Systemic Risk Measures: Taking Stock from 1927 to 2023

Viral Acharya, Markus Brunnermeier, Diane Pierret

November 2024

Systemic Risk Measurement Stocktake

Renewed interest for early warning indicators of financial vulnerability since 2023 banking stress episode.

The goal is not to predict the next crisis, but rather the cross-section (ranking) of bank vulnerability during a stress episode.

The literature already documented the performance of such measures during

- the global financial crisis (Adrian and Brunnermeier, 2016; Acharya et al., 2017; Brownlees and Engle; 2017)
- the sovereign debt crisis, in addition to regulatory measures (Acharya et al., 2014).

This paper: systemic measurement stocktake from 1927 until 2023.

Systemic Risk Measurement Stocktake: what we do

We derive systemic risk measures (Adrian and Brunnermeier, 2016; Acharya et al., 2017; Brownlees and Engle; 2017)

- sample of public financial institutions available in CRSP
- from 1927q1 - 2023q4

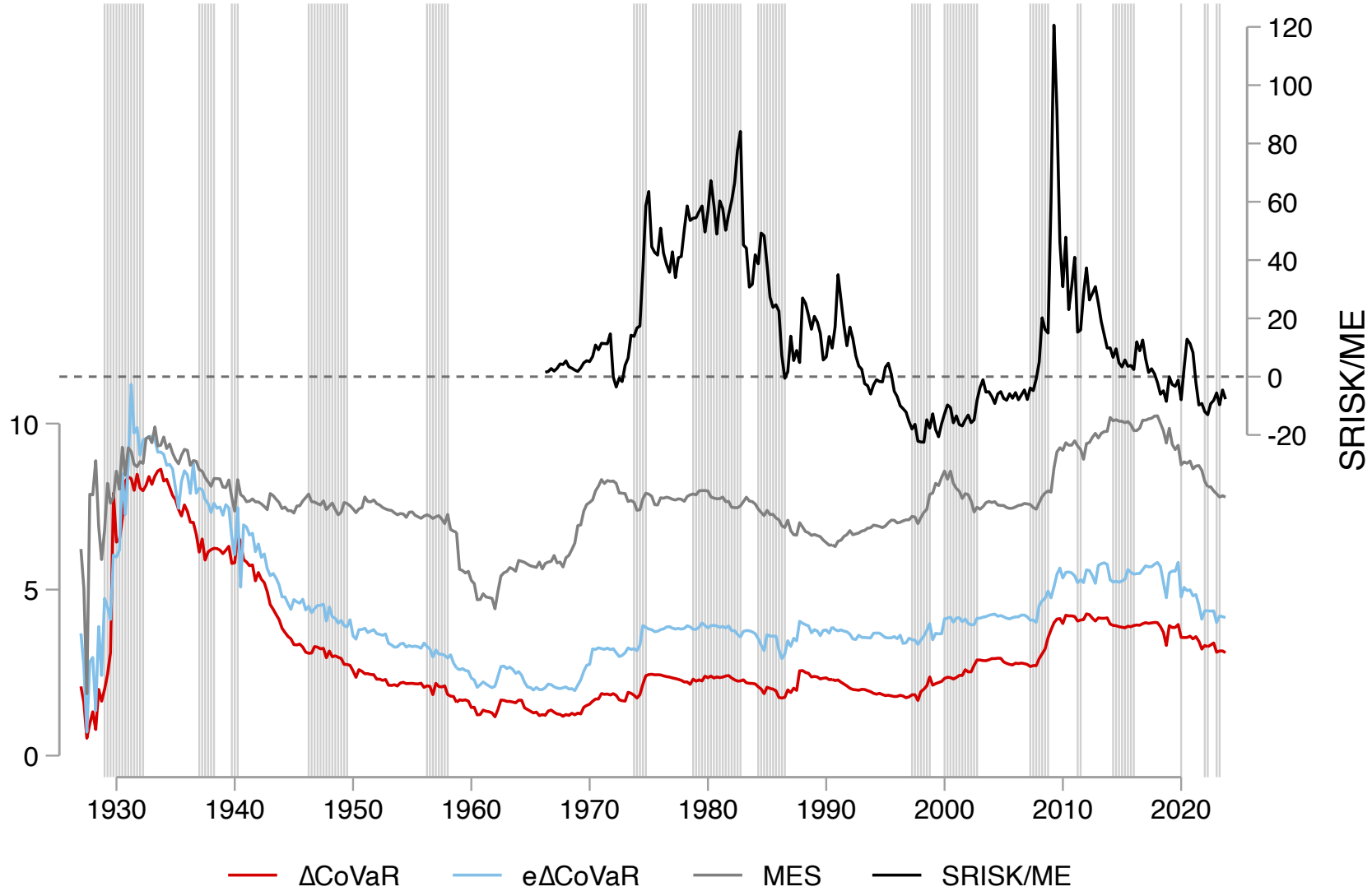
We propose a methodology for dating stress episodes

