Bank Economic Capital

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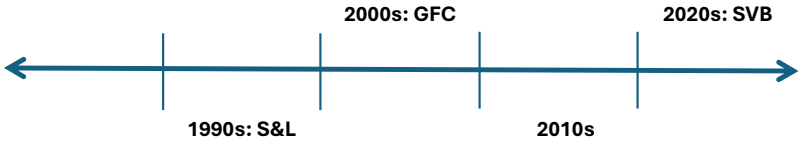
Motivation

- Assessments of bank solvency (e.g., capital) are central to the monitoring of financial institutions
- Conventional measures of bank capital are grounded in accounting rules that do not account for the timing of payments
  - Accrual-based accounting assumes the bank remains an 'ongoing concern'
  - Theories of capital structure (Modigliani and Miller, 1958) emphasize *market* leverage
- These differences are especially salient for banks, where book leverage is high and risks are unique:
  - Market risks (e.g., interest rate risk)
  - Funding liquidity risks (Diamond and Dybvig, 1983)
- When these differences are addressed, they are distinct from solvency

Evolution of risk measurement (not comprehensive!)



Solvency/Capital

Capital/Credit:	Leverage ratio	RWA	TCE, CET1	Stress testing	
Market risks:		IRR/EVE	MTM TCE		IRR/MTM TCE (again)
Liquidity	Cash/Reserves		LCR	NSF	Uninsured deposits

This paper

1. How can we incorporate liquidity and market risks into a quantitative assessment of solvency?
   - Map public regulatory data into a solvency measure that spans several business cycles
2. Does such a measure help identify 'at risk' banks?
   - A superior predictor of bank failure than other capital metrics
3. What can we learn more broadly about financial stability?
   - Reveals material dynamics in bank solvency and risk

Our approach: Economic capital (EC)

Calculate a market solvency constraint:

$$\begin{aligned} \text{EC} &= \sum_{t=1}^{T} \frac{A_t}{(1 + rf_t + rp_t)^t} - \sum_{t=1}^{T} \frac{L_t}{(1 + rf_t)^t} \\ &= PV_{Assets} - PV_{Liabilities} \end{aligned}$$

- The value of assets available to service liabilities assuming they are repaid in full
  - Excludes fee-based franchises and intangible assets
  - Does not account for derivatives (Lihong, et al., 2024; Granja, et al., 2024)
  - No asset illiquidity discounts
- Assets are discounted according to risk, liabilities at risk-free (or near risk-free) rates
- Can sensitize to depositor behavior, market prices (e.g., IRR), and credit losses

A condensed window into related literature...

- **Deposit runs and funding liquidity:** Diamond and Dybvig (1983), Goldstein and Pauzner (2005)
  - Demandable debt may run (reprice) if depositors face potential losses
  - **This paper:** Incorporates deposit repricing into an empirical measure of solvency
- **Interest rate risk:** Flannery (1981), English et al (2014), Drechsler, Savov, and Schnabl (2021), Abdymomunov, Gerlach, and Sakurai (2023), Demarzo, Krishnamurthy and Nagel (2024)
  - Earnings/equity are sensitive to interest rates, but ALM and deposit assumptions are critical
  - **This paper:** Evaluates the role of IRR on bank solvency; cyclical variation in 'natural' hedge
- **Funding stability and IRR:** Drechsler, Savov, Schnabl, and Wang (2024); Haddad, Hartman-Glaser, Muir (2024); Jiang, Matvos, Piskorski, Seru (2024)
  - Rate changes reduce asset values and the likelihood of a run (i.e., SVB)
  - **This paper:** Nests this eventuality along with other drivers of solvency

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Market solvency constraints are central to banking theory (and practice?!?), but remain a rarity for market monitors and empiricists.

Key data sources

1. Call Report: 1997:Q2 - 2025:Q1
   - Quarterly panel of commercial banks, excludes trusts and banks <$50m in assets
   - Sample period dictated by reporting of maturity schedules for loans and liabilities
2. FDIC Summary of Deposits: 1987 - 2024
   - Annual location and nature of branch networks
   - Useful for predicting deposit behavior and understanding expenses
3. Discount rates / Miscellany:
   - Risk free rates: par coupon yield curve & risk-neutral yield curve (ACM)
   - Credit spreads: AAA through B corporate OAS (BofA ICE), corporate yield curve

Converting data to fair value: Assets

	% of Assets	
	Mean	**Industry**
Fair Value:		
IB balances	3.94	4.91
NIB balances	2.80	2.37
FF & Repo	2.61	3.71
AFS securities	18.83	15.98
Equity securities	0.20	0.17
HFS loans	0.43	1.48
Trading assets	0.04	4.51
Other	1.11	0.88
Supplementary Report:		
HTM securities	3.58	3.51
Mort. servicing rights	0.04	0.29
Amortized Cost:		
Book Value Used		
Fixed assets	1.77	1.03
Intangibles	0.42	1.99
Other	1.64	3.71
Fixed-Rate Portfolio:		
HFI Loans	63.50	56.41
Loan loss reserves	-0.92	-0.96

- Reporting limitations are a *challenge*
- Par/Fair value items are used as reported
- If booked at amortized cost:
  1. Fair value may be reported elsewhere
  2. Book value is used as the closest approximation
  3. The present value is estimated (i.e., HFI loans)
- Loans represent the largest category of estimated assets ($\sim 60\%$)
  - AFS securities are reported at market value
  - HTM securities are reported in supplementary schedules

Notes: This table summarizes the composition of the bank balance sheets in our sample from 1997:Q2 through 2025:Q1. All items are scaled by book assets. Ratios are reported based on the sample mean and in aggregate (Industry). Items are categorized based on our approach to obtaining present values.

Converting data to fair value: Liabilities

- Time deposits and demand deposits are the largest source of financing
  - Time deposit are treated as a portfolio of fixed rate instruments
  - Demand deposits are modeled as a quasi-fixed rate declining perpetuity
- Relative to the average bank, the industry has,
  - Greater exposure to repo, other debt, and demand deposits
  - Less exposure to time deposits

	% of Assets	
	Mean	**Industry**
Fair Value:		
FF & Repo	1.33	4.88
Trading liabilities	0.01	2.13
Other	0.05	0.24
Amortized Cost:		
Book Value Used		
Other	0.69	2.16
Fixed-Rate Portfolio:		
Sub. debt	0.03	0.92
Other debt	3.76	7.16
Time deposits	34.22	16.76
Demand Deposits:		
Domestic	49.18	48.16
Foreign	0.08	7.43
Total	49.25	55.59

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Three methodologies to recover unobserved values

1. Portfolios with fixed-rate instruments
   - Loans, time deposits, subordinated debt, other borrowing
   - Market values are not reported but fixed-rate instruments fluctuate with rates and spreads
   - Modeled value is a function of duration (maturity & prepayment), credit risk (loan losses & risk prices) and interest rates

