Interest-Rate Risk in Banking
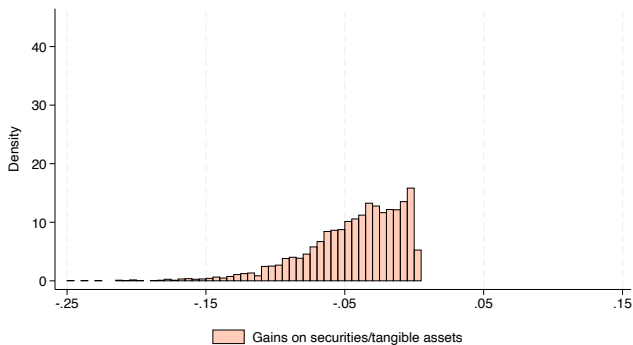
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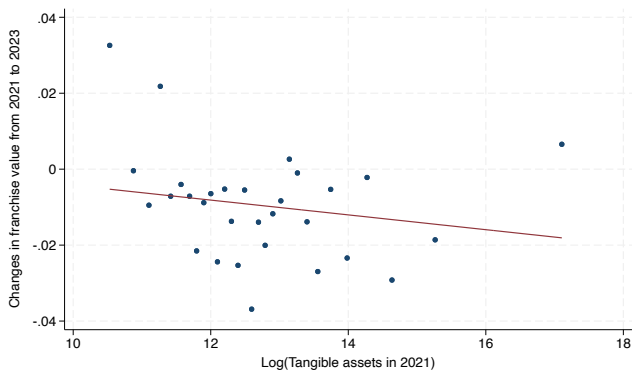
June 24, 2024

Security losses 2021-2023 histogram
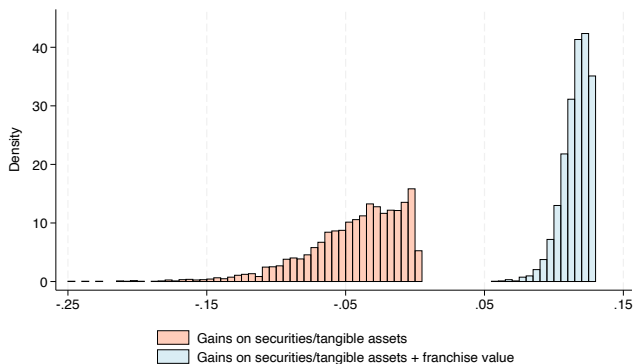

Gains on securities/tangible assets

▶ Gains/losses units is in fraction of total tangible assets

Banks lose franchise value when rates rise

▶ Gains/losses units is in fraction of total tangible assets

Security losses 2021-2023 histogram (L) with 2023 FV included (R)

▶ Gains/losses units is in fraction of total tangible assets

Bank balance sheet

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

- ▶ T, B, and equity issuance are all market-based with zero NPV at time of trade
- ▶ Value is created from loan making and deposit taking relative to risk-less rate r^*
  - ▶ Deposit rate spread $S_t^D \equiv D(r^* - r^D)$
  - ▶ Loan rate spread $S_t^L \equiv L(r^L - r^*)$

Losses and Franchise Value

▶ $S_t \equiv \underbrace{D_t(r_t^* - r_t^D)}_{S_t^D} + \underbrace{L(r_t^L - r_t^*)}_{S_t^L}$

▶ Cost to run the bank is C_t

▶ Initial value of bank equity $= PV(S_t - C_t)$

Given mark-to-market changes in value, solvent if:

$$\text{Market Equity} = \underbrace{L + S - D}_{\text{Book Equity}} + MTM_{L,S} + \underbrace{PV(S_t - C_t)}_{\text{Franchise Value}} > 0.$$

Deposit franchise valuation: (1) floating

Deposit rate:
$$r_t^D = -\alpha^D + \beta_1^D r_t^*$$

Profits from deposit spread
$$S_t^D = D(r_t^* - r_t^D)$$

Then,

Floating Dep. Value $= PV\left(D(1 - \beta_1^D)r_t^*\right) = D(1 - \beta_1^D).$

- ▶ Note: Deposit spread increases with rates, but so does discount rate ... offsets each other.
- ▶ Zero duration of this flow