1. episodes are identified based on narrative analysis and previous studies that date financial crises or stress periods
2. the start and end points of each episode: trough and peak values on credit spread index.

We predict bank outcomes during stress episodes using systemic risk measures, estimated the quarter before each episode starts.

- outcomes: realized returns, realized volatility, loan growth, profitability, and uninsured deposits.
- bank failures (following Correia, Luck, Verner, 2024).

Systemic Risk Measurement Stocktake: 1927 - 2023



Market-capitalization weighted average ΔCoVaR, eΔCoVaR, MES and SRISK divided by the market capitalization (ME) from 1927 until 2023. The grey vertical bars represent stress episodes.

Systemic Risk Measurement Stocktake: key takeaways

Stock-market based systemic risk measures predict realized stress (returns, volatility), conditional on a crisis, especially for banks, over a long time series (1927 - 2023).

The measures predict bank failures, together with other leading fundamental indicators.

The measures also predict bank balance sheet outcomes on lending, profitability, and deposit drawdowns, over and above book capital measures of solvency.

Outline

Outline

Outline

Data and sample

- Daily stock prices from CRSP from December 1925 to December 2023.

- All (5,417) financial institutions in the U.S., where "financial institutions" are defined based on the same SIC codes as in Adrian and Brunnermeier (2016).
  - Four financial sectors: commercial banks, security broker-dealers (including investment banks), insurance companies, and real estate companies.

- The CRSP dataset is merged with Compustat to retrieve total bank liabilities that are available starting in 1965.

- Call Reports: available for commercial banks only, and collected from 1959 onwards by Correia, Luck, Verner (2024).
  - NY Fed CRSP-FRB linking table (1986-2023) and manual procedure (1959-1986) to match with the CRSP database.
  - Aggregation of Call Reports at the parent bank level (using the FFIEC relationships table), where the parent is the bank with publicly listed stocks in CRSP.

- FDIC list of bank failures and assistance transactions (1934 to the present).

