On depositor runs and bank resilience in view of Silicon Valley Bank's collapse

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SVB's collapse and exploding unrealized losses

On March 9, 2023, Depositors withdrew $42 billion from SVB.
94% of deposits were uninsured. $100 billion scheduled for next day.

Losses from SVB's collapse to the FDIC estimated at $20 billion.

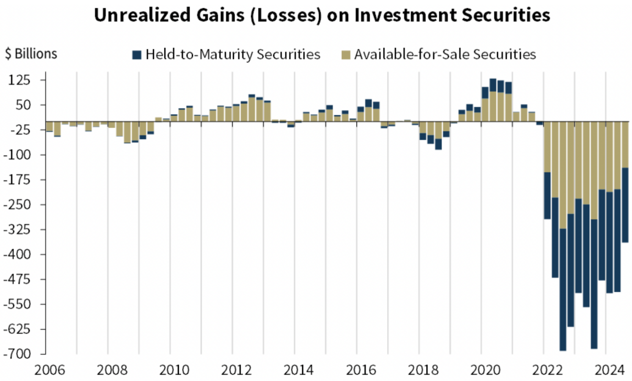


Figure: https://www.fdic.gov/news/speeches/2024/quarterly-banking-profile-third-quarter-2024

Conclusions after collapse of SVB

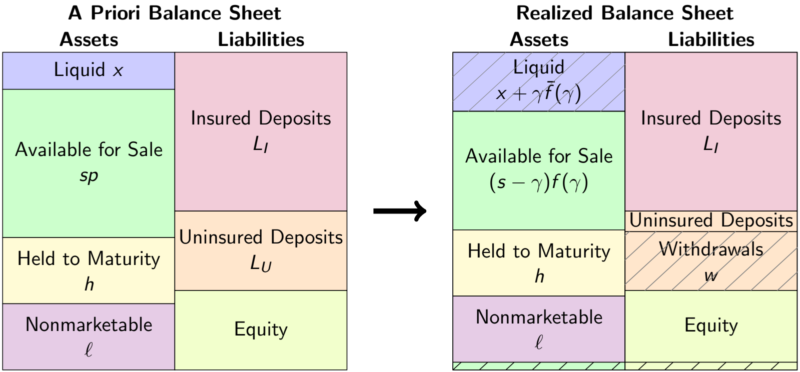
Vice Chair for Supervision at the Federal Reserve, Michael S. Barr (2023):

> *"we should re-evaluate the stability of* **uninsured deposits** *and the treatment of* **held-to-maturity** *securities in our standardized liquidity rules and in a firm's internal liquidity stress tests"*

Empirical findings of Granja and Kim et. al (2023-24):

- ⇝ Banks classified fixed-rate securities as HtM rather than AfS when HtM was preferred for accounting and regulatory capital constraints, *not* because of a distinct economically motivated intent and ability to hold the securities to maturity.
- ⇝ More vulnerable banks (lower capital ratios, higher share of uninsured depositors, larger exposure to interest rate risk) were more likely to reclassify securities as HtM

Our framework in a simple picture



Here w is the *withdrawals*, and γ is the *quantity sold* (mkt. securities).

Fire sales (price impact) captured by inverse demand function f.

Bank obtains volume-weighted average price $\bar{f}(\gamma) := \frac{1}{\gamma}\int_0^\gamma f(t)dt$.

Run mechanics

Assumptions:

- Uninsured depositors have a maximum acceptable leverage ratio $\lambda_{\text{max}} > 1$ before withdrawals are initiated.
- The inverse demand function $f : [0, s + h] \to (0, p]$ is non-increasing with initial price $f(0) = p \in (0, 1]$.

The realized **leverage ratio** for any pair (w, γ) is

$$\lambda = \frac{\text{Assets}}{\text{Equity}} = \frac{A(w,\gamma)}{A(w,\gamma) - (L - w)},$$

where

$$\begin{aligned}
A(w,\gamma) &= x + \gamma \bar{f}(\gamma) && \text{(liquid assets)} \\
&\quad + [s-\gamma]^+ f(\gamma) && \text{(AfS)} \\
&\quad + (h - [\gamma - s]^+)(\mathbb{I}_{\{\gamma \le s\}} + f(\gamma)\mathbb{I}_{\{\gamma > s\}}) && \text{(HtM}\to\text{AfS)} \\
&\quad + \ell && \text{(non-mkt. assets)} \\
&\quad - w && \text{(withdrawals)}
\end{aligned}$$

Equilibrium deposits withdrawals and assets sold

Bank run is a solution to a **clearing problem** that is **jointly in**

- the equilibrium amount of withdrawals w^*, and
- the equilibrium quantity sold γ^* out of the marketable securities.