Deposit franchise valuation: (2) fixed spread

Costs to run franchise of c^D-per-deposit. Then

$$S_t^D - c^D D = D(r_t^* - r_t^D) - c^D D$$

Fixed Dep. Value $= PV\left(D(\alpha^D - c^D)\right) = D\left(\dfrac{\alpha^D - c^D}{r_t^\infty}\right).$

Deposit franchise valuation: Term deposits, fraction $1 - \lambda$

Suppose y_t^T is the T-period market interest rate on date t

$$
\begin{aligned}
r_t^D &= -\alpha^D + \lambda \beta_1^D r_t^* + (1-\lambda) \overbrace{\left[\frac{1}{T} \sum_{j=1}^{T} \beta_T^D y_{t-j}^T \right]}^{\text{Avg. rate on term deposits}} \\
&= -\alpha^D + \underbrace{\left[\lambda \beta_1^D + (1-\lambda) \beta_T^D \right]}_{\hat{\beta}_1^D = \text{ Avg. deposit beta}} r_t^* + (1-\lambda) \beta_T^D \underbrace{\left[\frac{1}{T} \sum_{j=1}^{T} y_{t-j}^T - r_t^* \right]}_{\ell_t^T = \text{ swap ladder paymen}} \\
&= -\alpha^D + \hat{\beta}_1^D r_t^* + (1-\lambda) \beta_T^D \ell_t^T.
\end{aligned}
$$

Deposit franchise valuation, summing up

Deposit spread is:

$$S_t^D = D_t(r_t^* - r_t^D)$$

Define $d = D_t/A_t$,

$$s_t^D \equiv \frac{S_t^D}{A_t} = \left[\underbrace{d\alpha^D}_{\phi_0^D} + \underbrace{d(1 - \hat{\beta}_1^D)}_{\phi_1^D} r_t^* + \underbrace{d(1 - \lambda)\beta_T^D}_{\phi_T^D} I_t^T \right]$$

Then:

$$\text{Total Deposit Franchise Value} = A\left[\frac{\phi_0^D - c}{r_t^\infty} + \phi_1^D + \phi_T^D PV(I^T) \right].$$

Total franchise value and duration

Loan rate modeled similarly

$$r_t^L = \alpha^L + \lambda^L \beta_1^L r_t^* + (1 - \lambda^L)\beta_T^L l_t^T$$

We can value loan franchise as well, and sum with deposit franchise to get total franchise value:

$$PV(S - C) = A \underbrace{\left[\frac{\phi_0 - c}{r_t^\infty} + \phi_1 + \phi_T PV(l^T)\right]}_{\text{dur} \approx \text{sign}(\phi - c)}.$$

where $\phi_0 = \phi_0^D + \phi_0^L$, and likewise for other ϕs.

Data

- ▶ U.S. Call Reports. We use data from 1984Q1 to 2021Q2
- ▶ 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.
- ▶ For banks that are publicly traded, we match the Call Report bank data to equity prices obtained from CRSP.

Deposit and loan rates

For bank b at time t:

$$r_{t,b}^D = \frac{\text{Interest Expense on Deposits}_{t,b}}{D_{t,b}}$$

and,

$$r_{t,b}^L = \frac{\text{Interest Income on Loans}_{t,b}}{L_{t,b}} - \text{Credit Risk Adjustment}(\rho)$$

with spreads defined as:

$$s_{t,b}^D = \frac{D_{t,b}}{A_{t,b}}(r_t^* - r_{t,b}^D)$$

and,

$$s_{t,b}^L = \frac{L_{t,b}}{A_{t,b}}(r_{t,b}^L - r_t^*)$$

Credit risk adjustment

$$\rho = \frac{\text{Historical Credit Loss Provisions}}{L} \times \frac{Q(\text{Loss})}{P(\text{Loss})}.$$

▶ Q/P based on Berndt. et. al (2018)

Franchise cost

Conceptually, we want to measure all costs associated with running the lending and deposit-taking business.