Outline

Definition of stress episodes: procedure

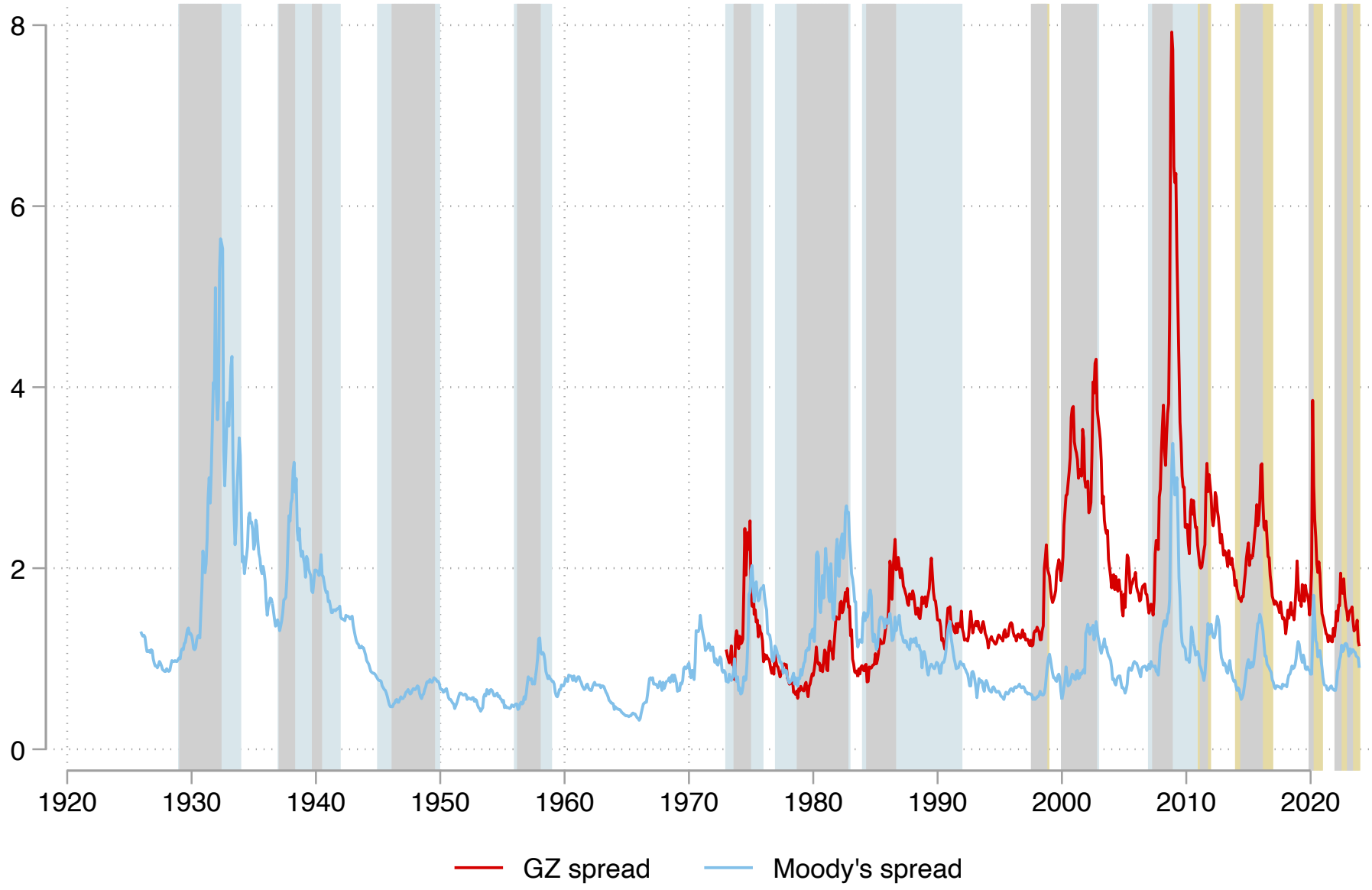
1. Identification of broad event "windows" from several sources
   - "early" sample (1927-1958): stock market crashes and banking crisis years in Reinhart and Rogoff (2009, 2011)
   - "modern" sample (1959-2023): narrative analysis of the most recent stress episodes to identify window years in addition to RR years.

2. For each window, search for trough and peak values as the start and end months of the episode
   - GZ spread (Gilchrist and Zakrajšek, 2012): corporate bond credit spread in month t

$$S_t^{GZ} = \frac{1}{N_t} \sum_i \sum_k S_{i,t}[k],$$

     where N_t denotes the number of bonds in month t and $S_{i,t}[k]$ is the spread of bond k (a security that is a liability of firm i) in month.
   - Before 1973: the difference between Moody's Seasoned Baa and Aaa Corporate Bond Yield indices ("Moody's spread).

Definition of stress episodes



Stress episodes

Panel A: Modern Sample (1959-2023)

