Bank Economic Capital

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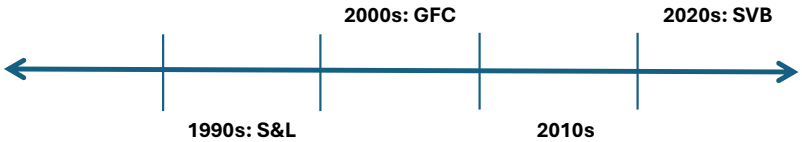
The views expressed are solely those of the authors, and do not represent the opinions of the Federal Reserve Bank of New York or the Federal Reserve System.

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'
- Hence, unique risks that banks face are not reflected in solvency measures:
  - Market risks (e.g., interest rate risk)
  - Funding liquidity risks (Diamond and Dybvig, 1983)
- To the extent we do measure other risks, they tend to be 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,
but remain a relative rarity for market monitors and empiricists.

Bridging regulatory data to economic capital is a pain

- Primary data based on Call Report: 1997:Q2 - 2024:Q3
  - Quarterly panel of commercial banks, excludes trusts and banks <$50m in assets
  - Sample period dictated by reporting of maturity schedules for loans and liabilities
- When available, we use fair value items as reported (e.g., AFS securities, HFS loans)
- If an item is booked at amortized cost,
  1. Fair value may be reported elsewhere in the Call Report
  2. The present value is estimated using an appropriate method
  3. Book value is used as the closest approximation (for small balance items only)
- The largest categories of assets/liabilities: loans, demand deposits, time deposits

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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2. 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)

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   - Capture benefits of scale across the size distribution (Hughes and Mester, 2013)
3. Demand deposits
   - Long effective maturity and heterogeneous, quasi-fixed rate pricing (Sheehan, 2013)
   - Subject to alternative equilibrium when solvency is in doubt
   - Price and quantity of deposits vary over time and in the cross-section

Demand deposits: Valuation

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: aggregate deposit growth, cycle length and final level of rates
- Use coefficients, bank characteristics, yields, and a 5% drawdown rate to estimate betas

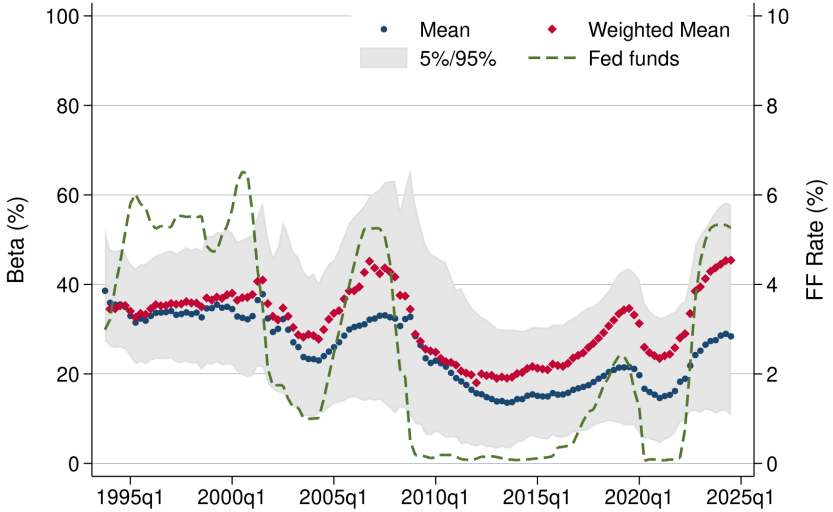
Demand deposits: Regression results

	β_{Deposits}
Bank variables	(1)
Dep. rate/f^{5-10} (%)	0.52***
	(0.05)
Deposits/Account ($ '000s)	0.10***
	(0.01)
NIB share (%)	-0.14***
	(0.01)
Small acct. share (%)	-0.08**
	(0.03)
MMDA share (%)	0.09***
	(0.01)
Deposits/Branch ($ mm)	0.02**
	(0.00)
Retail share (%)	-0.07**
	(0.02)
ln(Liquidity/Deposits)	-2.71**
	(0.82)

	β_{Deposits}
Cycle variables	(1)
ln(Cycle length)	11.00***
	(2.00)
ln(ff_T) (%)	10.93***
	(1.06)
Deposit growth (%)	0.30*
	(0.12)
Observations	29968
Adj. R^2	0.59
Fixed Effects	No
Y mean	29.76

