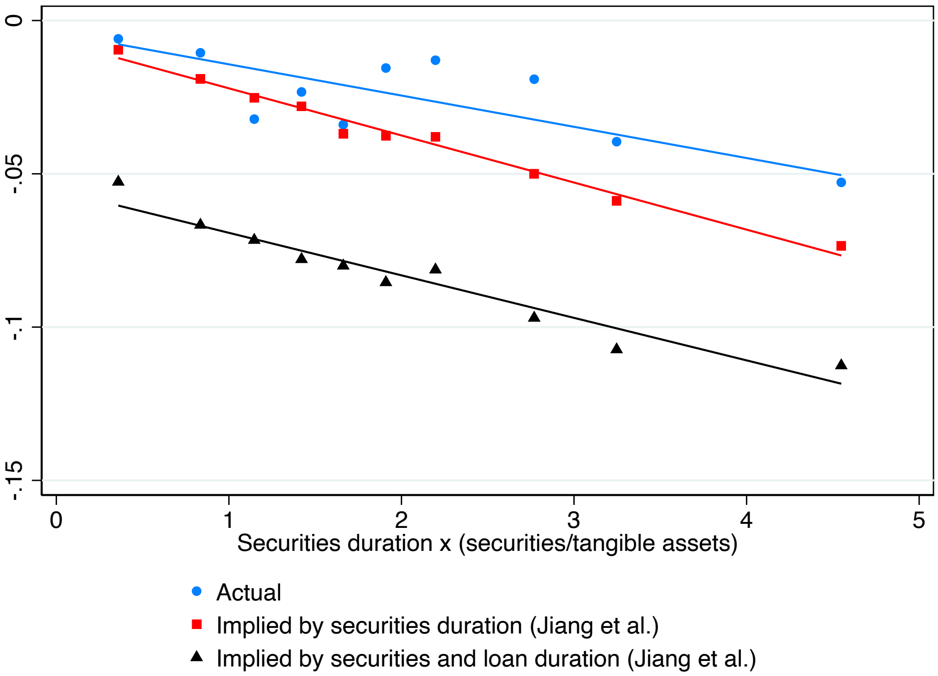


FIGURE 10
Changes in market-to-book assets ratio from 2021Q2 to 2023Q1: Actuals and Jiang et al. (2023) loss estimates

Figure 10 shows the change in the market measured M/B from end of 2021Q2 to end of 2023Q1 for banks binned by their long-duration securities exposure. For comparison, we also show the change in M/B implied by only the losses on securities from Jiang et al. (2023)'s calculations, and the change in M/B implied by only the losses on loans from Jiang et al. (2023)'s calculations. As the figure shows, the losses on securities alone roughly match the actual change in M/B. Including the losses on loans, but without considering franchise value, gives a fall in value far greater than that measured by the equity market.

We next include the change in the franchise value in the implied M/B. Figure 11 shows the result. The figure shows that the change in the valuation of the fixed franchise value component only makes a relatively small contribution for banks with high exposure to long-duration securities. That is most of the losses for these banks still come from the securities losses. In contrast, for banks with little exposure to long-duration securities, the estimated

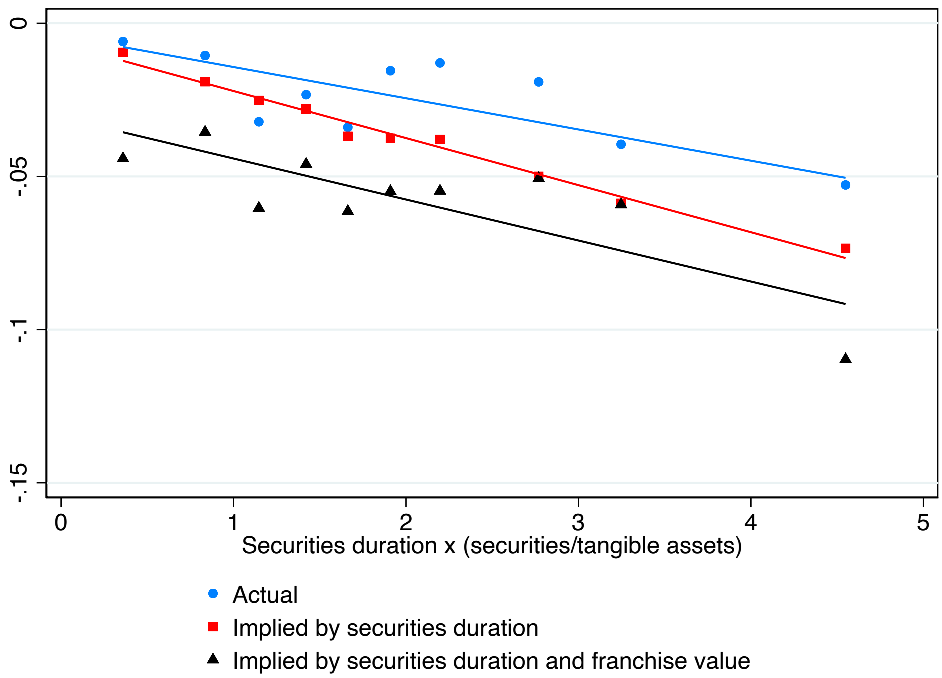


FIGURE 11
Changes in market-to-book assets ratio from 2021Q2 to 2023Q1: Estimates based on franchise values

losses are smaller, and mostly due to the franchise value changes.

The change in implied M/B based on securities losses and franchise value changes combined is larger than the actual M/B changes in market data. It is possible that the actual M/B may also reflect a misvaluation in the stock market or option value components (Kelly et al., 2016) that we do not capture in our calculations.

6.3 Banks' own loss estimates

As we describe in Section 5.2, in their annual 10-K filings, many banks report measures of interest rate risk exposure of their net interest income and equity market value. We collect this information from the 2021 10-K filings of all publicly traded bank holding companies in the U.S and compare the estimates to the calculations we have done.