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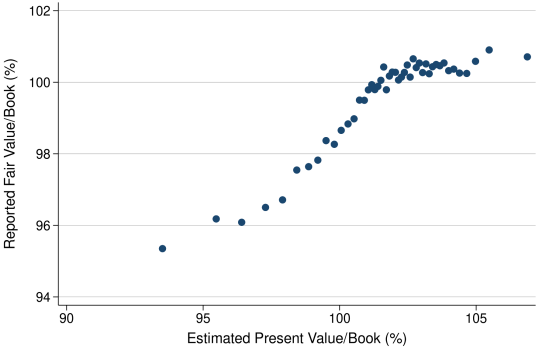
3. Necessary expenses
   - Off-balance sheet 'liability' — banks require expenses to realize assets & retain deposits
   - Exclude expenses related to off-balance sheet assets (most noninterest income)
   - Capture benefits of scale across the size distribution (Hughes and Mester, 2013)

Fixed-rate valuation: Loans

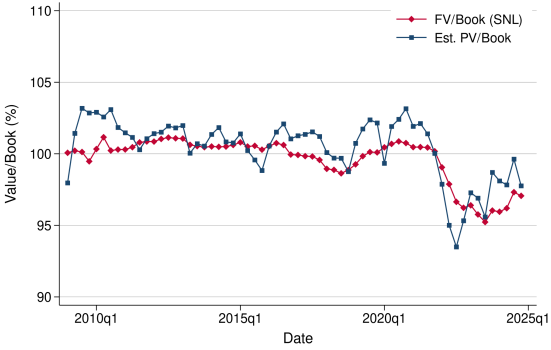
- We estimate *changes* in value based on *duration* and changes in *discount rates*
  - Assumes that book and market values are equal at turning points in the interest rate cycle
  - Consistent with observed behavior of securities and a sample of loans
- Duration: Calculated using reported maturity schedules and estimated prepayment
  - Prepayment only applied to loans: attenuates valuation gains when rates fall
- Discount rates: Risk-free rates for liabilities, but risk premium for loans
  - Risk premium based on credit spreads ranges from single-A to -BB/B corporate credit curve
  - Loan portfolio risk based on interest rate spread conditional on maturity
- Resulting risk assessments predict loan loss reserves and correspond public bank reports (although with greater sensitivity to risk)

Estimated loan values versus what public banks report

(a) Cross Sectional Bin Scatter

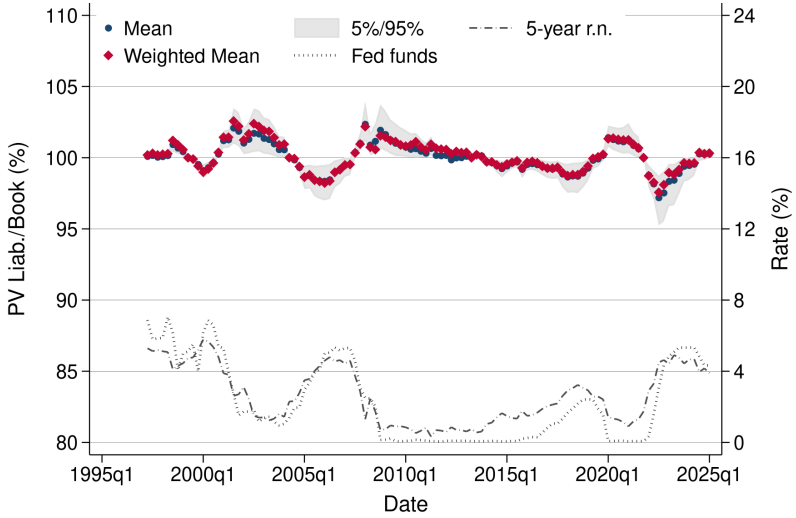


(b) Time Series Average

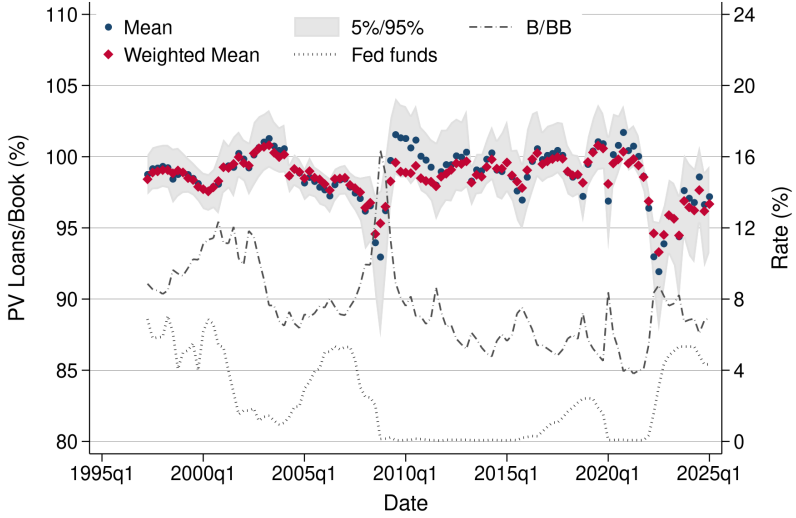


Notes: This figure plots the correlation of estimated loan present values with bank estimates of loan fair values in the cross section and in the time series. Bank reported fair values are from SEC filings of public BHCs as reported by S&P SNL. Estimated present values are our estimates.

Fixed-Rate Liabilities PV/Book: Varies with risk-free rates



Loans PV/Book: Influenced by credit risk and prepayment



Notes: The estimated value of loans are plotted relative to the book value gross of loan loss reserves.

Demand deposits: Valuation Approach

A dollar of deposits at bank i and time t is valued as a perpetuity with drawdowns,

$$PV_{i,t}^{D} = \frac{\beta_{i,t} y_t^D + \delta}{y_t^D + \delta}$$

- Demand deposits include interest bearing (savings) and noninterest bearing (checking)
  - Accommodates migration across product types over time
- Discount rate for deposits, y_t^D, based on risk-neutral yields
  - Removes term and liquidity premia from zero-coupon bonds
- Drawdown rate (i.e., maturity), δ and sensitivity of deposit rates with discount rates, $\beta_{i,t}$
  - No consensus on the key parameters, but PV is increasing in both
  - Conceptually and empirically linked: Higher beta is associated with greater growth
- Will fix δ (5%) and estimate $\beta_{i,t}$

Demand deposits: Recovering deposit betas

The ideal beta given the present value calculation:

1. Forward looking & long term: Expectation over 10+ years $\neq$ current beta
2. Reflect the data: Cross-sectional and time-series variation in betas

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2. Reflect the data: Cross-sectional and time-series variation in betas

Explain ultimate deposit betas, $\beta_{i,T}$, over five prior tightening cycles, T:

$$\beta_{i,T} = \alpha + \mathbf{\Gamma X}_{i,T} + \mathbf{\Theta Z}_T + \varepsilon_{i,T},$$

- $\beta_{i,T}$: Implied deposit rate / Fed funds rate ▸ Deposit betas
- $\mathbf{X}_{i,T}$: Bank/deposit characteristics at the start of the cycle
- $\mathbf{Z}_t$: Cycle characteristics: cycle length and maximum level of rates
- Use coefficients, bank characteristics, yields, and a 5% drawdown rate to estimate betas