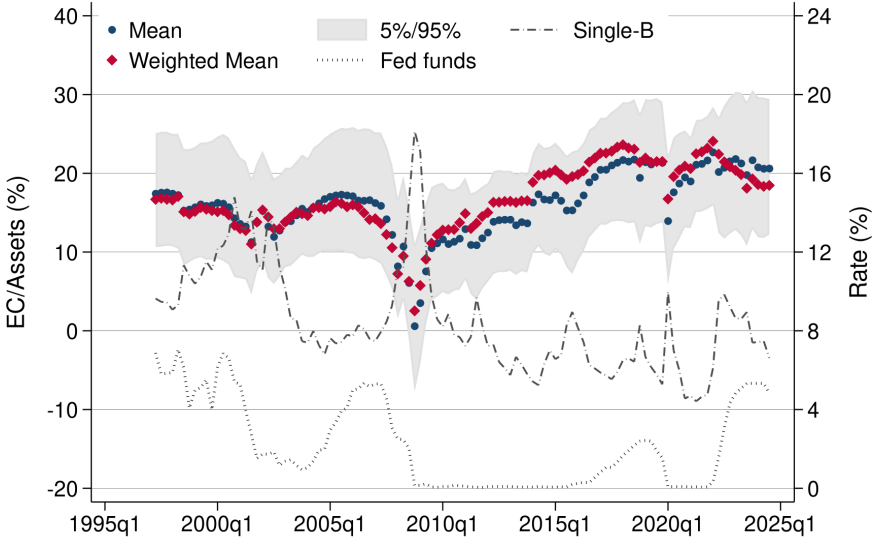
Notes: Reports the estimated coefficients from regressions of bank demand deposit betas on bank and time-series controls for 5 hiking cycles. Deposit betas are the ratio of deposit rates to the fed funds rate. Bank controls are as of the first quarter of each hiking cycle. Column (2) includes time fixed effects and (3) bank fixed effects. Standard errors are clustered by date. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Distribution of betas varies with long rates and across banks



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-terms rates equal to the five-year r.n. rate.

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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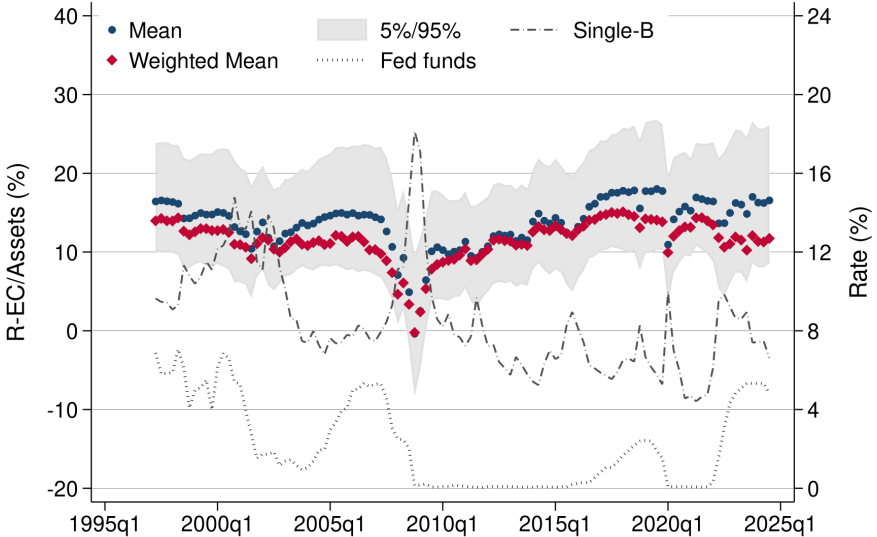
IRR and Credit:

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

- 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 is lower, especially for larger banks, attenuating post-GFC solvency



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Results

1. Validation
   - March, 2023 (IRR / Funding risk)
   - Bank failures 1997-2024 (Credit risk)
   - Equity prices
2. Economic capital and risk exposures
   - Evolution of 'run' risk
   - Exposure to interest rate risk