Represented by **fixed points** of $\Phi : [0, L_U] \times [0, s+h] \to [0, L_U] \times [0, s+h]$ defined by $\Phi = (\Phi_w, \Phi_\gamma)$, where

$$\Phi_w(\gamma^*) = L_U \wedge \Big[\lambda_{\max} L - (\lambda_{\max} - 1)(x + \gamma^* \bar{f}(\gamma^*) + [s - \gamma^*]^+ f(\gamma^*) + [h - (\gamma - s)^+](\mathbb{I}_{\{\gamma^* \le s\}} + f(\gamma^*)\mathbb{I}_{\{\gamma^* > s\}}) + \ell)\Big]^+ \quad (1)$$

$$\Phi_\gamma(w^*, \gamma^*) = [s + h] \wedge \frac{(w^* - x)^+}{\bar{f}(\gamma^*)}. \quad (2)$$

Here (1) enforces the depositors' maximum acceptable leverage ratio, while (2) aligns the withdrawal requests with the quantity sold

Clearing algorithm – no dipping into HtM

The minimal clearing solution $(w^{\downarrow}, \gamma^{\downarrow})$ is determined by the following six-step algorithm:

1. **(No sales)** If either $L_U \leq x$ or $\lambda_{\max} L - (\lambda_{\max} - 1)(x + sp + h + \ell) \leq x$, then $\gamma^{\downarrow} = 0$ and $w^{\downarrow} = L_U \wedge [\lambda_{\max} L - (\lambda_{\max} - 1)(x + sp + h + \ell)]^{+}$. Else, continue to next step.
2. **(Run without re-marking HtM I)** If

$$L - x - (1 - \tfrac{1}{\lambda_{\max}})(h + \ell) \in [(1 - \tfrac{1}{\lambda_{\max}})sp, s\bar{f}(s)], \quad \text{and}$$
$$L_U \geq \lambda_{\max} L - (\lambda_{\max} - 1)(x + \gamma^* \bar{f}(\gamma^*) + (s - \gamma^*) f(\gamma^*) + h + \ell), \quad \text{for}$$
$$\gamma^* \bar{f}(\gamma^*) + (1 - \tfrac{1}{\lambda_{\max}})(s - \gamma^*) f(\gamma^*) = L - x - (1 - \tfrac{1}{\lambda_{\max}})(h + \ell), \quad \gamma^* \in [0, s],$$

   then $\gamma^{\downarrow} = \gamma^*$ and $w^{\downarrow} = x + \gamma^* \bar{f}(\gamma^*) \in (x, L_U)$. Else, continue to next step.
3. **(Run without re-marking HtM II)** If $L_U \in (x, x + s\bar{f}(s)]$ and $L_I \geq (1 - \frac{1}{\lambda_{\max}})[(s - \gamma^*) f(\gamma^*) + h + \ell]$ for $\gamma^* \in [0, s]$ solving $\gamma^* \bar{f}(\gamma^*) = L_U - x$, then $\gamma^{\downarrow} = \gamma^*$ and $w^{\downarrow} = L_U$. Else, continue to next step.

Clearing algorithm – dipping into HtM or a default

4. **(Re-marking HtM I)** If

$$L - x - (1 - \tfrac{1}{\lambda_{\max}})\ell \in [s\bar{f}(s) + (1 - \tfrac{1}{\lambda_{\max}})hf(s), (s+h)\bar{f}(s+h)], \quad \text{and}$$
$$L_U \geq \lambda_{\max} L - (\lambda_{\max} - 1)(x + \gamma^* \bar{f}(\gamma^*) + (s + h - \gamma^*)f(\gamma^*) + \ell), \quad \text{for}$$
$$\gamma^* \bar{f}(\gamma^*) + (1 - \tfrac{1}{\lambda_{\max}})(s + h - \gamma^*)f(\gamma^*) = L - x - (1 - \tfrac{1}{\lambda_{\max}})\ell, \ \gamma^* \in [s, s+h],$$

then $\gamma^\downarrow = \gamma^*$ and $w^\downarrow = x + \gamma^* \bar{f}(\gamma^*) \in (x, L_U)$. Else, continue to next step.