Figure 12 shows banks' estimates for the effect of a 100bp parallel upward shift in the

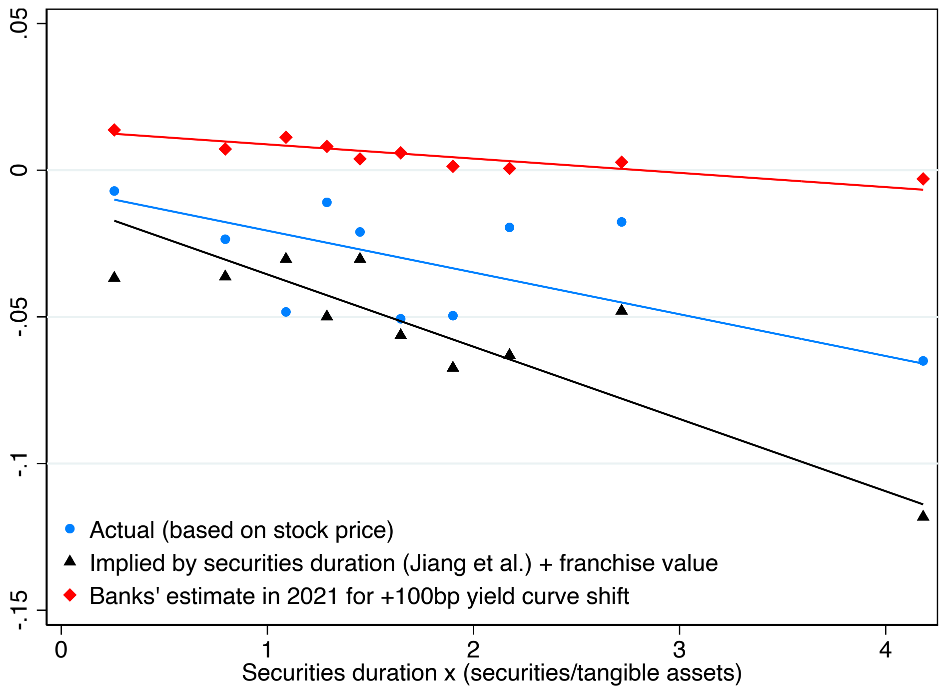


FIGURE 12
Comparison of losses in 2023 with banks' estimates in 2021 of potential losses

yield curve, expressed as the implied change in the market-to-book assets ratio, binned by the duration contribution of securities holdings. Virtually all banks, except those with the highest securities duration contribution, had expected that a rise in interest rates would *raise* their market value of equity! This is in stark contrast to what actually happened, as shown in the plot by the changes in actual market-to-book asset ratios. The figure also shows the loss estimate based on franchise value changes and securities losses from 11, but here only for the subset of bank holding companies for which the loss estimates from 10k filings are available.[15]

[15]These estimates from 10k filings are available for 56 of 150 bank holding companies.

7 Conclusion

The franchise value of the typical bank—derived from its deposit-taking and lending activities—has a positive duration. Holding longer-term securities helps to stabilize earnings, but adds to the duration of the bank. These are positive statements. We conclude by discussing the normative implications of these findings.

Should a bank choose, and should regulators encourage, cash-flow hedging or value hedging when managing interest rate risk?

Questions about whether the deposit beta adjusts non-linearly over the rate hike cycle, or whether transaction deposits should be bucketed as overnight or two-years are ones which give primacy to the cash-flow dynamics of banks. Answering these questions is important in the case where it is optimal for a bank to hedge cash-flows. In models with costly external finance, there is a motive for banks to optimally hold liquidity to align with investment opportunities (Froot et al., 1993). If investment opportunities are orthogonal to interest rate fluctuations, then it is optimal for a bank to insulate liquidity (cash-flows) from interest rate shocks. Such behavior would be consistent with banks' actions of stabilizing earnings and NIM. This mechanism is operative in Di Tella and Kurlat (2021). We note that it is unlikely that interest rate fluctuations are orthogonal to investment opportunities, so the stark prediction of earning stabilization is unlikely to be optimal. Moreover, there can be a difference in the objectives of the government and a bank. The government has mechanisms to provide liquidity to a solvent bank that has investment opportunities but lacks liquidity. The government cannot do so to an insolvent bank.

Turning to the case where solvency is the primary consideration for banks, the concern of banks and regulators is to hedge value to minimize the risk of the bank falling below a default boundary. Solvency is measured using the market value of assets, including franchise value, relative to liabilities. Models such as Jiang et al. (2023), Drechsler et al. (2023a), and Haddad et al. (2023) feature a solvency run, where depositors grow concerned about default risk, exit a banking relationship and in the process erode franchise value, possibly in a selffulfilling fashion. Hedging against this possibility requires ensuring sufficient solvency in all states of the world (including states where interest rates change), not simply ensuring stable earnings. Further research is needed to clarify which model is appropriate for which types of banks and in which states of the world. Our findings show how duration risk affects these considerations.

References

Abdymomunov, Azamat, Jeff Gerlach, and Yuji Sakurai, 2023, Interest rate risk in the us banking sector, Working paper, Federal Reserve Bank of Richmond.

Barr, Michael S., 2023, Review of the federal reserve's supervision and regulation of silicon valley bank .

BCBS, 2016, Interest rate risk in the banking book, Basel Committee on Banking Supervision .

Begenau, Juliane, Monika Piazzesi, and Martin Schneider, 2015, Banks' risk exposures, Working paper, National Bureau of Economic Research.

Begenau, Juliane, and Erik Stafford, 2019, Do banks have an edge?, Working paper, Stanford University.