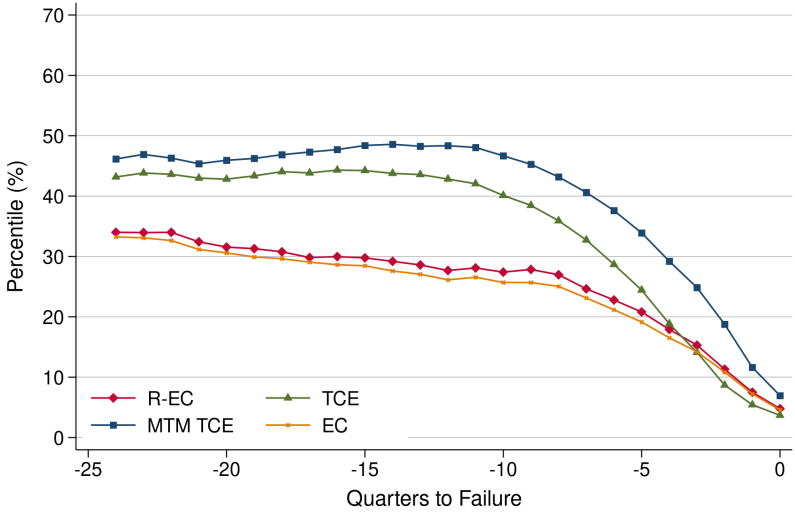
Prior to the rise in rates, 2021:Q4, R-EC identifies banks that fail

- 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)
  - Similar to others evaluating these failures (Drechsler et al. 2024; Haddad et al, 2024; Jiang et al, 2024)

	R-EC		EC		+200bps R-EC		MTM TCE	
	Rank	%	Rank	%	Rank	%	Rank	%
Silvergate	1	2.90	58	22.58	2	-2.51	98	2.66
Silicon Valley	2	3.39	24	19.01	1	-2.71	42	-0.78
Signature	3	4.36	18	17.92	4	1.93	102	3.10
First Republic	8	8.31	26	19.35	3	0.96	43	-0.77
Industry ($>$ \$10b)		13.84		22.46		14.22		1.10

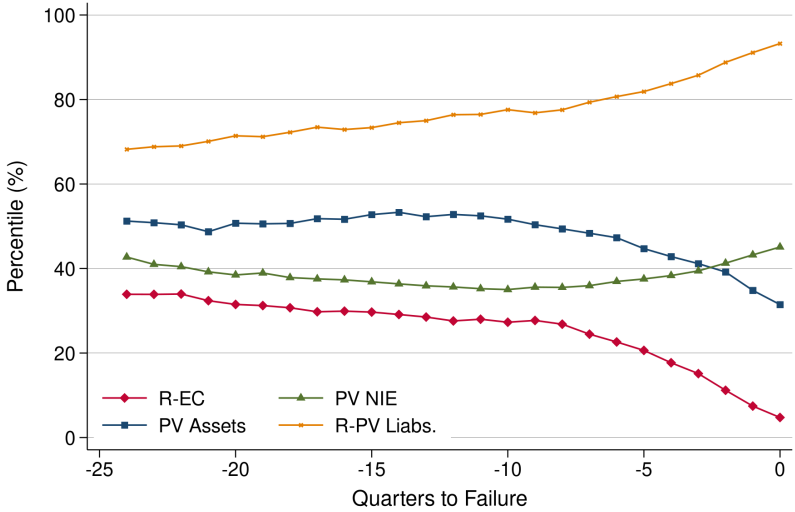
Notes: This table summarizes several measures of bank capital for banks that failed in 2023:Q1 as of 2021:Q4. The table reports the rank relative to banks with more than \$10bn in assets as well as the level of capital to assets (in percent). Ranks are reported from low to high. R-EC is the economic capital in a deposit run scenario. Stress R-EC is the R-EC assuming a 200bps increase in risk-free rates. MTM TCE is TCE where the MTM assets are based on our PV estimates.

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



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.

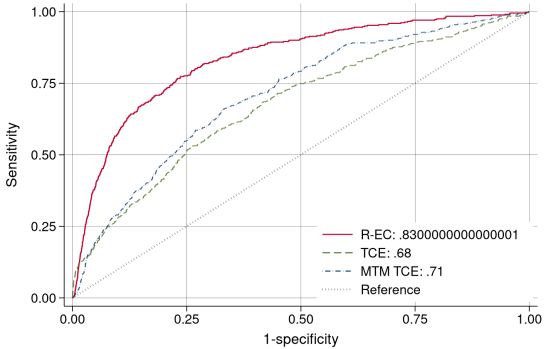
... primarily due to higher liability values!



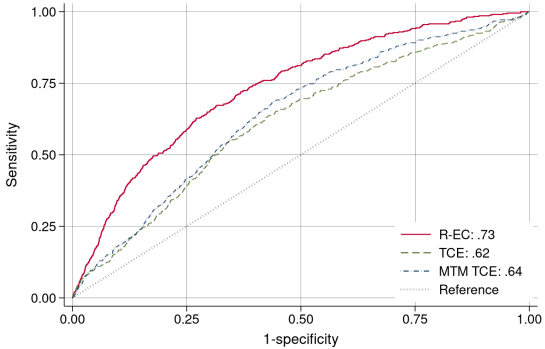
Notes: This figure plots the percentile for the components of R-EC in the run-up to bank failure in order to illustrate the importance of both assets, liabilities and expenses in assessing risk. Percentiles are calculated quarter-by-quarter.