5. **(Re-marking HtM II)** If $L_U \in (x, x + (s+h)\bar{f}(s+h)]$ and $L_I \geq (1 - \frac{1}{\lambda_{\max}})[(s + h - \gamma^*)f(\gamma^*) + \ell]$ for $\gamma^* \in [s, s+h]$ solving $\gamma^* \bar{f}(\gamma^*) = L_U - x$, then $\gamma^\downarrow = \gamma^*$ and $w^\downarrow = L_U$. Else, continue to next step.

6. **(Illiquidity)** If it gets to this final step, then $\gamma^\downarrow = s + h$ and depending on whether

$$\lambda_{\max} L - (\lambda_{\max} - 1)(x + (s+h)\bar{f}(s+h) + \ell) \geq L_U \quad \text{and} \quad L_U - x \geq (s+h)\bar{f}(s+h), \quad \text{or}$$
$$\lambda_{\max} L - (\lambda_{\max} - 1)(x + (s+h)\bar{f}(s+h) + \ell) < L_U \quad \text{and} \quad L \geq x + (s+h)\bar{f}(s+h) + (1 - \tfrac{1}{\lambda_{\max}})\ell,$$

we either have $w^\downarrow = L_U$ or $w^\downarrow = \lambda_{\max} L - (\lambda_{\max} - 1)(x + (s+h)\bar{f}(s+h) + \ell) \in (x, L_U)$, respectively.

SVB case – build up of balance sheet vulnerabilities

		In USD billion										*Ratio*	
		Total deposits	Other funding	Insured deposits	Capital	Total assets	Cash	AfS	HtM	Unrealised Gains/Losses (HtM)	Unrealised Gains/Losses (AfS)	Tier 1 lev. ratio	Lev. ratio implied by Unrealised Gains/Losses
2020	q1	56	8.9	5	10.1	75	8	20	10	0.8	1.6	6.4	6.0
	q2	70	7.9	5	12.1	90	10	25	10	0.8	1.6	6.4	6.2
	q3	80	6.5	5	13.5	100	12	28	12	0.8	1.6	6.4	6.3
	q4	95	8.8	5	16.2	120	13	35	15	0.8	1.6	6.4	6.5
2021	q1	110	11.7	5	18.3	140	16	30	40	0.0	0.0	6.6	7.6
	q2	130	18.3	6	21.7	170	18	25	60	0.0	0.0	6.8	7.8
	q3	152	10.0	7	23.0	185	21	25	80	-0.5	0.0	7.0	8.2
	q4	172	16.9	8	26.1	215	23	27	103	-1.0	0.0	7.2	8.6
2022	q1	181	17.3	9	26.7	225	22	27	101	-7.5	-1.5	7.4	12.7
	q2	170	20.0	10	25.0	215	20	27	98	-11.5	-2.0	7.6	18.7
	q3	162	28.5	10	24.5	215	19	27	95	-16	-3.0	7.8	39.2
	q4	160	31.0	10	24.0	215	17	27	93	-15	-3.0	8.0	35.9

Table: Balance sheet evolution of the SVB

Numbers shown starting from the beginning of 2020 when the dynamics of assets and liabilities started to materially change. "Lev. ratio implied by Unrealized Gains/Losses" = [Total assets]/([Capital]-[Unrealised Gains/Losses (HtM)]-[Unrealised Gains/Losses (AfS)]); "Other funding" = calibrated such that balance sheet identity is preserved and leverage ratio reported by SVB ([Tier 1 ratio]) equals to the calculated leverage ratio (i.e., [Total assets]/[Capital]), "AfS" = securities in available for sale accounting portfolios; "HtM" = securities in held-to-maturity accounting portfolios

Source: SVB financial reports and FRB (2023)