Benetton, Matteo, 2022, Wide or narrow? competition and scope in financial intermediation, Working paper, CEPR Discussion Papers.

Berger, Allen N, and Loretta J Mester, 1997, Inside the black box: What explains differences in the efficiencies of financial institutions?, Journal of banking & finance 21, 895–947.

Berndt, Antje, Rohan Douglas, Darrell Duffie, and Mark Ferguson, 2018, Corporate credit risk premia, Review of Finance 22, 419–454.

Bolton, Patrick, Ye Li, Neng Wang, and Jinqiang Yang, 2023, Dynamic banking and the value of deposits, Working paper, National Bureau of Economic Research.

Cyree, Ken B, 2010, What do bank acquirers value in non-public bank mergers and acquisitions?, The Quarterly Review of Economics and Finance 50, 341–351.

Di Tella, Sebastian, and Pablo Kurlat, 2021, Why are banks exposed to monetary policy?, American Economic Journal: Macroeconomics 13, 295–340.

Diebold, Francis, and Steven Sharpe, 1990, Post-deregulation bank-deposit-rate pricing: The multivariate dynamics, Journal of Business and Economic Statistics 8, 281–291.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, 2017, The deposits channel of monetary policy, The Quarterly Journal of Economics 132, 1819–1876.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, 2021, Banking on deposits: Maturity transformation without interest rate risk, Journal of Finance 76, 1091–1143.

Drechsler, Itamar, Alexi Savov, Philipp Schnabl, and Olivier Wang, 2023a, Banking on uninsured deposits, Working paper, National Bureau of Economic Research.

Drechsler, Itamar, Alexi Savov, Philipp Schnabl, and Olivier Wang, 2023b, How to value the deposit franchise, Working paper, NYU Stern.

Driscoll, John, and Ruth Judson, 2013, Sticky deposit rates, Finance and Economics Discussion Series, Report 2013-80, Divisions of Research and Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.

Egan, Mark, Stefan Lewellen, and Adi Sunderam, 2022, The cross-section of bank value, The Review of Financial Studies 35, 2101–2143.

English, William B, et al., 2002, Interest rate risk and bank net interest margins, BIS Quarterly Review 10, 67–82.

English, William B, Skander J Van den Heuvel, and Egon Zakrajšek, 2018, Interest rate risk and bank equity valuations, Journal of Monetary Economics 98, 80–97.

Flannery, Mark J, 1981, Market interest rates and commercial bank profitability: An empirical investigation, The Journal of Finance 36, 1085–1101.

Flannery, Mark J, and Christopher M James, 1984, The effect of interest rate changes on the common stock returns of financial institutions, The journal of Finance 39, 1141–1153.

Flannery, Mark J, and Sorin M Sorescu, 2023, Partial effects of fed tightening on us banks' capital, Available at SSRN 4424139 .

Froot, Kenneth A, David S Scharfstein, and Jeremy C Stein, 1993, Risk management: Coordinating corporate investment and financing policies, the Journal of Finance 48, 1629–1658.

Golding, Edward L, and Deborah Lucas, 2024, Preventing another svb: The case for mandatory duration gap disclosure, MIT Sloan .

Greenwald, Emily, Sam Schulhofer-Wohl, and Josh Younger, 2023, Deposit convexity, monetary policy and financial stability, Working paper, FRB of Dallas Working Paper.

Haddad, Valentin, Barney Hartman-Glaser, and Tyler Muir, 2023, Bank fragility when depositors are the asset, Available at SSRN 4412256 .

Hannan, Timothy, and Allen Berger, 1991, The rigidity of prices: Evidence from the banking industry, The American Economic Review 81, 938–945.

Hanson, Samuel G, Victoria Ivashina, Laura Nicolae, Jeremy C Stein, Adi Sunderam, and Daniel K Tarullo, 2024, The evolution of banking in the 21st century: Evidence and regulatory implications, Brookings Papers on Economic Activity 27.

Hoffmann, Peter, Sam Langfield, Federico Pierobon, and Guillaume Vuillemey, 2019, Who bears interest rate risk?, The Review of Financial Studies 32, 2921–2954.

Hutchison, David E, and George G Pennacchi, 1996, Measuring rents and interest rate risk in imperfect financial markets: The case of retail bank deposits, Journal of Financial and Quantitative Analysis 31, 399–417.

Jiang, Erica Xuewei, Gregor Matvos, Tomasz Piskorski, and Amit Seru, 2023, Monetary tightening and us bank fragility in 2023: Mark-to-market losses and uninsured depositor runs?, Working paper, National Bureau of Economic Research.

Kelly, Bryan, Hanno Lustig, and Stijn Van Nieuwerburgh, 2016, Too-systemic-to-fail: What option markets imply about sector-wide government guarantees, American Economic Review 106, 1278–1319.

Koont, Naz, Tano Santos, and Luigi Zingales, 2023, Destabilizing digital banks, Available at SSRN .

Luck, Stephan, Matthew Plosser, and Josh Younger, 2023, How do interest rates (and depositors) impact measures of bank value?, Liberty street economics, Federal Reserve Bank of New York.

Metrick, Andrew, 2024, The failure of silicon valley bank and the panic of 2023, Journal of Economic Perspectives 38, 133–152.

Neumark, David, and Steven Sharpe, 1992, Market structure and the nature of price rigidity: Evidence from the market for consumer deposits, Quarterly Journal of Economics 107, 657–680.

Paul, Pascal, 2023, Banks, maturity transformation, and monetary policy, Journal of Financial Intermediation 53, 101011.

Sheehan, Richard G, 2013, Valuing core deposits, Journal of Financial Services Research 43, 197–220.