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

(a) 8-quarter



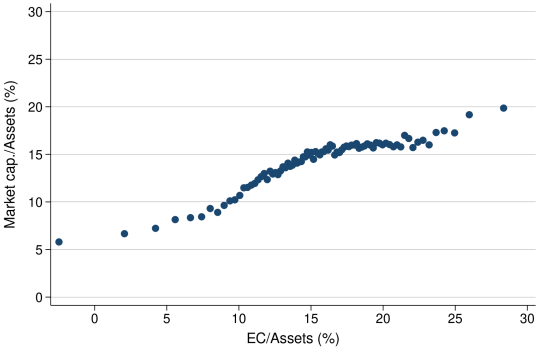
(b) 12-quarter



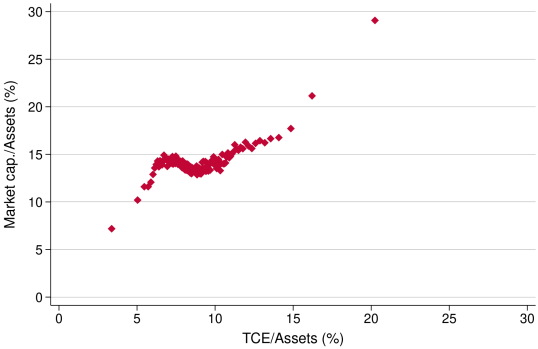
Notes: Plots ROCs for a variety of measures of bank solvency. ROCs are based on a logit model with a failure dummy as the dependent variable and a lagged measure of capital as the independent variable. We consider two models: one with an 8-quarter and a second with a 12 quarter lag. Line labels also report the AUC.