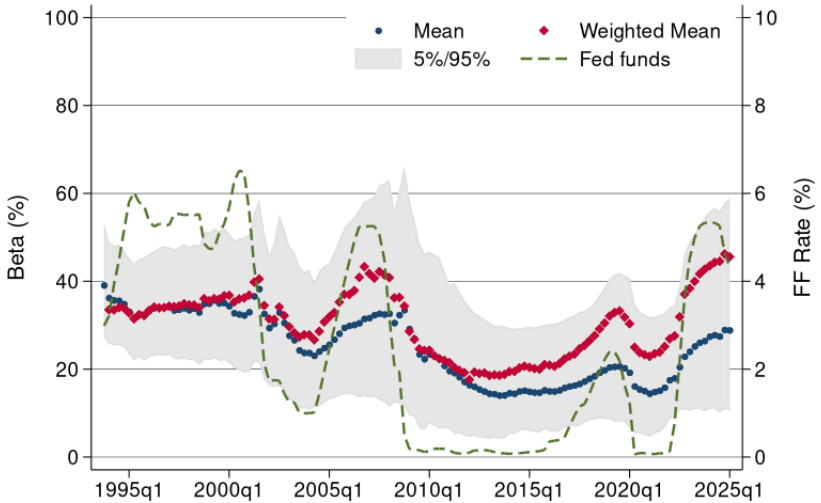
Demand deposits: Regression explains 2/3rds of variation

	β_{Deposits}
Bank Controls	(1)
Dep. rate/f^{5-10} (%)	0.53***
	(0.03)
Deposits/Account ($ '000s)	0.09***
	(0.01)
NIB share (%)	-0.16***
	(0.02)
Small acct. share (%)	-0.10**
	(0.03)
MMDA share (%)	0.09***
	(0.01)
Deposits/Branch ($ mm)	0.02***
	(0.00)
Deposit growth (%)	0.26**
	(0.09)

	β_{Deposits}
Time-series Controls	(1)
ln(Cycle length)	12.80***
	(2.27)
ln(ff_T) (%)	9.36***
	(0.60)
Observations	30085
Adj. R^2	0.62
Fixed Effects	None
Y mean	29.76

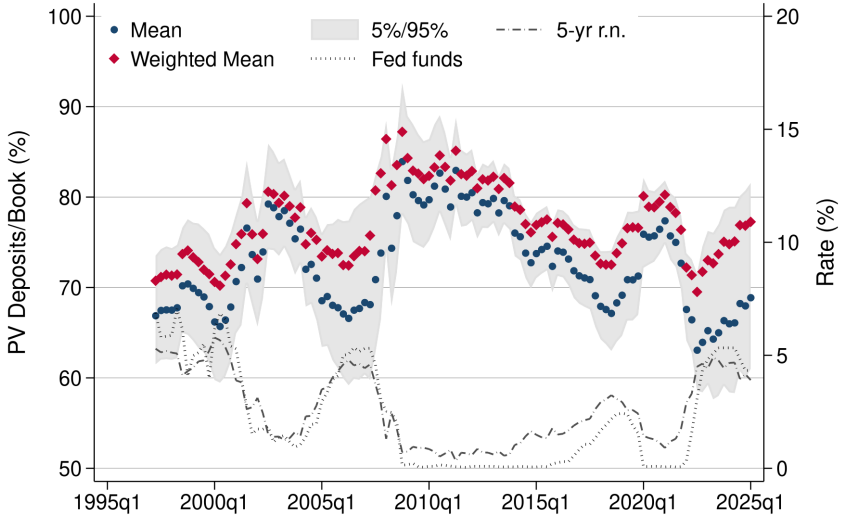
Notes: Estimated coefficients from regression of deposit betas on bank and time-series controls for 5 hiking cycles. Deposit betas are the ratio of deposit rates to the fed funds rate. Bank controls are as of the first quarter of each hiking cycle. Standard errors clustered by date and bank. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Demand deposits: Betas vary with long rates and bank characteristics

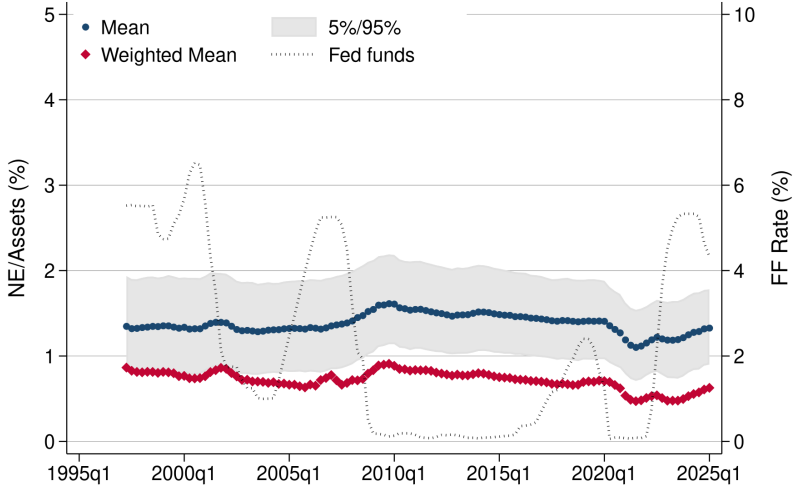


Notes: Estimated future deposit betas based on predicted values from regression of tightening cycle betas on bank and cycle characteristics. Predicted values assume a 5% drawdown rate, 12 quarter cycle, and long-term rates equal to the five-year r.n. rate.

Demand deposits: PV/Book materially deviates from one

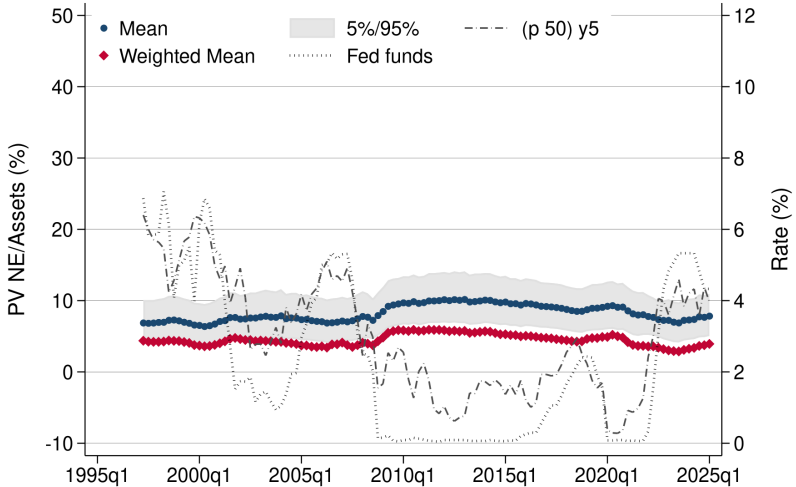


Hedonic regression suggests necessary expenses vary by size...