episode	start	end	months	GZ	SP500		fin. index	
				sprd (%)	ret (%)	dd (%)	ret (%)	dd (%)
High inflation in the U.S.	9-1973	12-1974	15	1.75	-36.77	-41.40	-35.73	-46.82
1977-82 stock market crash	10-1978	10-1982	48	1.21	43.54	-23.79	43.44	-34.12
S&L Crisis	5-1984	8-1986	27	1.58	68.00	0	54.24	-11.14
LTCM hedge fund failure	8-1997	10-1998	14	1.12	22.15	-15.57	-10.08	-36.40
Dot.com Bubble	1-2000	10-2002	33	2.36	-36.48	-46.28	-24.11	-36.84
Global Financial Crisis	5-2007	11-2008	18	6.44	-41.45	-42.16	-52.09	-52.09
European Sovereign Debt Crisis	3-2011	9-2011	6	1.16	-14.66	-17.03	-18.99	-20.15
2014-16 oil price shock	6-2014	2-2016	20	1.52	-1.43	-8.89	0.90	-9.81
Covid19 Pandemic	12-2019	3-2020	3	2.37	-20.00	-20.00	-18.47	-18.47
Ukraine war/energy crisis	12-2021	6-2022	6	0.70	-20.58	-20.58	-8.77	-8.77
Bank Failures in 2023	1-2023	5-2023	4	0.15	2.53	0	-2.96	-5.97

Panel B: Early Sample (1927-1958)

episode	start	end	months	Moody's	DJI		fin. index	
				sprd (%)	ret (%)	dd (%)	ret (%)	dd (%)
The Great Depression	2-1929	5-1932	39	4.64	-85.90	-88.24	-95.59	-95.59
Recession of 1937–38	2-1937	4-1938	14	1.86	-40.34	-47.13	-49.50	-60.00
1939-41 stock market crash	10-1939	6-1940	8	0.42	-19.63	-23.48	-19.42	-31.00
Post-World War II Recession	3-1946	7-1949	40	0.32	-11.85	-21.42	5.22	-15.25
Recession of 1958	4-1956	1-1958	21	0.79	-12.81	-15.86	-16.21	-23.39

"GZ sprd" is the change in the GZ spread (Gilchrist and Zakrajšek, 2012) in p.p. "Moody's sprd" is the change in the spread between Moody's Baa and Aaa Corporate Bond Yields in p.p. "dd" is the maximum drawdown on an index, defined as the percentage difference between its minimum and the prior maximum value within an episode.

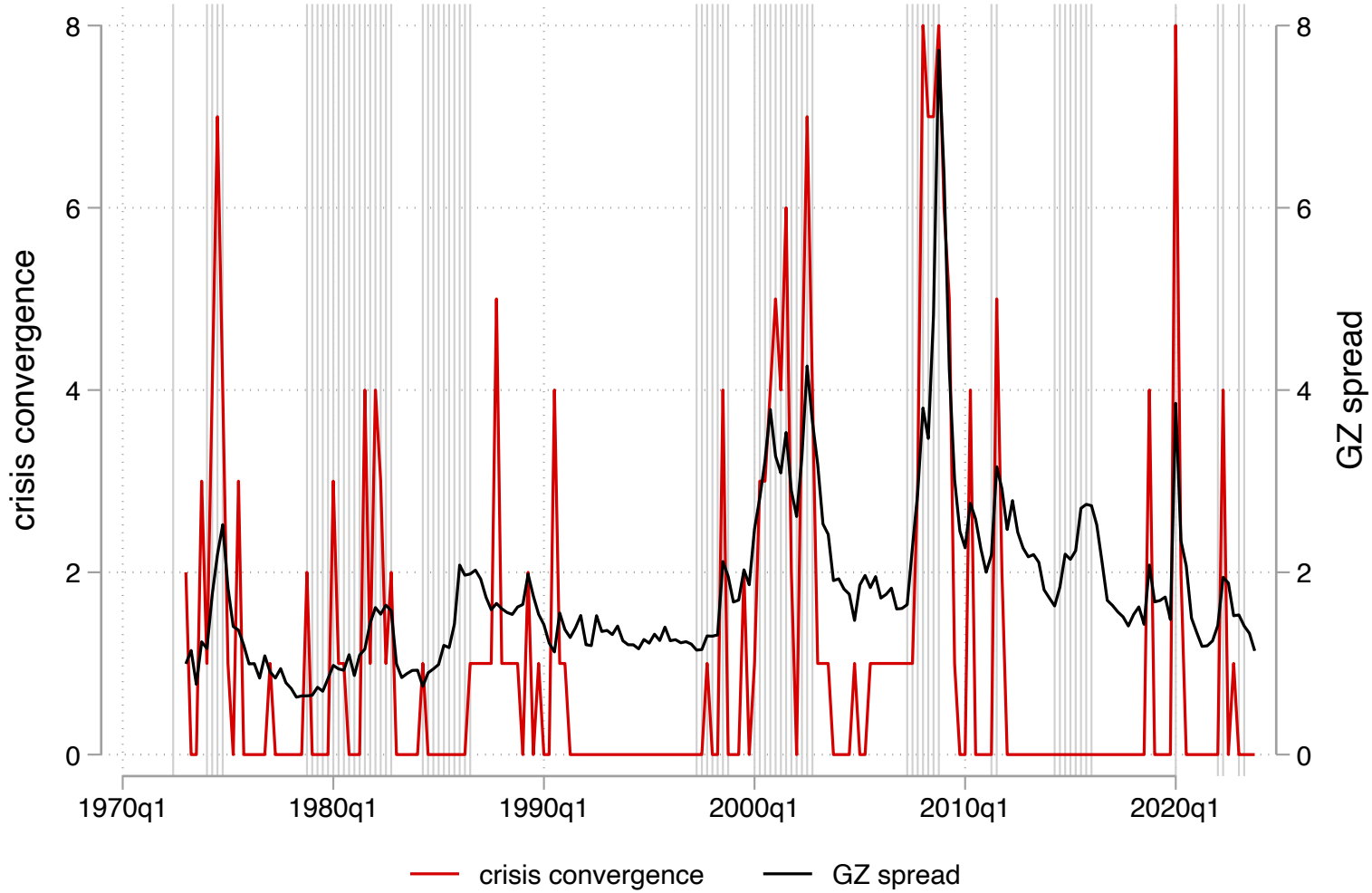
Stress episodes: alternative definitions