EC correlates with market assessment of equity value

(a) EC



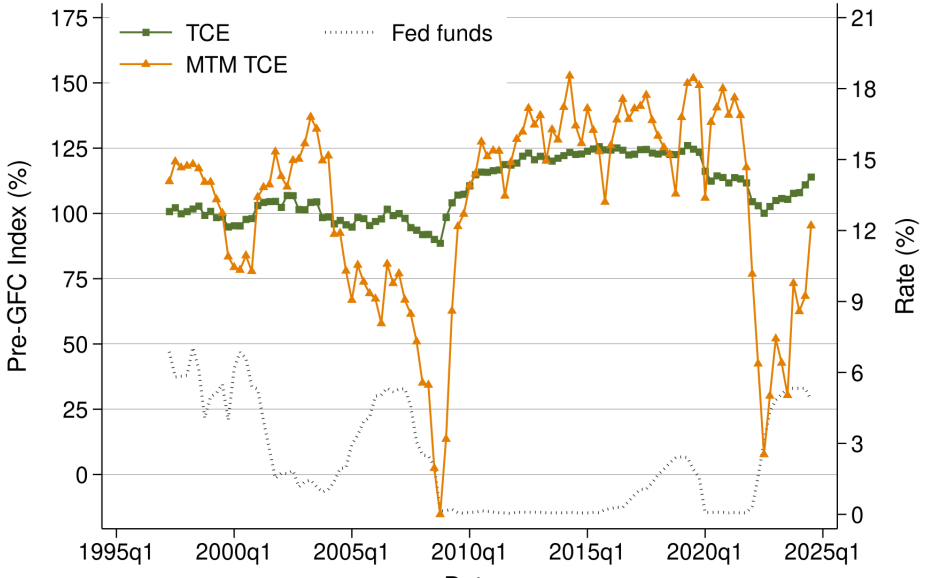
(b) TCE



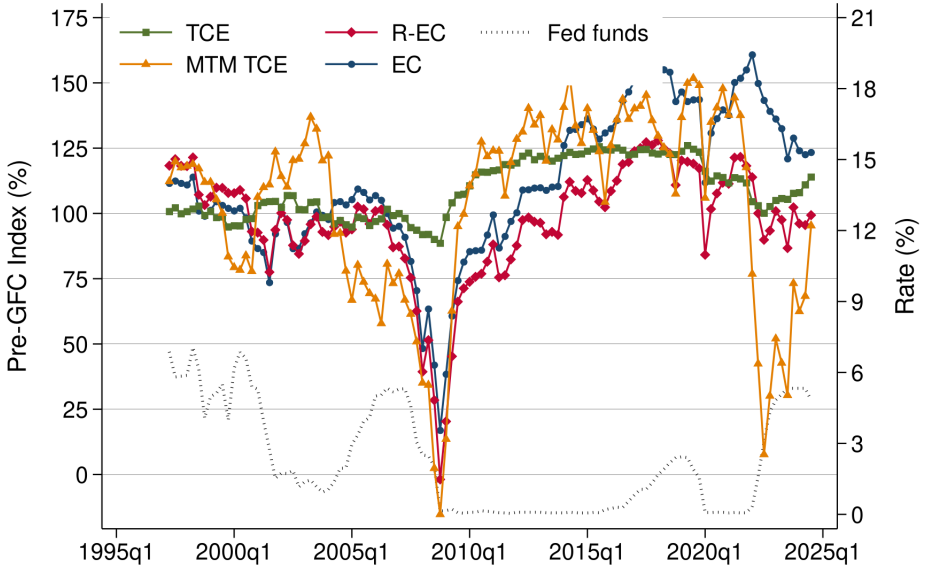
Notes: Plots the correlation of market capitalization and capital ratios in the sample of public BHCs from 1997 to 2024. EC is aggregate across Call Report filers. Market capitalization and capital measures are scaled by book assets. (a) contains a bin scatter of market cap. versus EC and (b) a bin scatter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

▸ Deviations

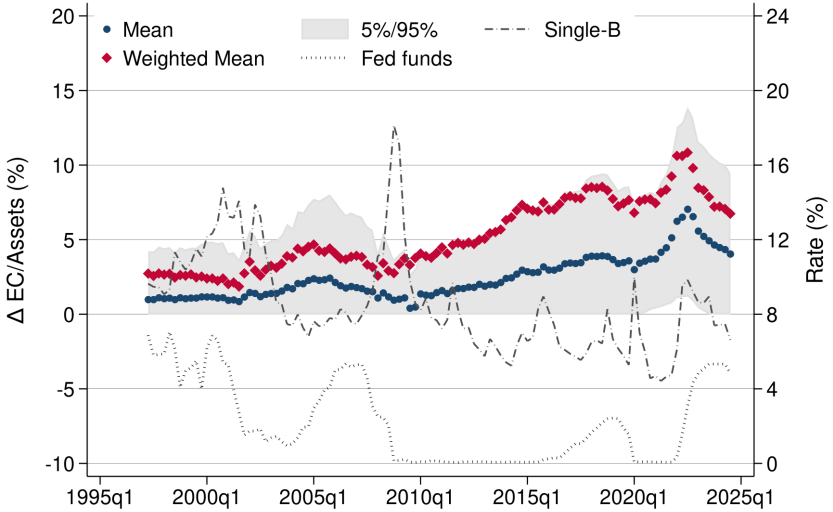
Industry capital ratios fell in the GFC and rebounded...