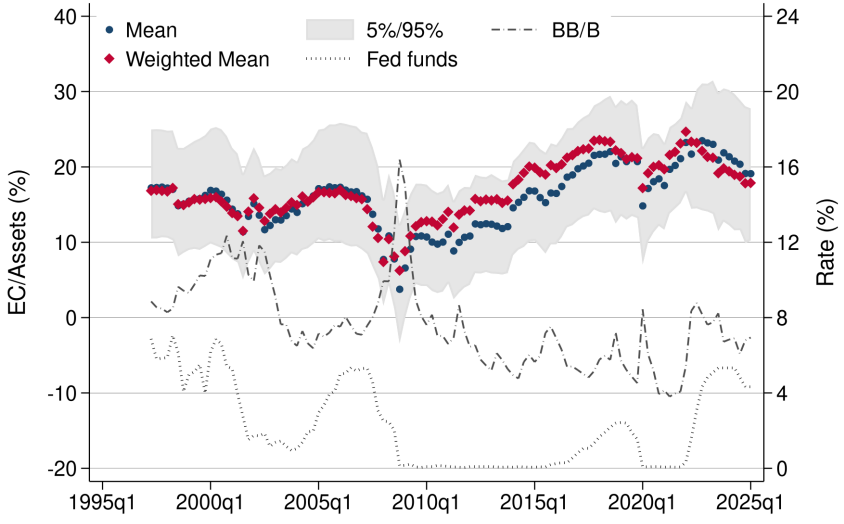
Notes: Estimates are calculated using the regression coefficients seeded with bank-specific ratios at each quarter.

... and PV is relatively immune to dynamics



Notes: Estimates are calculated using the regression coefficients seeded with bank-specific ratios at each quarter. Interest income is assumed to be equal to interest expense, noninterest income (excl. deposit fees) are set to zero, and loan loss reserves are set to zero.

Economic Capital: Similar in the size distribution and elevated post-GFC



Notes: Plots the implied distribution of EC from 1997:Q2 to present. Chart includes the 5th-95th percentile, the average and the weighted average.

Risk: Exposures can be derived and compared to EC

Funding liquidity:

- If depositors are concerned about the solvency of the firm, they may 'run'
  - Uninsured deposits reprice to market rates (i.e., they receive a deposit beta of one)
  - If bank looks unhealthy, it suggests it is at risk of sudden insolvency (i.e., sunspot)
- The extreme funding scenario, R-EC, is the binding scenario for solvency (R-EC$<$EC)

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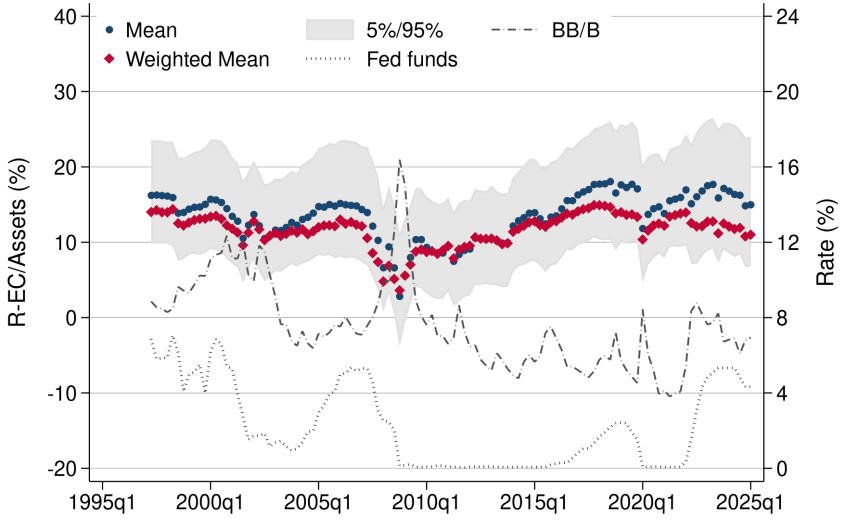
IRR and Credit:

$$\frac{\mathrm{dEC}}{Assets} = \underbrace{(\beta^{A}_{rf} - \beta^{L}_{rf})\mathrm{d}rf}_{\text{Interest rates}} + \underbrace{\beta^{A}_{rp}\mathrm{d}rp}_{\substack{\text{Credit}\\ \text{spreads}}} \quad .$$

- Can incorporate short vs. long rates, credit losses, specific spreads, asset illiquidity, etc.
- Exposures can be combined to consider economic scenarios
- Scale by EC or R-EC to gauge materiality

R-EC attenuates post-GFC gains, especially for larger banks



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Results

1. Validation
   - March, 2023 (IRR / Funding risk)
   - Bank failures 1997-2024 (Credit risk)
   - Equity prices
2. Applications
   - Financial stability and stress
   - Credit provision
   - Policy counterfactuals

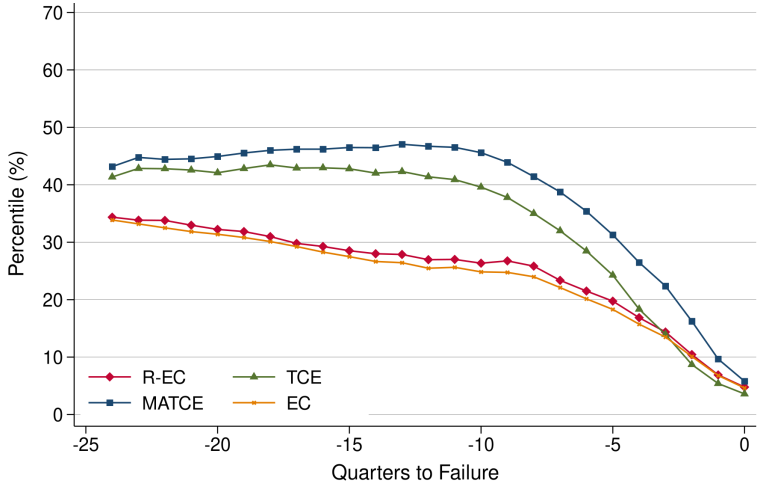
Prior to 2022 rate hikes, R-EC highlights banks that fail

- Out of $\sim$ 140 banks $>$ 10\$Bn in assets, they clearly identify the banks closer to insolvency (R-EC) and exposed to IRR (+200bps R-EC)
- IRR and MTM assets do not uniquely identify banks that fail — BUT the interaction between R-EC and IRR does!