Alternative definitions of stress episode dates:

- NBER recession dates (1),
- stress episode dates corresponding to the 10% largest GZ spread (2), the 10% largest excess bond premium (3), and the 10% largest estimated probability of a recession (3) from Gilchrist and Zakrajšek (2012),
- stress episode dates corresponding to the 10% largest credit-to-GDP gap as defined by the BIS (4),
- stress episode dates corresponding to the 10% worst performance quarters of an index: S&P500 (5), CRSP financial (6), and CRSP bank indices (7),
- stress episode dates corresponding to the 10% largest realized volatility of the S&P500 index (8).

In total, the definitions yield 8 additional stress episode indicators independent from our definition of event windows, and from the narrative analysis.

Convergence of stress episode definitions



Stress episode convergence indicator and GZ spread. The convergence indicator takes a maximum value of 8 if all 8 alternative stress episode definitions indicate the date as a stress episode quarter. Vertical lines indicate stress episode quarters from the methodology Source (GZ): Federal Reserve. Sample starts in 1973.

Outline

Systemic risk measures: definitions

△**CoVaR:** change in the VaR of the financial system portfolio conditional on a firm being under distress relative to its median stat":

$$\Delta CoVaR^{system|i} = CoVaR^{system|X^i=VaR^i_q} - CoVaR^{system|X^i=VaR^i_{\mathbf{50}}}, \tag{1}$$

where X^i is a "return loss" for firm i, X^{system} is the net return loss for a financial index, and q=95%.

e△CoVaR: change in the VaR of the firm conditional on the financial index being under distress (q=95%) relative to its median state:

$$e\Delta CoVaR^{i|system} = eCoVaR^{i|X^{syst}=VaR^{syst}_q} - eCoVaR^{i|X^{syst}=VaR^{syst}_{\mathbf{50}}}. \tag{2}$$

LRMES: 6-month return loss of a firm conditional on a 40% loss ($C = -0.4$) on the market index:

$$LRMES_{it} = -\mathrm{E}_t(R_{it+1:t+h}|R_{mt+1:t+h} < C). \tag{3}$$

MES: weekly return loss of the firm conditional on a $-c$ loss on the market index during a week:

$$MES_{it} = -\mathrm{E}_t(R_{it+1}|R_{mt+1} < c). \tag{4}$$

SRISK: the expected capital shortfall (in USD) of the firm in the scenario above:

$$SRISK_{it} = k * (ME_{it}(1 - LRMES_{it}) + D_{it}) - ME_{it}(1 - LRMES_{it}), \tag{5}$$

where ME_{it} is the market value of equity of institution i, D_{it} are its total non-equity liabilities, and k=8%.