Online Appendix

A Franchise cost adjustments

The fees earned from credit cards (CCF) are included in other business income (OBI). To estimate them, we assume the magnitude of these fees are related to the bank's credit card interest income ($CCII$). We therefore use data for all banks to regress OBI/A on the credit card interest income to tangible assets ratio ($CCII/A$),

$$OBI_i/A_i = \eta_0 + \eta_1 CCII_i/A_i + \varepsilon_i, \tag{A.1}$$

The fitted value from this regression provides an estimate of CCF:

$$\widehat{CCF}_i = \eta_1 CCII_i \tag{A.2}$$

Next we estimate the average profit margins from lines of business that generate other business income by regressing the ratio of total non-interest expenses ($TNIE$) to tangible assets on other business income (OBI) to tangible assets using data for all banks:

$$TNIE_i/A_i = \gamma_0 + \gamma_1 OBI_i/A_i + \varepsilon_i. \tag{A.3}$$

The fitted value from this regression provides an estimate of other business expenses (OBX) that come from non-credit card activities:

$$\widehat{OBX}_i = \gamma_1(OBI_i - \widehat{CCF}_i) \tag{A.4}$$

We then adjust the franchise cost computation for a given bank i downwards by subtracting the estimated OBX_i:

$$\text{Franchise Cost}_i = TNIE_i - DSC_i - \widehat{OBX}_i - \widehat{CCF}_i \tag{A.5}$$

$$= TNIE_i - DSC_i - \gamma_1 OBI_i - (1-\gamma_1)\eta_1 CCII_i. \tag{A.6}$$

In our estimation, we find $\gamma_1 \approx 0.7$, consistent with a 30% profit margin on other business activities. We also estimate $\eta_1 \approx 2.1$, suggesting that credit card fee income is roughly double the income earned from credit card interest.

Table A.1 shows the magnitudes of the adjustments of franchise costs at the bank level for other business expenses (OBX) and credit card fees as a fraction of the dollar amount of costs before these adjustments. The OBX adjustment is substantial, especially for some banks in the tails of the distribution with large non-interest business. In contrast, the CCF adjustment is minor for all banks in the sample.

A.1 Alternative franchise cost measurement

We drop banks with more than 30% of total income from other business income. This screen drops about 7.5% of banks, including some of the largest banks. We then compute

TABLE A.1
Franchise Cost Adjustments As Fraction of Unadjusted Costs

	(1) Mean	(2) S.D.	(3) 1st Pctile	(4) 10th Pctile	(5) Median	(6) 90th Pctile	(7) 99th Pctile
OBX	0.1422	0.2008	-0.0059	0.0296	0.1079	0.2956	0.7247
CCF	0.0015	0.0081	0.0000	0.0000	0.0000	0.0035	0.0215

TABLE A.2
Franchise Value Statistics: Alternative Franchise Cost Measurement

	(1) Mean	(2) Median	(3) S.E. of Mean
Panel A: Franchise value inputs			
ϕ_0	0.0209	0.0209	0.0001
ϕ_r	0.1460	0.1430	0.0030
Franchise cost/Assets	0.0182	0.0177	0.0001
Panel B: Franchise value components			
Floating FV	0.1460	0.1430	0.0030
Fixed FV	0.1035	0.1132	0.0054
Term inertia component	0.0018	0.0021	0.0003

Franchise Cost $= TNIE - OBI - DSC$. That is, we do not follow a regression procedure to estimate $\widehat{OBX}$ and $\widehat{CCF}$ as in the main text. We instead include all other business income, which includes credit card fees, and reduce the franchise costs with such income (note that other business income does not comove with interest rates in a statistically significant fashion). This approach effectively includes all income and costs from other business lines, and we use the screen to eliminate banks where those other business lines are too large.

Table A.2 redoes Table 5. We note that the floating FV is similar in magnitude across the tables, while the fixed FV increases and is substantially higher than in the baseline analysis in the main text. We believe that our regression-based approach for adjusting costs in the baseline analysis provides better estimates of franchise costs, but the analysis here shows that our main conclusion that franchise value duration is positive is robust to this alternative measurement approach here.

B Robustness checks

B.1 Spread beta Estimates With Moving Averages or Inclusion of Lagged Explanatory Variables

Tables B.1 repeats the bank-level estimation of interest rate factor loadings from Tables 4 but with four-quarter moving averages dependent and explanatory variables in levels regressions (Panel A), and with inclusion of lagged explanatory variables in the changes regression (Panel B) to remove potential seasonality effects. In the latter case, the dependent variable is the quarterly change in the spread and the slope coefficients shown in this panel are the sum of slope coefficients on the contemporaneous quarterly change and on three lags of changes in the explanatory variables, the same approach as in Drechsler et al. (2021). As the table shows, the estimates are generally very similar to those in Tables 4, especially in the levels regressions that we use for our baseline franchise value calculations. Thus, seasonality does not seem to play a relevant role for the variables that we consider in this analysis.

B.2 Franchise value estimation based on recent subsample estimates

Tables B.2 and B.3 repeat the bank-level estimation of interest rate factor loadings and franchise value components using only more recent data from the 2011 to 2021 subsample. The benefit of this approach is that the more recent estimates of factor loadings may better reflect the properties of bank cash flows in 2021. The downside is that the sample is shorter and the variation in interest rate factors during the 2011 to 2021 time period was quite limited. These subsample estimates lead to broadly similar conclusions as our main analysis. Franchise costs are more than offset by fixed spreads earned from the lending and deposit business, and hence franchise value duration is positive. However, both the fixed and floating components of franchise value are larger than in our main analysis. The term inertia component value is negligible, as in the main analysis.