Anatomy of SVB run risk

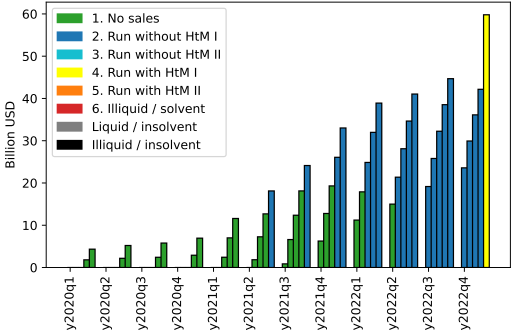


Figure: Equilibrium withdrawal of funding from SVB for various calibrations of targeted leverage ratios. For each period there is a group of bars, each of them corresponding to a $\lambda_{\max}$ from $\{7.0, 7.25, 7.5, 7.75, 8.0\}$. λ_{max} calibration

- Equilibrium funding withdrawals rose...
- implying runs necessitating liquidation of AfS portfolios.
- As of Q4 2022, runs following a higher leverage targeting could deprive SVB of available liquid resources (dipping into HtM)

What if unrealised losses were realised?

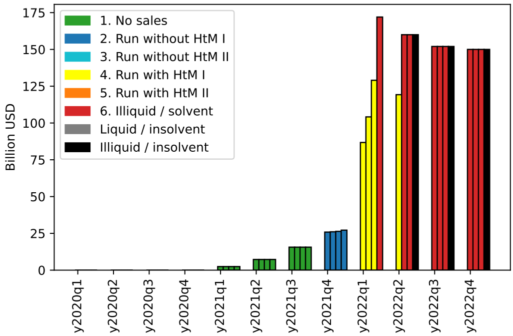


Figure: Equilibrium funding withdrawals from SVB assuming unrealised losses in AfS and HtM portfolios hit capital with $\lambda_{\max} = 7.5$. For each period there is a group of bars, each of them corresponding to one parameter b of the linear impact function from $\{0.0001, \ 0.0002, \ 0.001, \ 0.002\}$.

- Considering accumulated unrealised losses, already in Q1 2022 financial conditions of SVB became conducive to bankruptcy
- SVB's income revised up in Q4 2021, attracting investors, then revised down in Q2 2022

HtM vs AfS trade-off

- More HtM reduced volatility of income that would be caused by MtM of assets following daily changes of market prices...
- ...but also reduces liquidity buffers used to cover funding withdrawals in distress market conditions

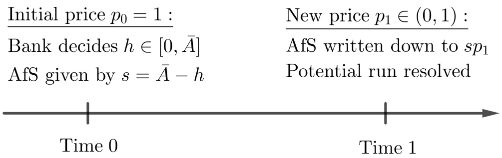


Figure: One-period model for choice of HtM. Here $\bar{A} := A - x - \ell$ are the total marketable securities (that may be designated as AfS or HtM).

- Bank decides on optimal h^*, so no selling of HtM is needed:

$$h^* = \max\{h \in [0, \bar{A}] \mid \mathrm{Asset\_sold}(p_1, \lambda_{\max}) \leq \bar{A} - h\} \tag{3}$$

Quantifying risk-taking at SVB

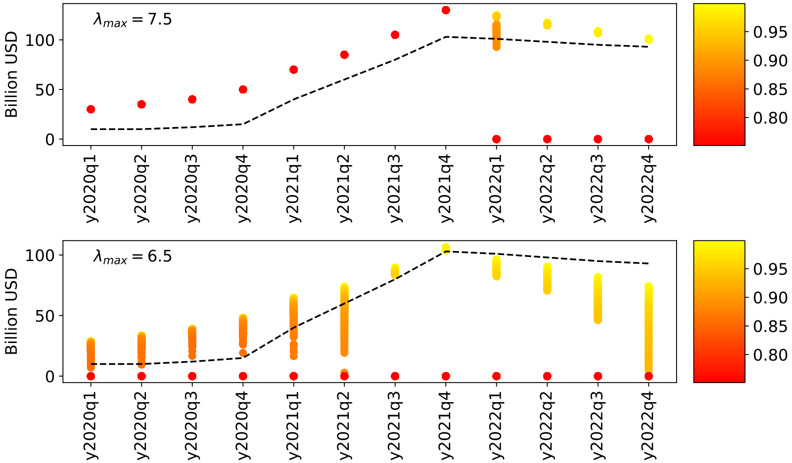


Figure: Optimized volume of HtM represented by colored circles, each of which corresponds to a price shock p_1 with values indicated in the colorbar.
The dashed black line $\equiv$ volumes of HtM portfolios.