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

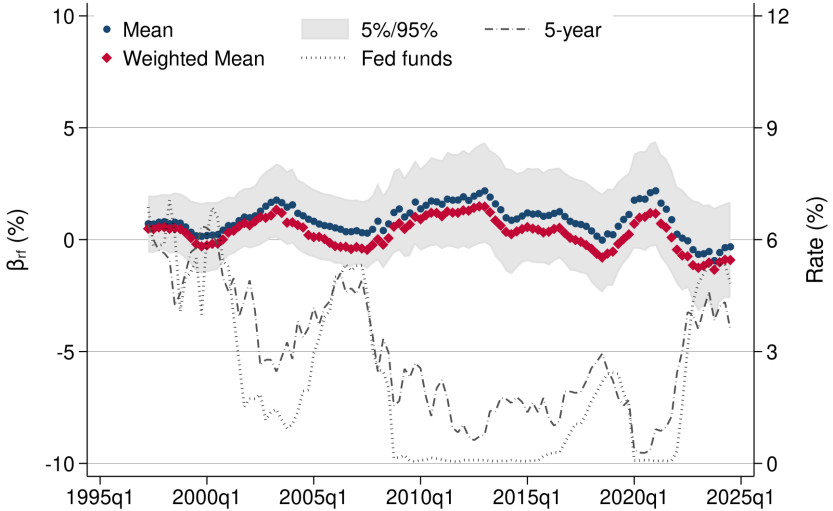


Deposit repricing risk (EC less R-EC) has grown since the GFC



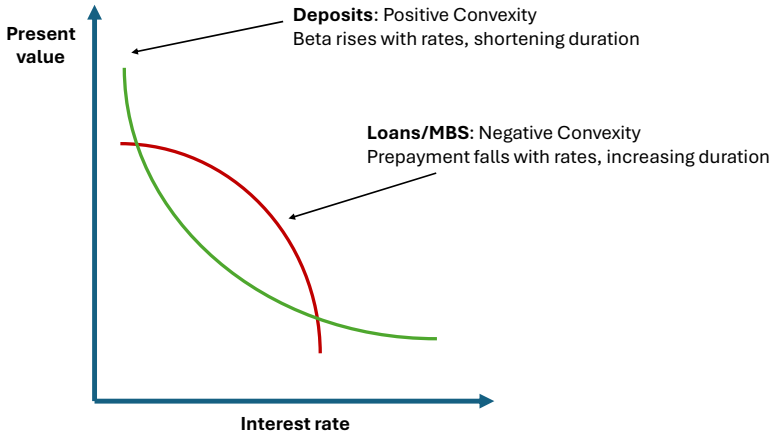
Notes: This figure plots the difference between EC and R-EC which reflects the value lost from a deposit run scenario.

Exposure to interest rates varies with rate cycle

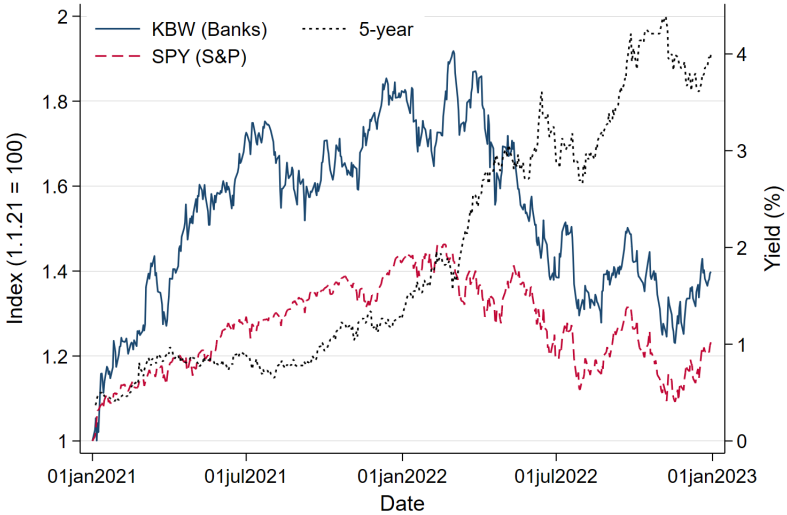


Notes: Depicts the sensitivity of R-EC to a parallel shock in interest rates.

In the absence of runs, dualing convexity complicates ALM



Anecdote: Banks outperformed early, underperformed late



Final thoughts

- Integrates credit, liquidity and market risks into a solvency framework
  - Can jointly quantify the impact of funding liquidity and price risks on bank health
  - Interactions are important to assessing materiality
  - Despite volume of post-GFC regulation, solvency risks persist for large banks
- EC is a more robust predictor of failure than alternative measures of capital
  - The treatment of liabilities contains critical information
- While EC improved post-GFC, deposit risk and interest rate risk have grown
- Highlights the use case for better public regulatory data on derivatives and deposits

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- While EC improved post-GFC, deposit risk and interest rate risk have grown
- Highlights the use case for better public regulatory data on derivatives and deposits
- Applications and future work:
  - Framework applicable to microprudential and macroprudential monitoring
  - What does this imply about the 'optimal' distribution of capital for financial stability?
  - How do banks manage economic vs. regulatory capital?

Appendices

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

Balance sheet summary

	% of Assets	
	Mean	**Industry**
Par/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
Amortized Cost:		
Fair Value Reported		
HTM securities	3.58	3.51
Mort. servicing rights	0.04	0.29
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