B.3 Franchise value calculations based on slope coefficients from regressions in changes

In our baseline analysis, the intercept and slope coefficients that go into the calculations of fixed and floating franchise values are from a regression of the level of total spreads on the level of the federal funds rate and the swap factors. Summary statistics of the estimated regression coefficients are shown in Panel A of Table 4. Regressions in levels are potentially contaminated with spurious correlations arising from the presence of trends in dependent and explanatory variables. For this reason, we check robustness by doing the franchise valuation with the coefficients from regressions in changes shown in Panel B of Table 4. To get the fixed spread component, we then take the two slope coefficients ϕ_r, ϕ_1, and ϕ_5 for each bank from the regression in changes and calculate an implied intercept as

$$\text{Mean(spread)} - \phi_r \times \text{Mean}(r^*) - \phi_1 \times \text{Mean}(\ell^1) - \phi_5 \times \text{Mean}(\ell^5) \qquad \text{(B.1)}$$

Table B.1
Summary Statistics of Bank-level Spread ϕ Estimates With Moving Averages or Lags

The sample includes U.S. commercial banks from 2001Q1 to 2021Q2. Unlike in the baseline specification in the main text, here the dependent and explanatory variables are four-quarter moving averages of levels in Panel A. In Panel B, the dependent variable is the quarterly change in the spread and the slope coefficients shown in this panel are the sum of slope coefficients on the contemporaneous quarterly change and on three lags of changes in the explanatory variables. The term swap variables are for 1-year and 5-year term swaps.

	(1) Intercept ϕ_0	(2) Fed Funds ϕ_r	(3) Term Swap ϕ_1	(4) Term Swap ϕ_5
		Panel A: Regression in levels		
		Deposit spread		
mean	0.0022	0.26	-0.32	-0.27
p50	0.0026	0.25	-0.31	-0.27
sd	0.0028	0.13	0.12	0.12
		Loan spread		
mean	0.018	-0.11	0.13	0.31
p50	0.018	-0.10	0.13	0.31
sd	0.009	0.18	0.23	0.21
		Total spread		
mean	0.020	0.15	-0.19	0.03
p50	0.020	0.15	-0.18	0.04
sd	0.009	0.22	0.24	0.21
		Panel B: Regression in changes		
		Deposit spread		
mean		0.29	-0.16	-0.20
p50		0.29	-0.14	-0.20
sd		0.16	0.19	0.15
		Loan spread		
mean		-0.17	0.09	0.21
p50		-0.15	0.11	0.21
sd		0.37	0.61	0.38
		Total spread		
mean		0.12	-0.07	0.00
p50		0.14	-0.04	0.01
sd		0.38	0.61	0.38

Table B.2

Summary Statistics of Bank-level Spread ϕ Estimates Based on 2011-2021 Sample

The sample includes U.S. commercial banks from 2011Q1 to 2021Q2. The term swap variables are for 1-year and 5-year term swaps.

	(1) Intercept ϕ_0	(2) Fed Funds ϕ_r	(3) Term Swap ϕ_1	(4) Term Swap ϕ_5
		Panel A: Regression in levels		
		Deposit spread		
mean	0.001	0.48	-0.07	-0.27
p50	0.001	0.48	-0.05	-0.26
sd	0.002	0.15	0.15	0.12
		Loan spread		
mean	0.022	-0.23	-0.03	0.30
p50	0.022	-0.22	-0.05	0.32
sd	0.009	0.28	0.45	0.30
		Total spread		
mean	0.022	0.25	-0.10	0.037
p50	0.022	0.26	-0.11	0.047
sd	0.009	0.33	0.45	0.30
		Panel B: Regression in changes		
		Deposit spread		
mean		0.44	-0.11	-0.25
p50		0.44	-0.09	-0.24
sd		0.16	0.11	0.12
		Loan spread		
mean		-0.18	0.16	0.27
p50		-0.17	0.14	0.28
sd		0.38	0.44	0.43
		Total spread		
mean		0.26	0.06	0.03
p50		0.27	0.04	0.03
sd		0.42	0.44	0.43

Table B.3

Franchise Value Statistics Based on 2011-2021 Sample Estimates

Beta estimates used in this analysis are those from Table B.2, Panel A, but now winsorized at a 5% level. In addition, we exclude banks in the bottom percentile by assets in 2021Q2.

	(1) Mean	(2) Median	(3) S.E. of Mean
Panel A: Franchise value inputs			
ϕ_0	0.0225	0.0224	0.0001
ϕ_r	0.2528	0.2584	0.0044
Franchise cost/Assets	0.0197	0.0193	0.0001
Panel B: Franchise value components			
Floating FV	0.2528	0.2584	0.0044
Fixed FV	0.1048	0.1177	0.0056
Term inertia component	0.0036	0.0043	0.0004

We then recalculate the fixed component of the franchise value in 2021Q2 based on this implied intercept.

Figure B.1 shows the result in the cross-section of banks binned by the ratio of franchise cost to tangible assets, which, as we show in the main part of the paper, is strongly associated with cross-sectional variation in the value of the fixed spread component. As the figure shows, switching to the alternative calculation only has a minor effect on the fixed spread component of the franchise value.

B.4 Interest rate sensitivity of franchise costs and loan loss provisions

Columns (1) and (2) in Table B.4 check the interest rate sensitivity of franchise costs by regressing aggregate franchise costs on the three interest rate factors. In levels, the franchise cost series shares a common downward trend with the federal funds rate. This leads to a positive coefficient on the federal funds rate in Panel A. However, as Panel B shows, this positive coefficient largely goes away in the differenced regression. None of the factor loadings in the differences regression are statistically significant and they are all quite small. So overall there is little evidence of interest rate sensitivity of franchise costs.

Columns (3) and (4) in Table B.4 show the results with loan loss provisions as dependent variable. In column (3) we see that loan loss provisions are insensitive to movements in the federal funds rate, both in levels in Panel A and changes in Panel B.