	R-EC		β_{rf}		Stress R-EC		Stress MATCE	
	Rank	%	Rank	%	Rank	%	Rank	%
Silvergate	1	2.37	3	-2.74	2	-3.10	83	2.39
Silicon Valley	2	3.21	2	-3.25	1	-3.29	29	-1.19
Signature	3	4.24	18	-1.02	4	2.21	94	2.93
First Republic	10	8.37	1	-3.29	3	1.79	22	-1.91
Industry ($>$ \$10b)	69.45	13.78	69.39	0.22	69.50	14.21	67.82	1.47

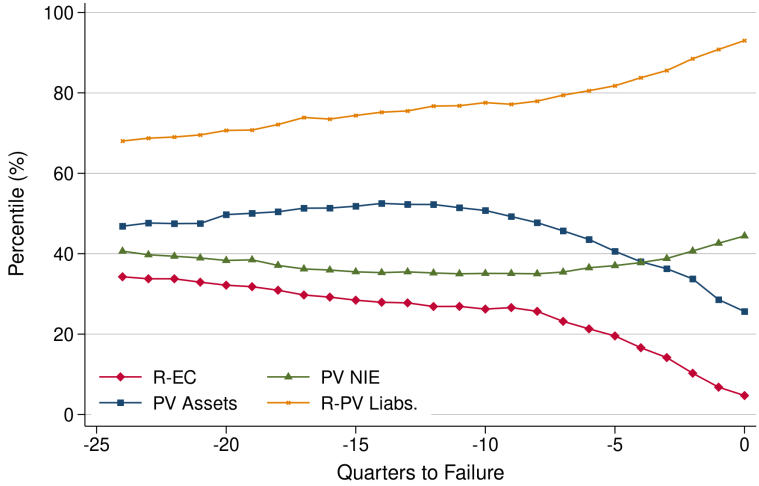
Notes: This table summarizes several measures of bank capital for banks that failed in 2023:Q1 as of 2021:Q4. Ranks are relative to banks with more than \$10bn in assets and are reported from low to high. R-EC is the economic capital in a deposit run scenario. β_{rf} is the exposure to interest rate risk, Stress R-EC is the R-EC assuming a 200bps increase in risk-free rates. Stress MATCE is TCE where the MTM assets are based on our PV estimates and a 200bps increase in interest rates.

Bank failures (1997-2024): R-EC/EC are lower years in advance ...



Notes: This figure plots the percentile for various solvency metrics in the run-up to bank failure as identified in FDIC failure list (1997 to present). Percentiles are calculated quarter-by-quarter.

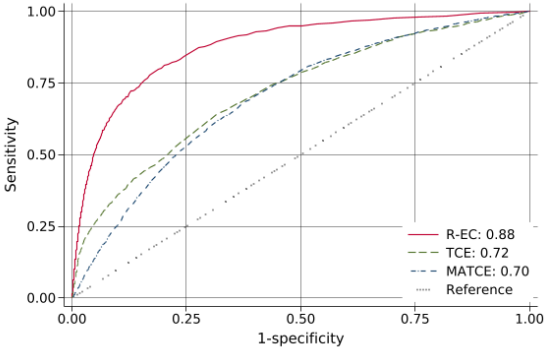
... primarily due to higher liability values



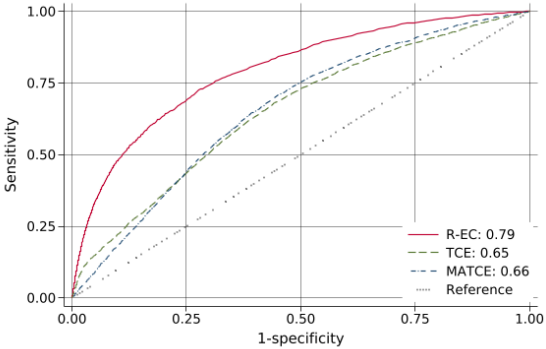
Notes: This figure plots the percentile for the components of R-EC in the run-up to bank failure in order to illustrate the importance of both assets, liabilities and expenses in assessing risk. Percentiles are calculated quarter-by-quarter.

Receiver Operating Curves suggest EC/R-EC are more predictive, especially at long horizons

(a) 8-quarter



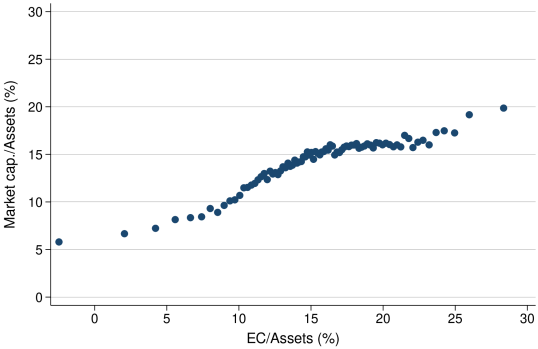
(b) 16-quarter



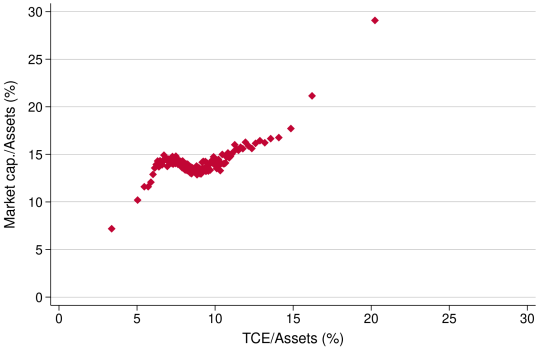
Notes: Plots ROCs for a variety of capital measures. ROCs are based on a logit model with a failure dummy as the dependent variable and a lagged measure of capital as the independent variable. We consider two dependent variables: a dummy equal to one if a bank fails in the 4-8 quarters in the future and a dummy equal to one if a bank fails in 4-16 quarters. Alternative specifications that include failure in the next 4 quarters retain the same ordering. Line labels also report the Area Under the Curve.

EC correlates with market assessment of equity value

(a) EC



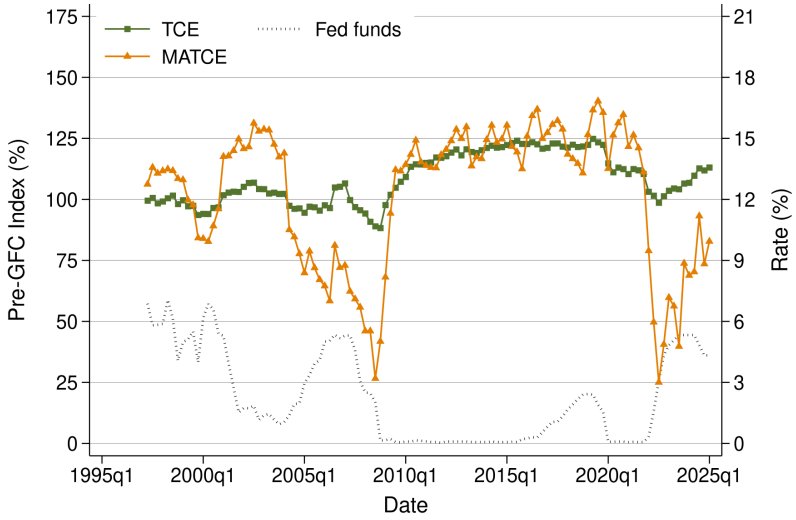
(b) TCE



Notes: Plots the correlation of market capitalization and capital ratios in the sample of public BHCs from 1997 to 2024. EC is aggregate across Call Report filers. Market capitalization and capital measures are scaled by book assets. (a) contains a bin scatter of market cap. versus EC and (b) a bin scatter of market cap. versus TCE. Results are similar in the presence of date and entity fixed effects.