Systemic risk measures: definitions

△**CoVaR:** change in the VaR of the financial system portfolio conditional on a firm being under distress relative to its median stat":

$$\Delta CoVaR^{system|i} = CoVaR^{system|X^i=VaR^i_q} - CoVaR^{system|X^i=VaR^i_{\mathbf{50}}}, \quad (1)$$

where X^i is a "return loss" for firm i, X^{system} is the net return loss for a financial index, and q=95%.

e△CoVaR: change in the VaR of the firm conditional on the financial index being under distress (q=95%) relative to its median state:

$$e\Delta CoVaR^{i|system} = eCoVaR^{i|X^{syst}=VaR^{syst}_q} - eCoVaR^{i|X^{syst}=VaR^{syst}_{\mathbf{50}}}. \quad (2)$$

LRMES: 6-month return loss of a firm conditional on a 40% loss ($C = -0.4$) on the market index:

$$LRMES_{it} = -\mathrm{E}_t(R_{it+1:t+h}|R_{mt+1:t+h} < C). \quad (3)$$

MES: weekly return loss of the firm conditional on a $-c$ loss on the market index during a week:

$$MES_{it} = -\mathrm{E}_t(R_{it+1}|R_{mt+1} < c). \quad (4)$$

SRISK: the expected capital shortfall (in USD) of the firm in the scenario above:

$$SRISK_{it} = k * (ME_{it}(1 - LRMES_{it}) + D_{it}) - ME_{it}(1 - LRMES_{it}), \quad (5)$$

where ME_{it} is the market value of equity of institution i, D_{it} are its total non-equity liabilities, and k=8%.

Systemic risk measures: estimation

Measures are derived at the end of each month, based on a rolling window of 10 years of weekly return data available up to that month.

△CoVaR, e△CoVaR, LRMES, and MES from January 1927 until December 2023.

- (LR)MES: requires the estimation of β_i and the market volatility σ_m (Brownlees and Engle, 2016, p. 55):

$$LRMES_{it} = -\sqrt{h}\beta_i \mathrm{E}(r_{mt+1} | r_{mt+1} < c) \tag{6}$$

  where $\mathrm{E}(r_{mt+1} | r_{mt+1} < c) = -\sigma_m \frac{\phi(c/\sigma_m)}{\Phi(c/\sigma_m)}$, $c = \log(1+C)/\sqrt{h}$. From the approximation in (6): $LRMES_{it} = \sqrt{h} MES_{it}$.

- Estimation of "rolling" $\Delta CoVaR^i_{q,t}$ and $e\Delta CoVaR^i_{q,t}$ (with q=95%)