SVB for range of max acceptable leverage ratios

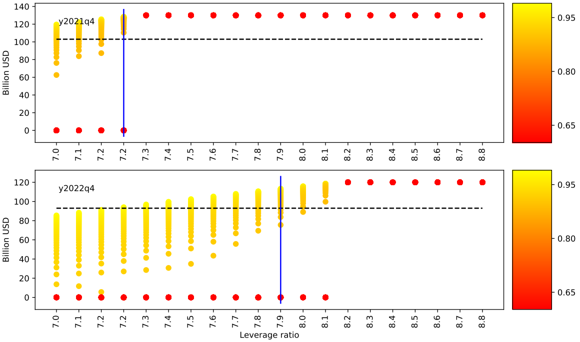


Figure: Theoretically optimal HtM portfolios for range of $\lambda_{\max}$ on x-axis.
Solid blue line represents the reported Tier 1 leverage ratio.
Dashed black line represents the actual level of the HtM portfolios.

First Republic Bank

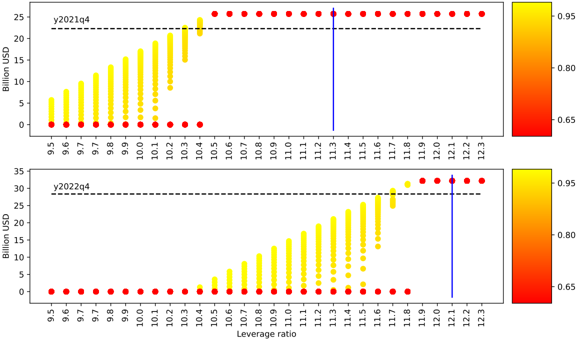


Figure: Theoretically optimal HtM portfolios for range of λ_{max} on x-axis.
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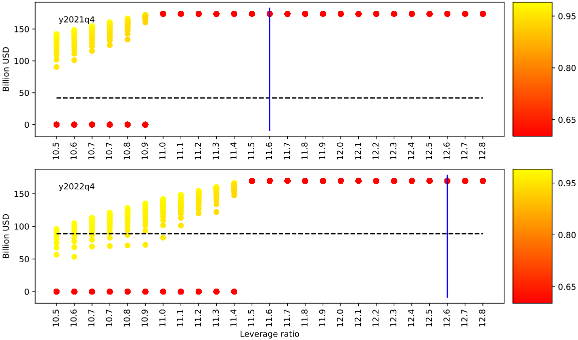
US Bancorp



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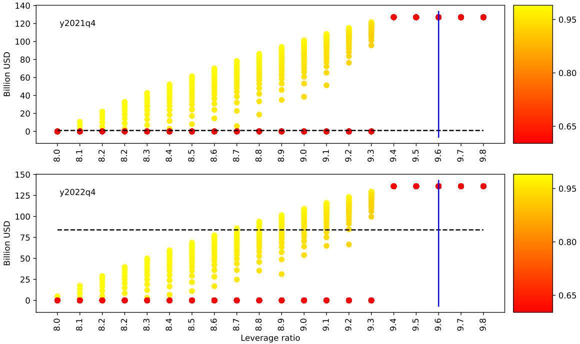
PNC Financial Services Group



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Thanks for listening!

How to calibrate λ_{max}?

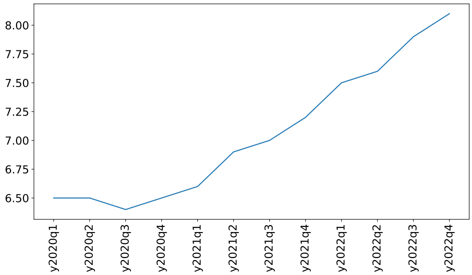

Figure: Minimum λ_{max} that, for a balance sheet of SVB with all securities held in HtM portfolio ($= s + h$), implies no selling of securities in equilibrium to simulations

- All investors that accept the bank's leverage ratio above the value displayed in Figure would 'confidently' place money at the bank
- The level of the max acceptable λ_{max} increases reflecting increasing balance sheet vulnerabilities of the bank
- A value from the range [6.5,8] can be considered as a benchmark