B.5 Interest rate sensitivity of assets

Table B.5 shows the interest rate sensitivity of tangible assets. In this case, a regression in levels does not make sense, due to clear trends in asset levels and the federal funds rate during the past decades. For this reason, this table only uses quarterly changes in log tangible assets

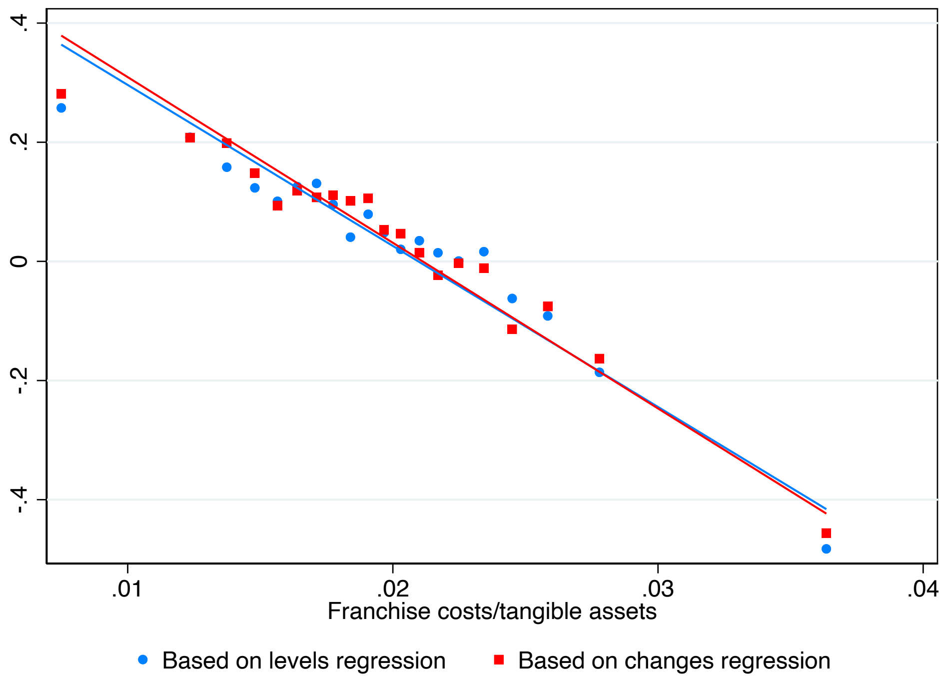


FIGURE B.1
Fixed components of franchise value based on intercept from levels regression and implied intercept from changes regression

TABLE B.4

Dynamics of Costs and Loan Loss Provisions at the Aggregate Level

The sample includes U.S. commercial banks from 1984Q1 to 2021Q2. The term swap variables are for 2-year and 5-year term swaps. The t-statistics shown in parentheses are based on Newey-West standard errors with 8 lags.

	(1) Costs	(2) Costs	(3) Loss prov.	(4) Loss prov.
Panel A: Regression in levels				
r_t^*	0.100	0.110	0.033	0.042
	(9.33)	(10.49)	(1.20)	(1.72)
ℓ_t^1		-0.023		0.158
		(-0.41)		(1.72)
ℓ_t^5		0.121		0.065
		(3.77)		(1.68)
Intercept	0.011	0.009	0.004	0.002
	(18.37)	(10.90)	(2.49)	(1.85)
R^2	50.70	71.25	5.24	27.83
Obs.	150	150	150	150
Panel B: Regression in changes				
Δr_t^*	-0.012	0.012	-0.037	0.117
	(-0.79)	(0.27)	(-0.74)	(0.57)
$\Delta \ell_t^1$		0.011		0.015
		(0.41)		(0.18)
$\Delta \ell_t^5$		0.016		0.142
		(0.35)		(0.69)
Intercept	-0.000	-0.000	-0.000	0.000
	(-1.48)	(-0.97)	(-0.42)	(0.24)
R^2	0.14	0.21	0.38	0.66
Obs.	149	149	149	149

TABLE B.5

Dynamics of Assets at the Aggregate Level: Regressions in Changes of Log Assets

The sample includes U.S. commercial banks from 1984Q1 to 2021Q2. The dependent variable is the quarterly change of log tangible assets. The term swap variables are for 1-year and 5-year term swaps. The t-statistics shown in parentheses are based on Newey-West standard errors with 8 lags.

	(1)	(2)
Δr_t^*	0.366	2.898
	(0.86)	(1.82)
$\Delta \ell_t^1$		0.121
		(0.19)
$\Delta \ell_t^5$		2.413
		(1.44)
Intercept	0.015	0.017
	(10.83)	(8.28)
R^2	0.35	1.01
Obs.	149	149

as dependent variable. Column (1) shows that a one percentage point increase in the federal funds rate is associated with roughly 0.4 percent increase in assets, but the estimate is not significantly different from zero at conventional levels. In column (2), when swap factors are included, the estimate is around 2.9, but again not statistically significant at conventional levels. The swap factors loadings are also statistically insignificant.

Incorporating this asset sensitivity to interest rates in our calculation would only have a minor effect on the franchise values. For a back-of-the-envelope calculation, focus on the deposit spread, and suppose it follows

$$\frac{S_t^D}{A_t} = 0.3 \times r_t^* \tag{B.2}$$

which is roughly in the ballpark of our empirical estimates. If asset levels are sensitive to interest rate, then we should conduct our valuation scaled by a steady-state asset level $\bar{A}$ rather than A_t. Multiplying both sides with $A_t/\bar{A}$, we obtain the desired scaling on the left-hand side:

$$\frac{S_t^D}{\bar{A}} = \left(\frac{A_t}{\bar{A}}\right) \times 0.3 \times r_t^*. \tag{B.3}$$

A first-order Taylor approximation of the right-hand side around $\bar{r}$ and $\bar{A}$ yields

$$\frac{S_t^D}{\bar{A}} = 0.3 \times \bar{r} + \left(\frac{\partial \log A_t}{\partial r_t^*}\bar{r} + 1\right) \times 0.3 \times (r_t^* - \bar{r}). \tag{B.4}$$

With $\frac{\partial \log A_t}{\partial r_t^*} \approx 0.4$ from column (1) and a plausible $\bar{r} \approx 3\%$, the term in parentheses is about $0.01 + 1 = 1.01$, which means that the floating deposit franchise value is $1.01 \times 0.3 = 0.303$ rather than the value of 0.3 that we would calculate based on the approach in the main text. This is a minor difference. Doing the same calculation with the larger slope coefficient in column (2) still yields a negligible difference.