- ▶ Costs (as fraction of tangible assets)
  - ▶ Tangible Non-Interest Expense minus Deposit Service Charges
    - ▶ (+) salaries
    - ▶ (+) expenses on premises
    - ▶ (+) other non-interest expenses
   - ▶ (-) deposit service charges

- ▶ Adjustment 1: Other business income at p90 this is 0.8% of assets.
  - ▶ We assign a fraction of the costs to other business income, and then subtract from total costs

- ▶ Adjustment 2: Credit card business generates fee income, not included in loan income.
  - ▶ We deduct the fee income from costs, based on fraction of income that comes from credit card business.
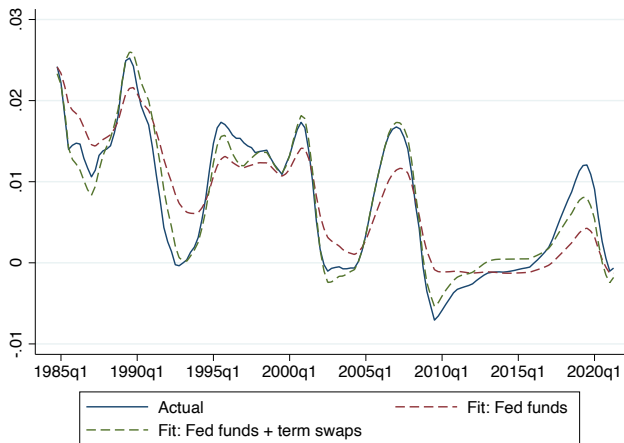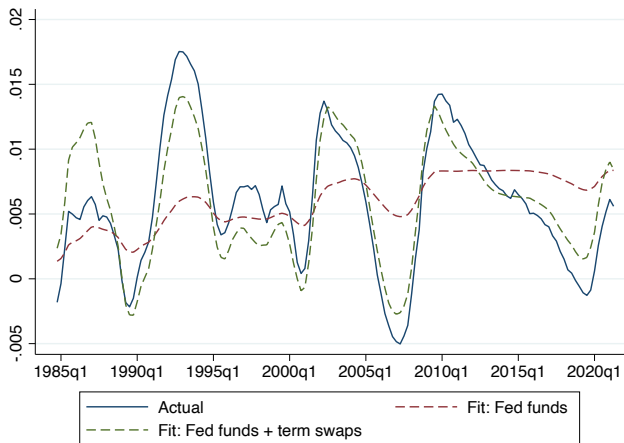
Aggregate analysis
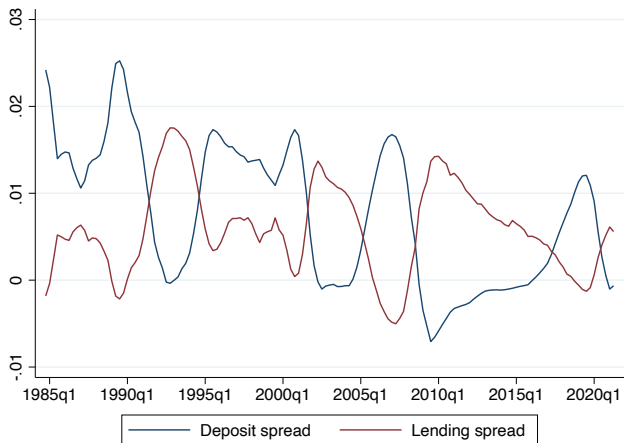
Aggregate analysis
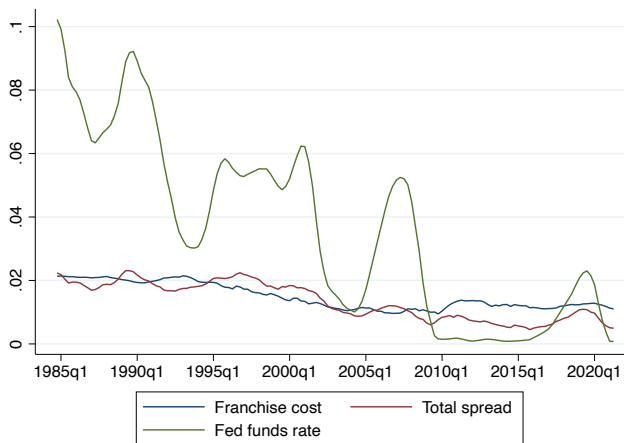
Deposit Spread Fit