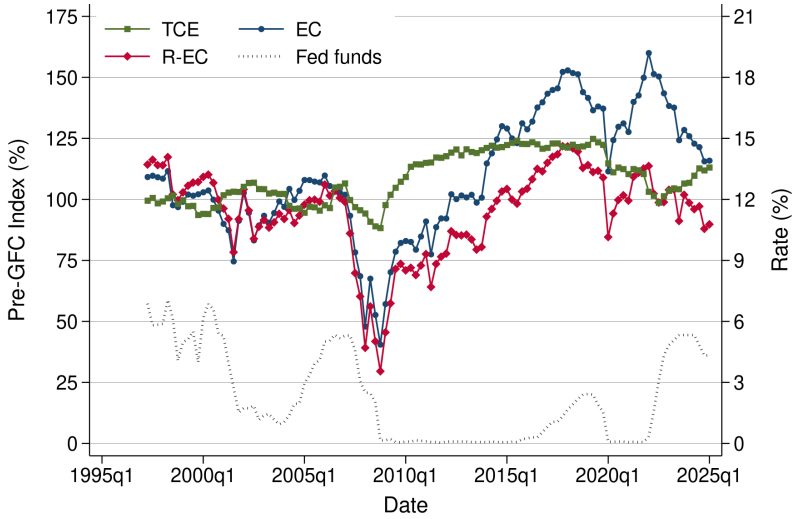
▸ Deviations

Financial stability: Industry capital ratios rebounded sharply post GFC ...



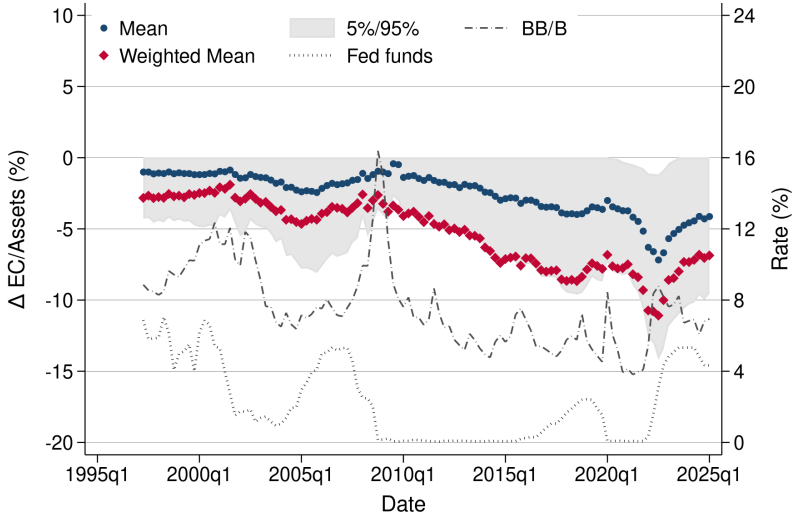
Notes: This figure plots the evolution of industry capital ratios over time. For comparison purposes, we index ratios to their pre-GFC average (1997:Q2-2007:Q1).

... whereas R-EC recovered slowly and now is below pre-GFC level



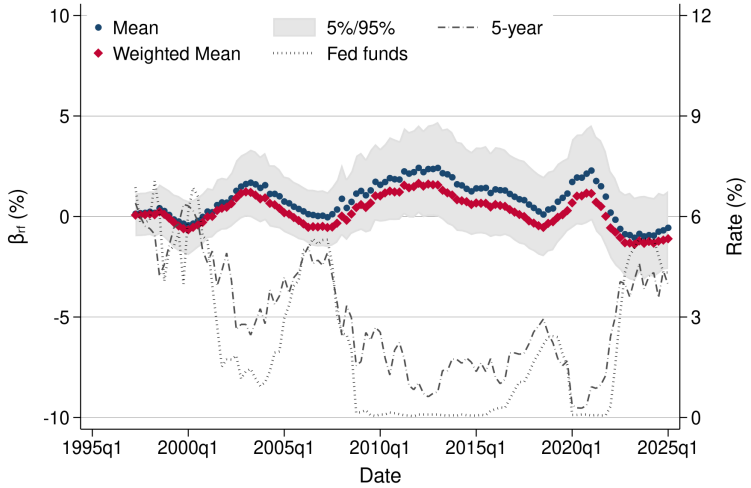
Notes: This figure plots the evolution of industry capital ratios over time. For comparison purposes, we index ratios to their pre-GFC average (1997:Q2-2007:Q1).

Deposit repricing risk (R-EC less EC) has grown since the GFC



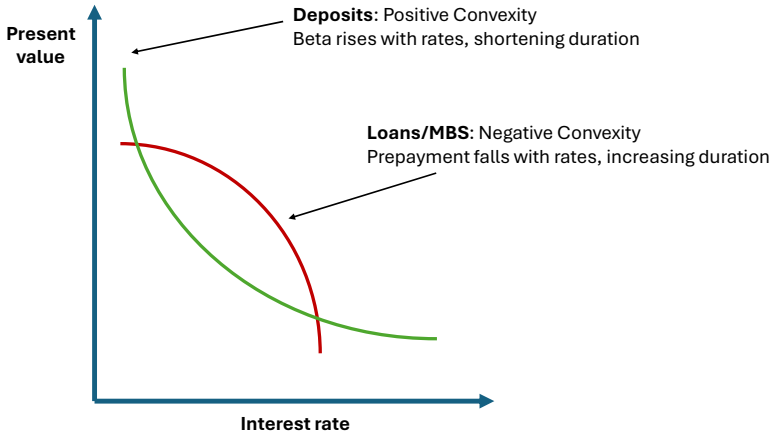
Notes: This figure plots the difference between R-EC and EC which reflects the value lost from a deposit run scenario.

Dynamics exposure to interest rates limits of 'natural' hedging

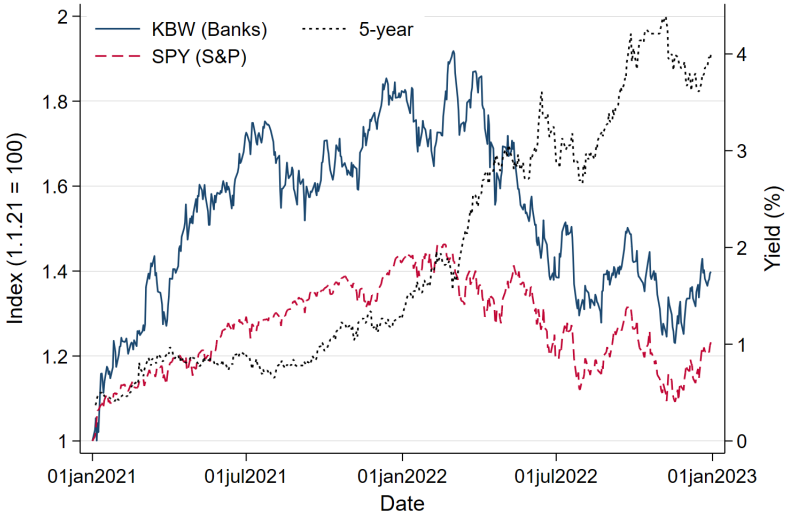


Notes: Depicts the sensitivity of R-EC to a parallel shock in interest rates.