B.6 Deposit betas based on interest expense to deposit ratios

The deposit spread that we use in our regressions and franchise value calculations is expressed as a share of tangible assets. The variation in this spread can therefore be decomposed into variation coming from variation in the interest expenses/deposits ratio and variation in the deposits/tangible assets ratio. In principle, therefore, the slope coefficient on the federal funds rate in our regression could capture some comovement between the federal funds rate and deposit in- or outflows rather than a relation with the pricing of deposits. Are these quantity movements contributing significantly to the estimated loading of deposit spreads on the federal funds rate? If not, then we should be able to run the regressions with interest expenses/deposits as dependent variable and get back from these estimates to our estimates based on our definition of deposit spreads by rescaling with the average deposit/tangible assets ratio (which is 0.84 on average across banks in the sample from 2001 to 2021 that we use for bank-level regressions).

Column (1) shows that in a regression of the deposit spread on just the federal funds rate (without the swap factors), we get a mean coefficient of 0.44. Using eq. 13, and $d = 0.84$, and assuming that quantity movements do not generate a distortion in estimated loadings, this implies that the deposit beta in a regression of interest expenses as a share of deposits on the federal funds rate should be $1 - 0.44/0.84 \approx 0.48$. (The deposit beta when interest expenses are scaled instead by tangible assets would be $0.48 \times 0.84 \approx 0.40$.) For comparison, running this regression in the data, as shown in column (3), yields a mean deposit beta estimate of 0.47, i.e., a value almost exactly the same as the one implied by this calculation. A calculation based on the coefficients from regressions in changes in columns (2) and (4) produces similar results: $1 - 0.64/0.84 \approx 0.24$ which is almost exactly the same as the estimated coefficient 0.23 in column (4). Hence, variation in the deposits to tangible assets ratio has a negligible effect on the deposit spread beta estimates.

B.7 Asymmetric response of spreads to federal funds rate changes

In Table B.7, we check whether the linear regressions in our main specification miss important nonlinearities, such as the upward deposit rate stickiness and downward flexibility of deposit rates documented by Hannan and Berger (1991), Neumark and Sharpe (1992), and Driscoll and Judson (2013). Focusing on analysis at the aggregate level, we repeat the regressions from Table 3, Panel B, but with an additional explanatory variable $\max(0, \Delta r_t^*)$ that allows for asymmetric reaction to positive and negative changes in r_t^*. As the table shows, at the quarterly frequency that we look at here, there is no statistically significant asymmetry for deposit spreads. Moreover, the gain in R^2 compared with Table 3, Panel B, is small. Table B.8 shows results for bank-level estimation. For the mean and median bank, there is virtually

Table B.6
Summary Statistics of Bank-level Spread beta and Deposit Beta Estimates

The sample includes U.S. commercial banks from 2001Q1 to 2021Q2. The fed funds rate is the only explanatory variable. The dependent variable in columns (1) and (2) is the deposit spread, as in our main analysis. The dependent variable in columns (3) and (4) is deposit interest expense divided by total deposits. The regressions in columns (1) and (3) are run in levels, those in columns (2) and (4) are run in changes.

	(1) Deposit spread	(2) Δ Deposit spread	(3) Int.exp./Deposits	(4) Δ Int.exp./Deposits
mean	0.44	0.64	0.47	0.23
p50	0.44	0.65	0.48	0.23
s.d.	0.090	0.085	0.097	0.080

Table B.7
Dynamics of Spreads at the Aggregate Level: Allowing for Asymmetry

The data and analysis is the same as in Table 3, Panel B, but with an additional explanatory variable $\max(0, \Delta r_t^*)$ to capture asymmetry. An intercept and an indicator for $\Delta r_t^* > 0$ are included in the regression, but omitted from the table.

	(1) Deposits	(2) Lending	(3) Total
Δr_t^*	0.299	-0.241	0.058
	(4.09)	(-2.51)	(0.73)
$\max(0, \Delta r_t^*)$	0.004	0.109	0.114
	(0.10)	(1.42)	(2.15)
$\Delta \ell_t^1$	-0.251	0.124	-0.127
	(-10.58)	(3.69)	(-4.50)
$\Delta \ell_t^5$	-0.038	0.074	0.036
	(-0.57)	(0.93)	(0.57)
R^2	88.32	52.63	28.42
Obs.	146	146	146

Table B.8

Summary Statistics of Bank-level Spread ϕ Estimates: Allowing for Asymmetry

The sample and analysis is the same as in Table 4, Panel B, but with an additional explanatory variable $\max(0, \Delta r_t^*)$, with coefficient $\phi_{r,pos}$, to capture asymmetry. The statistics for the coefficient estimates for this variable are shown in the column (2).

	(1) ϕ_r	(2) $\phi_{r,pos}$	(3) Term Swap ϕ_1	(4) Term Swap ϕ_5
		Deposit spread		
mean	0.26	0.00	-0.25	-0.26
p50	0.26	0.00	-0.25	-0.25
sd	0.18	0.12	0.09	0.16
		Loan spread		
mean	-0.15	0.06	0.13	0.25
p50	-0.12	0.05	0.13	0.26
sd	0.41	0.30	0.16	0.39
		Total spread		
mean	0.10	0.06	-0.12	-0.01
p50	0.14	0.05	-0.12	0.01
sd	0.42	0.30	0.17	0.39

no asymmetry in deposit spread adjustment to federal funds rate changes.