Lending Spread Fit

Dynamics of spreads at the aggregate level

	(1) Deposits	(2) Deposits	(3) Lending	(4) Lending	(5) Total
Panel A: Regression in levels					
r_t^*	0.251	0.239	-0.069	-0.053	0.186
	(11.88)	(17.22)	(-3.03)	(-2.41)	(11.33)
ℓ_t^2		-0.195		0.159	-0.036
		(-3.80)		(2.44)	(-0.60)
ℓ_t^5		-0.069		0.147	0.078
		(-1.73)		(2.61)	(1.40)
Intercept	-0.001	0.002	0.008	0.004	0.006
	(-1.34)	(1.83)	(5.69)	(3.09)	(5.61)
R^2	79.18	95.10	14.86	75.41	83.16
Obs.	147	147	147	147	147

Bank-level ϕ estimates 2001-2021

	(1)	(2)	(3)	(4)
			Synthetic loan	
	ϕ_0 fixed	ϕ_1 float	ϕ_2 term	ϕ_5 term
Panel A: Regression in levels				
Deposit spread				
mean	0.0019	0.25	-0.23	-0.22
p50	0.0023	0.25	-0.23	-0.22
s.d.	0.0029	0.13	0.096	0.13
Loan spread				
mean	0.018	-0.10	0.090	0.28
p50	0.018	-0.098	0.093	0.29
s.d.	0.0089	0.18	0.20	0.22
Total spread				
mean	0.020	0.15	-0.14	0.068
p50	0.020	0.15	-0.13	0.070
s.d.	0.0089	0.22	0.20	0.22

Bank hedging via securities portfolio

(a) Securities duration
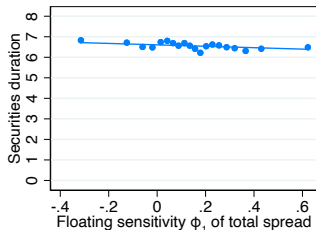
(b) Securities share
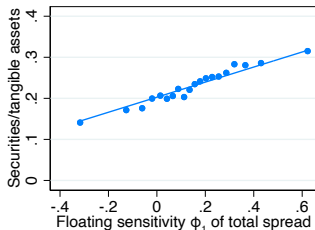
Sample: 2001 - 2021

► Regulatory guidance: sticky deposits = LT fixed-rate liabilities?

► NIM hedging? Swap $(1 - \beta)r_t^*$ into $(1 - \beta) \times$ fixed?

Bank valuation

- ▶ 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_1.
    - ▶ Term inertia component: The PV of the cash flow component represented by the exposures ϕ_2 and ϕ_5 to the synthetic term swaps l_t^2 and l_t^5

# Public BHC: Implied and actual market-to-book ratio in 2021Q2
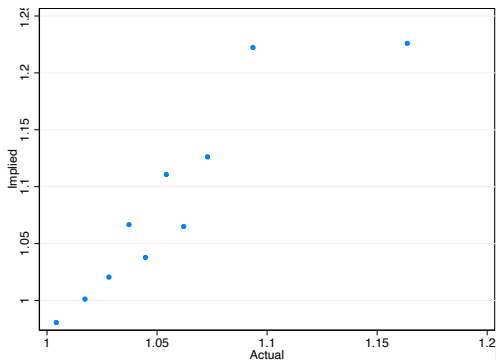
$$\text{Asset } M/B = 1 + \frac{(1-\tau)\left(\text{MTM}_{T-B} + PV(S-C)\right) - \tau \text{ Book Equity}}{\text{Book Assets}}$$