In the absence of runs, dueling convexity complicates ALM



Anecdote: Banks outperformed early, underperformed late



Credit Supply: Economic capital better explains lending

	Loan Growth$_{t \to t+8}$	
	Coefficient	Std. Error
EC_{t-8}	0.39***	(0.04)
TCE_{t-8}	0.13	(0.11)
Bank & Time FE	Yes	
Observations	477,346	
Adj. R^2	0.51	

Economic Interpretation:

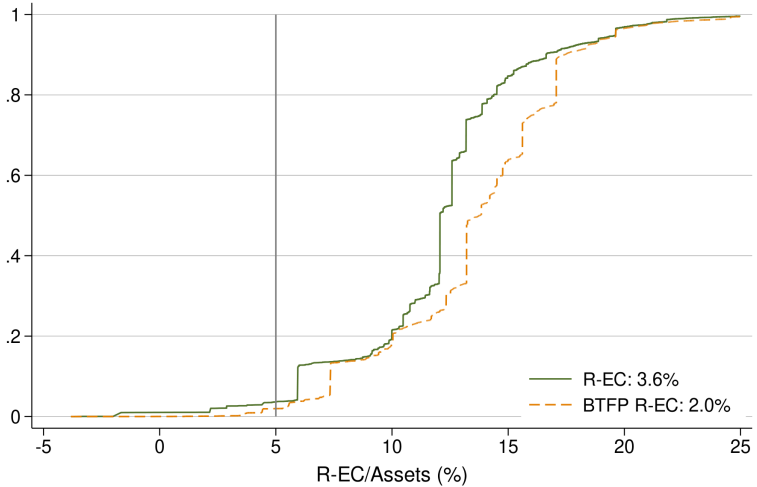
- 1pp higher EC/Assets
  $\rightarrow$ 0.39pp more lending growth
- Economic constraints bind before regulatory

Implications:

- Monetary transmission mechanism
- Low deposit betas = funding advantage
- Relevant for credit provision research

Notes: 8-quarter horizon, loan growth winsorized 5th/95th percentiles. Standard errors cluster by bank and year.

Application: Policy interventions and solvency distributions (e.g., BTFP)



Notes: Plots the cumulative distribution of R-EC in 2022Q4 and the distribution assuming implementation of the BTFP. Both distributions are asset weighted. The vertical line indicates a 5% economic capital to assets ratio. Labels indicate the percent of assets below 5%.

Final thoughts

- Integrates credit, liquidity and market risks into a solvency framework
  - Jointly quantifies funding liquidity and market price risks
  - Interactions matter
  - Despite post-GFC regulation, risks accumulated
- EC is superior predictor of failure at long horizons
  - The treatment of liabilities contains critical information
- While EC improved post-GFC, deposit risk and interest rate risk have grown

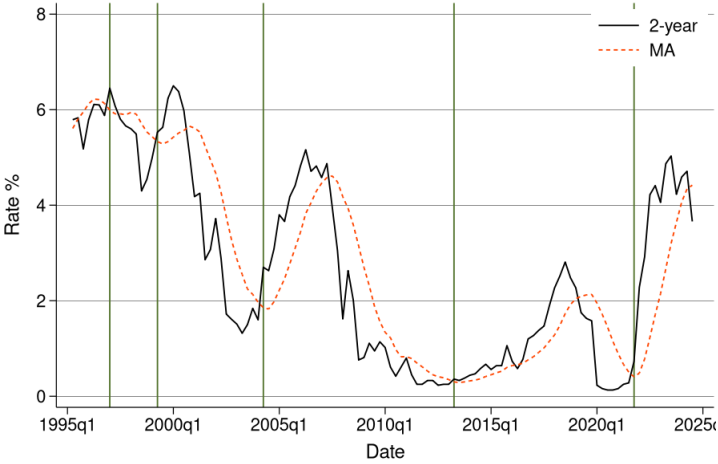
Final thoughts

- Integrates credit, liquidity and market risks into a solvency framework
  - Jointly quantifies funding liquidity and market price risks
  - Interactions matter
  - Despite post-GFC regulation, risks accumulated
- EC is superior predictor of failure at long horizons
  - The treatment of liabilities contains critical information
- While EC improved post-GFC, deposit risk and interest rate risk have grown
- Applications demonstrate utility:
  - Microprudential: early warning system for supervision
  - Macroprudential: assessment of systemic vulnerabilities
  - Credit supply: EC is the more relevant constraint on intermediation than reg. capital
  - Policy evaluation: framework for assessing interventions (e.g., BTFP)
- Highlights the use case for better public regulatory data on derivatives and deposits

Appendices

1. Data & balance sheets
2. Fixed-rate portfolios
3. Demand deposits

Appendix: Fixed-rate portfolio cycle dates



Notes: illustrates how we select the dates by illustrating the two-year GSW yield and its two-year moving average. PV_0 dates are those dates where the yield exceeds the moving average for at least two quarters for the first time in a year.

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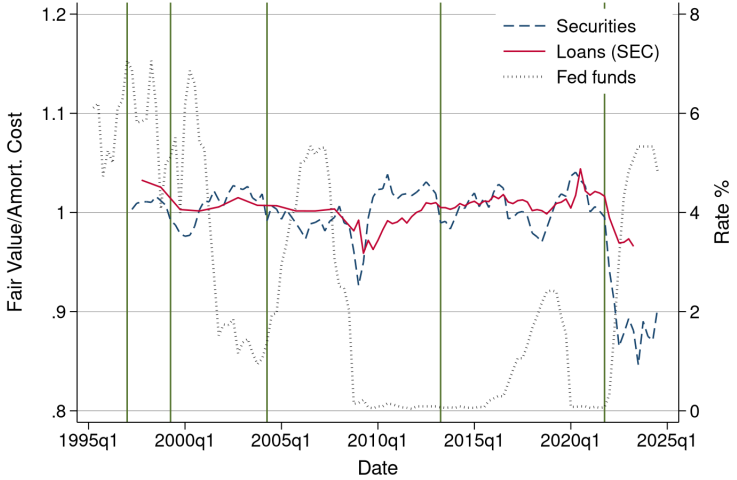
Appendix: Fixed-rate portfolio FV/Book



Notes: Illustrates the relative fair value to amortized cost for securities (Call Report) and loans (sub sample of SEC filings) over time. Both are calculated as weighted averages.

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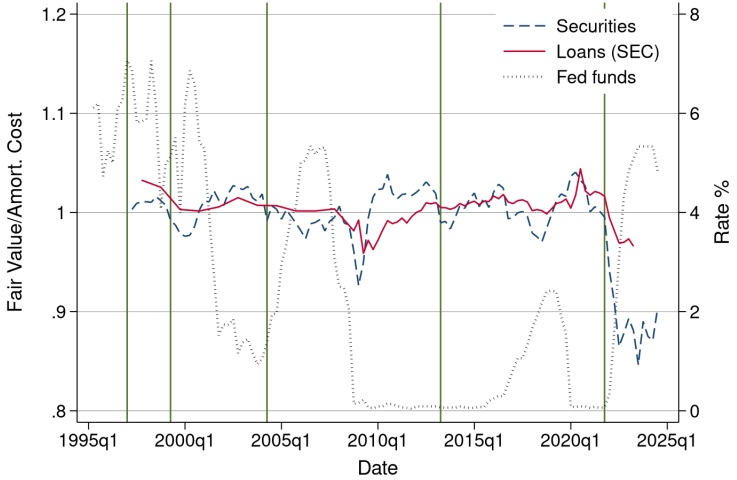
Appendix: Fixed-rate portfolio FV/Book



Notes: Illustrates the relative fair value to amortized cost for securities (Call Report) and loans (sub sample of SEC filings) over time. Both are calculated as weighted averages.