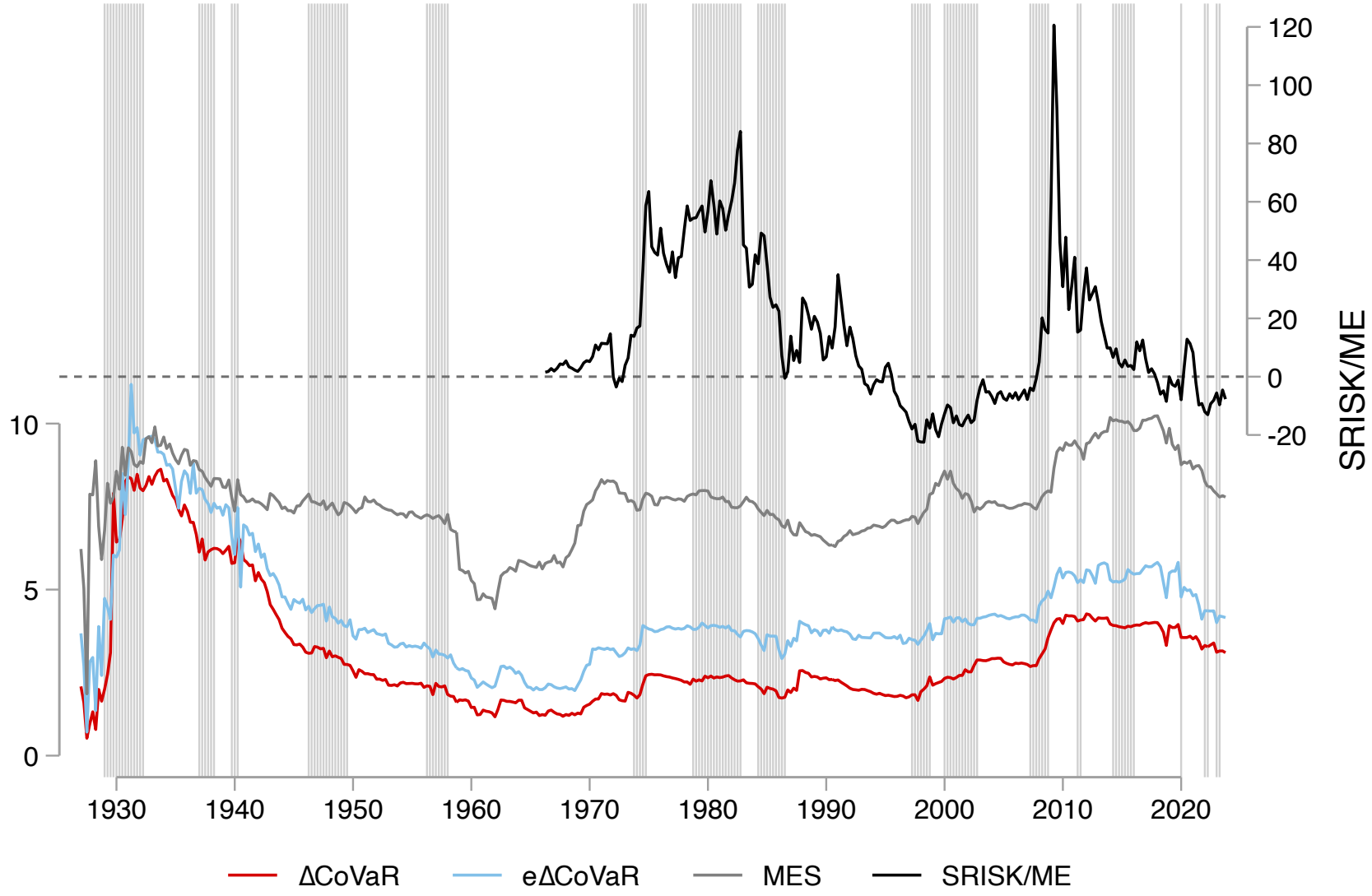
$$\Delta CoVaR^i_{q,t} = \hat{\beta}^i_{q,t}(VaR^i_{q,t} - VaR^i_{50,t}) \tag{7}$$

$$e\Delta CoVaR^i_{q,t} = \hat{\beta}^{i,e}_{q,t}(VaR^{syst}_{q,t} - VaR^{syst}_{50,t}). \tag{8}$$

- Choices: system index for △CoVaR and e△CoVaR is the CRSP financial index, the market index for (LR)MES is the S&P500 (modern sample) or the CRSP financial index (early sample), $C = -0.4$ (-40%), and $h = 24$ weeks (6 months).

SRISK is derived for a shorter time period starting in the 1960s due to the limited availability of liabilities from Compustat.

Systemic Risk Measures: 1927 - 2023



Market-capitalization weighted average ΔCoVaR, eΔCoVaR, MES and SRISK divided by the market capitalization (ME) from 1927 until 2023. The grey vertical bars represent stress episodes.