In contrast to deposit spreads, we find some asymmetry in the loan spread response. Column (2) in Table B.7 and Table B.8 shows a fairly large positive coefficient, suggesting that loan spreads decrease less when the federal funds rate rises than they increase when the federal funds rate falls. However, such asymmetry must necessarily be temporary. Eventually, loan spreads will adjust to recent rate declines. The present value implications of such delay in adjustment would be minor.

B.8 Delayed response of spreads to federal funds rate changes

In Table B.9 we rerun the bank-level regressions summarized in Table 4 with a modified version of the swap factors

$$\ell^T_{ffr,t} = \frac{1}{T}\sum_{j=1}^{T} r^*_{t-j} - r^*_t. \tag{B.5}$$

We replace lagged long-term yields y^T_{t-j} that we use in our baseline specification with the lagged federal funds rate r^*_{t-j}. As the table shows, the results are very similar to those in

Table B.9

Summary Statistics of Bank-level Spread ϕ Estimates: Allowing for Delayed Response to Federal Funds Rate Changes

The sample and analysis is the same as in Table 4, but with the term swap factors modified to compute factors based on moving averages of lagged federal funds rate observations.

	(1) Intercept ϕ_0	(2) Fed Funds ϕ_r	(3) Mod. Term Swap ϕ_1	(4) Mod. Term Swap ϕ_5
Panel A: Regression in levels				
Deposit spread				
mean	-0.0015	0.27	-0.19	-0.25
p50	-0.0012	0.27	-0.18	-0.25
sd	0.0021	0.12	0.077	0.097
Loan spread				
mean	0.022	-0.12	0.048	0.27
p50	0.022	-0.12	0.049	0.28
sd	0.0081	0.18	0.14	0.19
Total spread				
mean	0.020	0.15	-0.14	0.018
p50	0.020	0.15	-0.13	0.021
sd	0.0080	0.22	0.15	0.19
Panel B: Regression in changes				
Deposit spread				
mean		0.31	-0.17	-0.22
p50		0.31	-0.17	-0.22
sd		0.12	0.064	0.100
Loan spread				
mean		-0.20	0.096	0.18
p50		-0.19	0.094	0.19
sd		0.25	0.11	0.23
Total spread				
mean		0.10	-0.076	-0.033
p50		0.12	-0.076	-0.025
sd		0.26	0.12	0.23

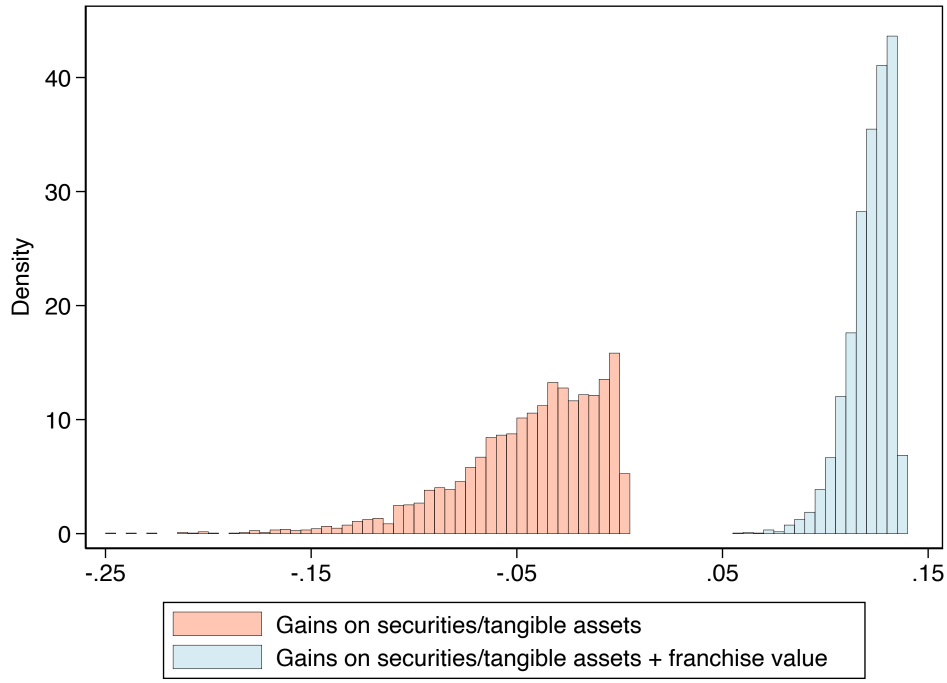


Figure C.1
Histogram of security losses in 2023 (orange), with FV adjusted based on projection (blue)

Table 4. Most importantly, the mean, median, and standard deviation of the ϕ_0 and ϕ_r estimates in Panel A are almost identical to that of our baseline specification. This means that with these estimates from Table B.9, we would obtain virtually the same values for the fixed and floating rate components of the franchise value that we obtain in our baseline specification.

C Security losses and franchise value

The left panel (orange) of Figure C.1 presents a histogram of security losses from 2021Q2 to 2023Q1, using the estimates of Jiang et al. (2023). We note in the main text that banks with higher security losses also happen to be banks that have a higher initial franchise value. Due to positive duration, their franchise value will typically also have decreased, but the right panel (blue) of the figure shows, since they started with a higher initial franchise value, these banks to still maintain substantial distance to insolvency. To construct this histogram, we project the franchise value on security losses in the cross-section of banks. We then use the regression fit to adjust the security losses to include the (projected) franchise value. We can see that the loss distribution is tighter and remains above zero. Note that we do not include loan credit losses that may have been induced by interest rate increases and potential credit losses on commercial real estate lending, which would tend to shift this distribution the left.