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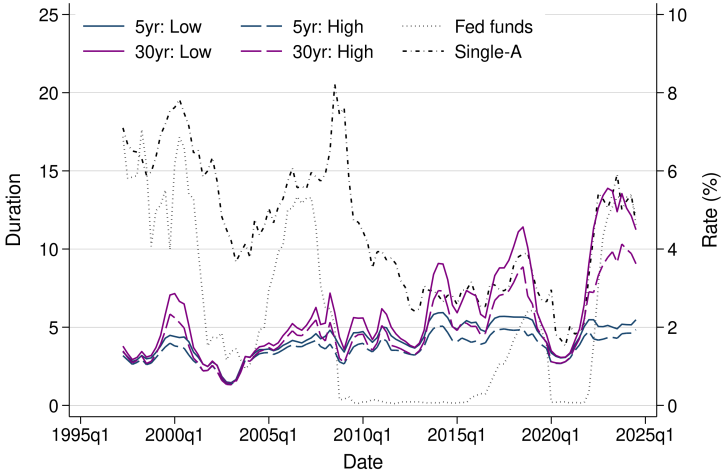
Appendix: Fixed-rate portfolios durations, RRE



Notes: Shows the range of durations using our estimates of heterogeneous risk premia with prepayment. The low risk durations (Single-A) are depicted in solid lines and the high risk durations (Single-B) are depicted in the dotted lines.

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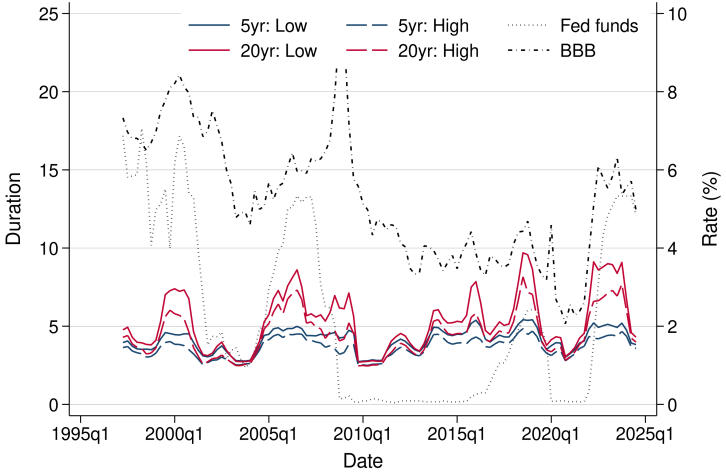
Appendix: Fixed-rate portfolios durations, Other



Notes: Shows the range of durations using our estimates of heterogeneous risk premia with prepayment. The low risk durations (Single-A) are depicted in solid lines and the high risk durations (Single-B) are depicted in the dotted lines.

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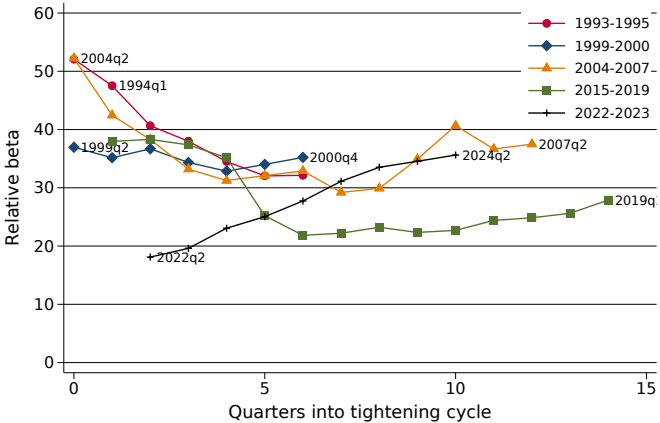
Appendix: Size-weighted deposit betas converge over tightening cycles



Notes: Plots the weighted average ratio of deposit rates to the fed funds rate. Deposit rates are implied by the quarterly deposit expense scaled by the average balance of demand deposits.

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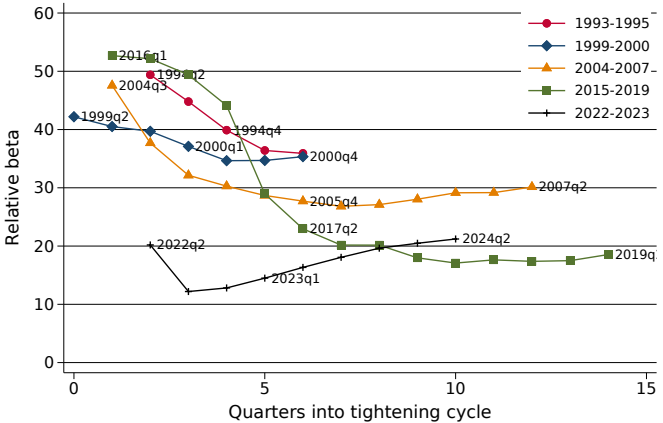
Appendix: Equal-weighted deposit betas have fallen over time



Notes: Plots the average ratio of deposit rates to the fed funds rate. Deposit rates are implied by the quarterly deposit expense scaled by the average balance of demand deposits.

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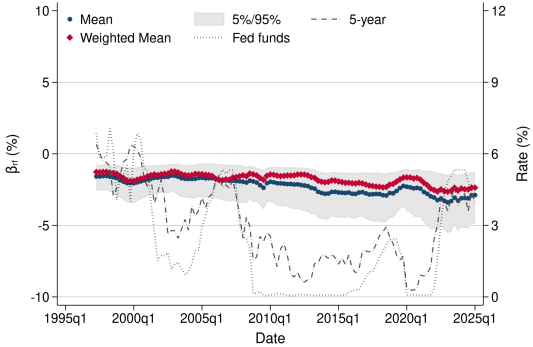
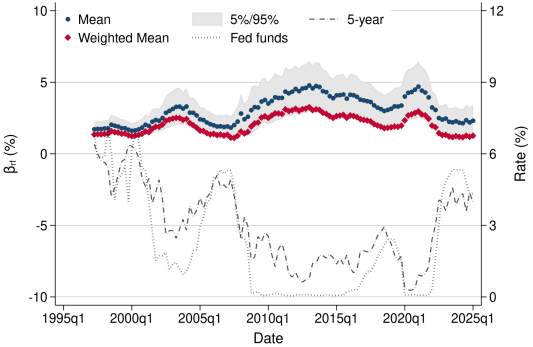
Negative convexity in assets, positive convexity of deposits

(a) Asset: β_{rf}



(b) Liability: -β_{rf}



Notes: Depicts the sensitivity to a parallel shock in interest rates assuming uninsured deposits have a beta of one and (b) the sensitivity to a shock to credit spreads.