	% of Assets	
	Mean	**Industry**
Par/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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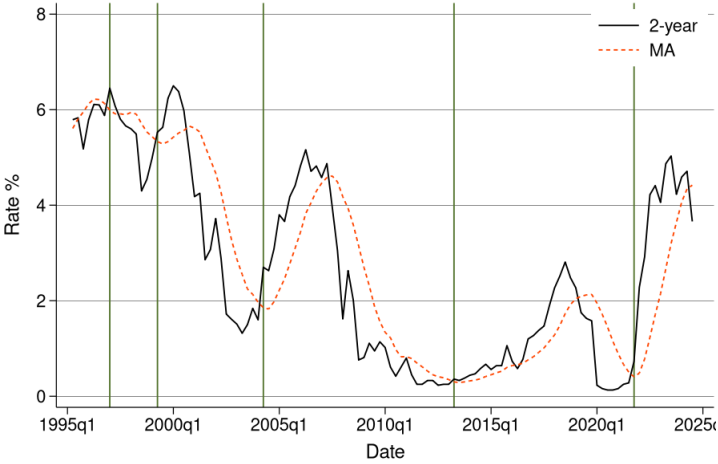
Appendix: Fixed-rate portfolio cycle dates



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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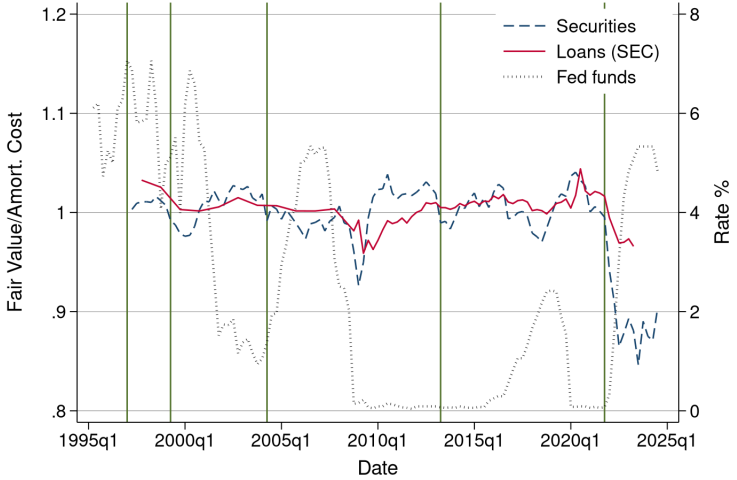
Appendix: Fixed-rate portfolio FV/Book



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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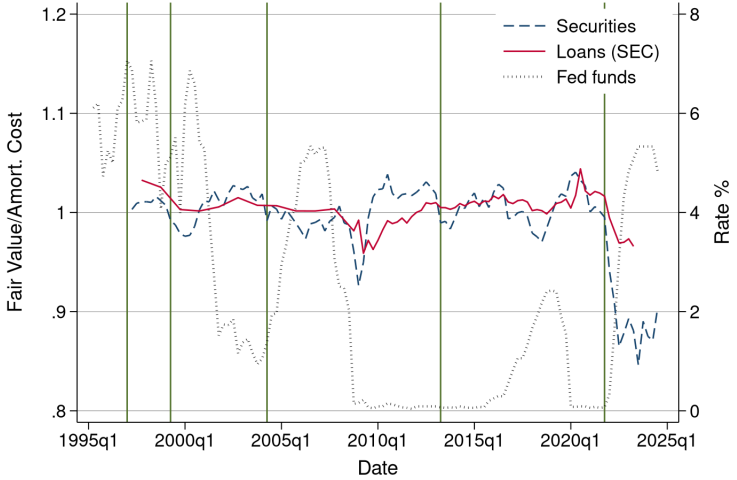

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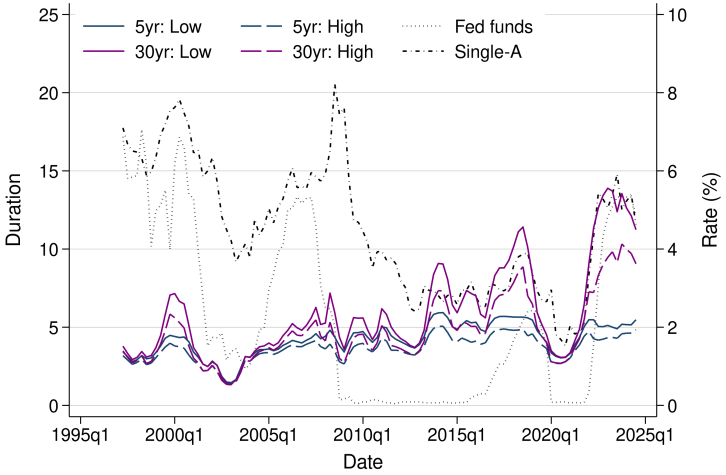
Appendix: Fixed-rate portfolios durations, RRE