Fixed FV generates +interest rate risk

	(1) Mean	(2) Median	(3) S.E. of Mean
Panel A: Franchise value inputs			
ϕ_0	0.0205	0.0206	0.0001
ϕ_1	0.1419	0.1396	0.0028
Franchise cost/Assets	0.0198	0.0194	0.0001
Panel B: Franchise value components			
Floating FV	0.1419	0.1396	0.0028
Fixed FV	0.0259	0.0405	0.0055

Fixed and floating components of franchise value in 2021Q2 (relative to book assets)
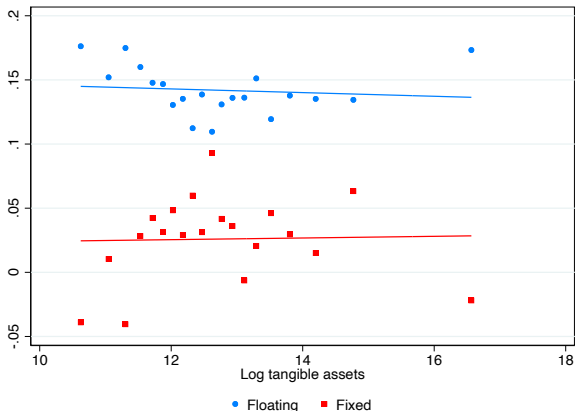
$$PV(S - C) = A \left[\frac{\phi_0 - c}{r_t^\infty} + \phi_1 + \phi_T PV(I^T) \right]$$
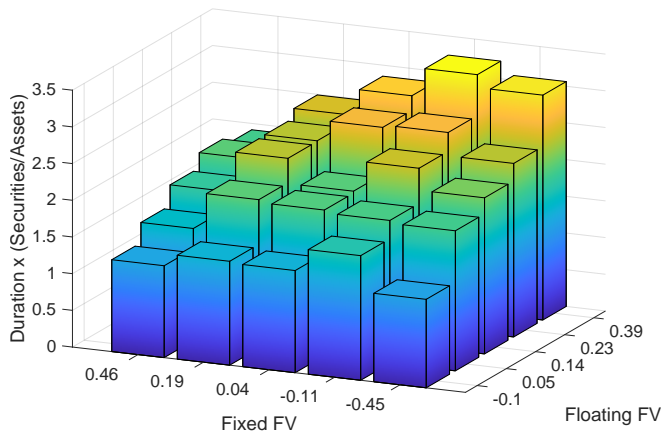
Fixed and floating components of franchise value in 2021Q2 (relative to book assets)
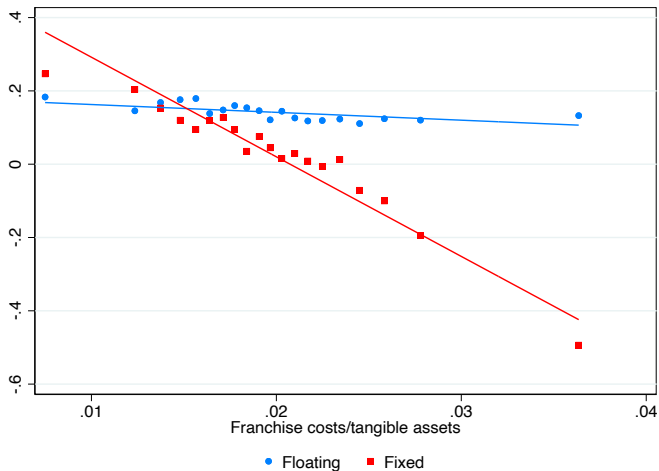
Determinants of bank securities duration