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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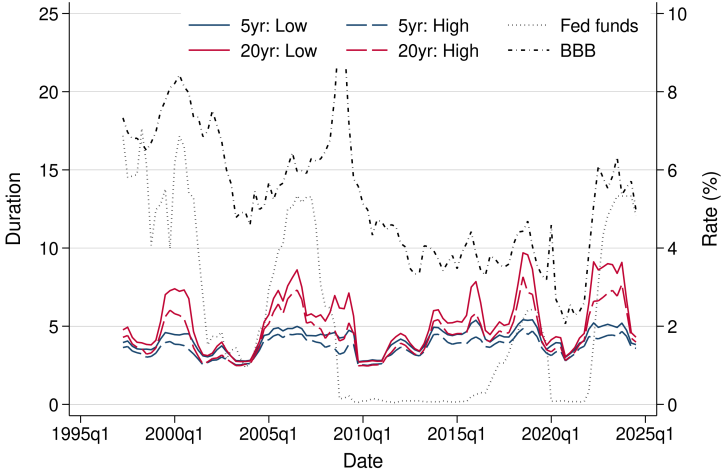
Appendix: Fixed-rate portfolios durations, Other



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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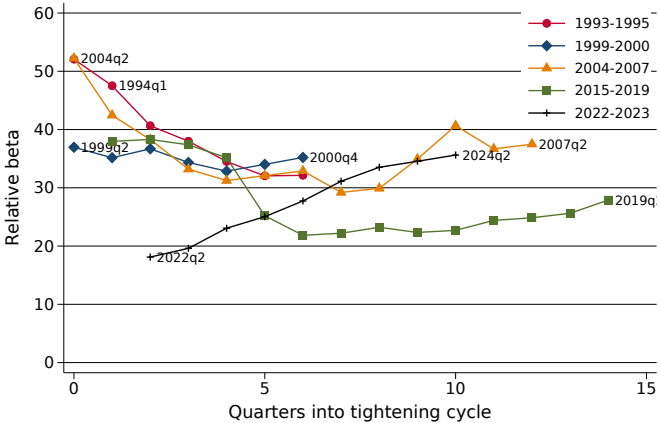
Appendix: Size-weighted deposit betas converge over tightening cycles



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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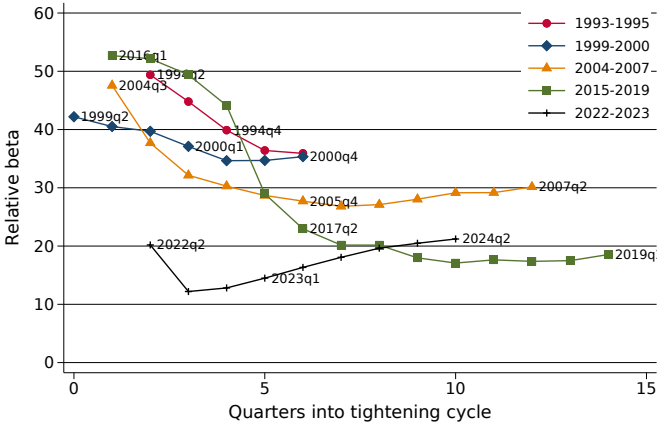
Appendix: Equal-weighted deposit betas have fallen over time



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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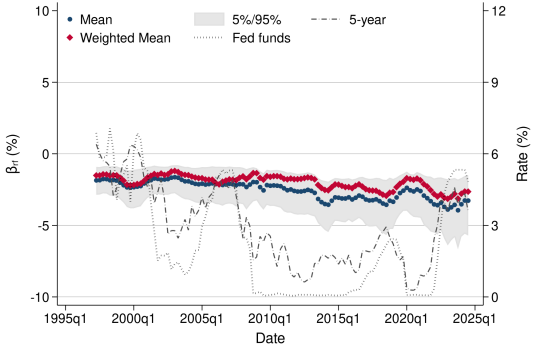
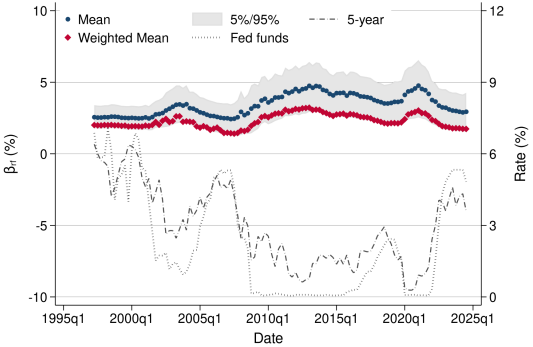
Negative convexity in assets, positive convexity of deposits

(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.