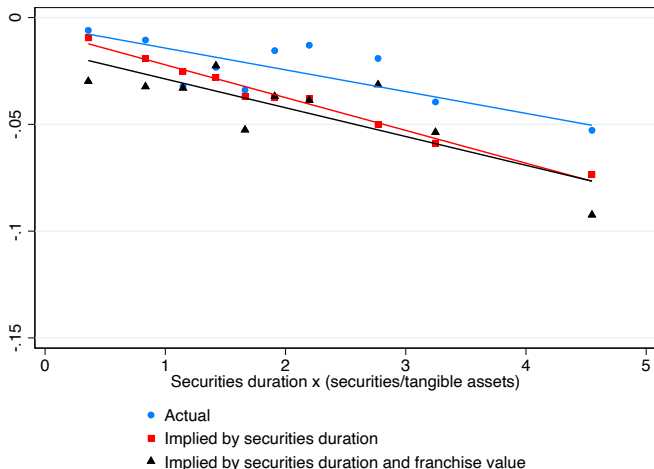|	(1)	(2)	(3)
Fixed FV component	-0.636 (-6.12)	-0.139 (-1.55)	-0.141 (-1.56)
Floating FV component		3.151 (15.99)	3.144 (15.95)
Log tangible assets			-0.052 (-2.74)
Intercept	2.177 (70.23)	1.713 (51.93)	2.373 (9.64)
R^2	0.01	0.09	0.09
Obs.	3772	3772	3772

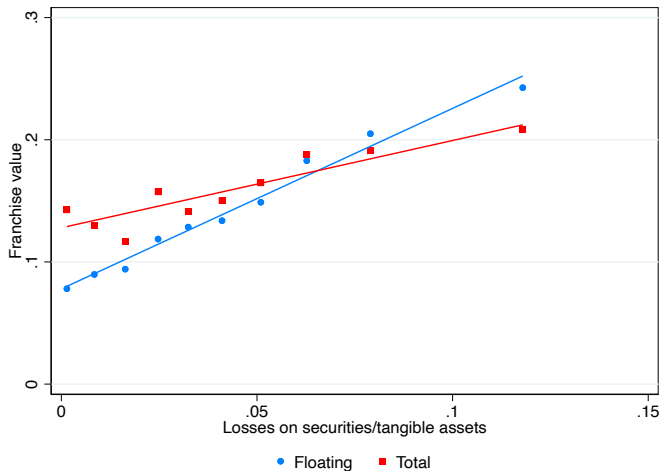# Bank securities duration

Banks' losses in 2023: Channels

▶ Deposit and lending business incur losses if
  ▶ positive fixed component of total spread: Higher yields $\Rightarrow$ higher discounting
  ▶ positive total spread exposure to synthetic loan portfolio: MtM losses

▶ Securities holdings: MtM losses

Changes in market-to-book assets ratio from 2021Q2 to 2023Q1, publicly traded BHC

Securities duration x (securities/tangible assets)

- Actual
- Implied by securities duration
- Implied by securities duration and franchise value

Comparison of franchise value in 2023 with losses on securities holdings, all banks

Security losses 2023 histogram, with FV adjusted based on projection

Legend:
- Gains on securities/tangible assets
- Gains on securities/tangible assets + franchise value
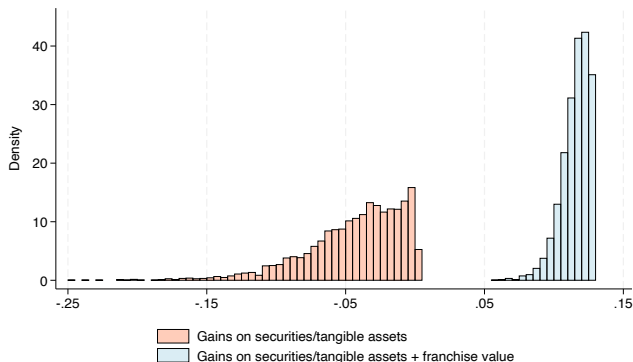
Conclusions

- Franchise value of typical bank has positive, not negative duration
  - Sticky deposits $\neq$ long-duration liabilities
  - Operating costs exist, but (more than) offset by fixed lending spread component

- Franchise values lower, not higher, in response to recent interest rate rise

- For typical bank, holding of long-term fixed-rate securities represents risk-taking, not hedging