SRISK ratio decomposition

The expected capital shortfall (in USD) of a firm in the stress scenario of a 6-month 40% loss on the market index:

$$SRISK_{it} = k * (ME_{it}(1 - LRMES_{it}) + D_{it}) - ME_{it}(1 - LRMES_{it})$$

$$SRISK_{it} = (k-1) * ME_{it}(1 - LRMES_{it}) + kD_{it}$$

SRISK scaled by the market capitalization:

$$\frac{SRISK_{it}}{ME_{it}} = (k-1) * (1 - LRMES_{it}) + k\frac{D_{it}}{ME_{it}}$$

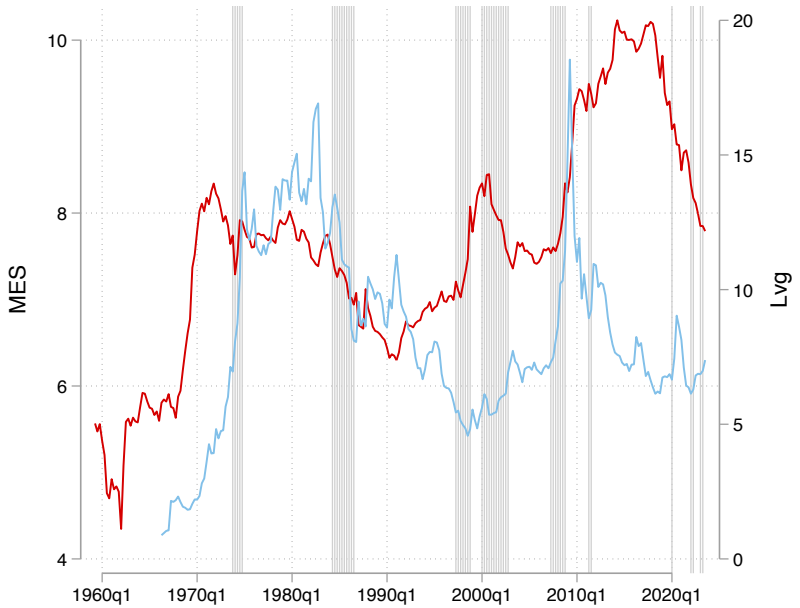
$$\frac{SRISK_{it}}{ME_{it}} = \underbrace{(k-1) * (1 - LRMES_{it})}_{\text{LRMES component}} + \underbrace{k\,(Lvg_{it} - 1)}_{\text{Lvg component}} \tag{9}$$

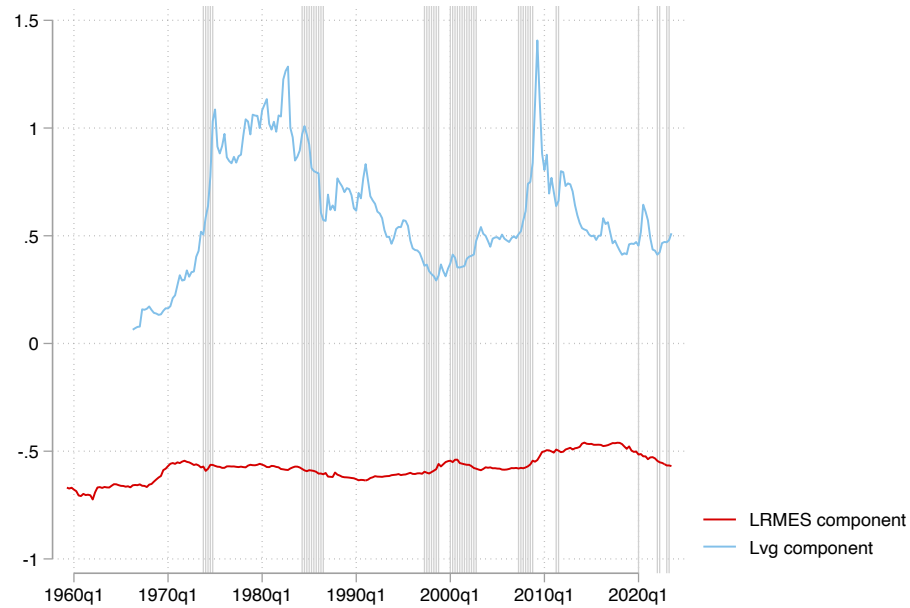
where $Lvg_{it} = (ME_{it} + D_{it})/ME_{it}$ and $k = 0.08$.

SRISK ratio decomposition

$$\frac{SRISK_{it}}{ME_{it}} = \underbrace{-0.92 * (1 - LRMES_{it})}_{\text{LRMES component}} + \underbrace{0.08\,(Lvg_{it} - 1)}_{\text{Lvg component}}$$

and $LRMES_{it} = \sqrt{h} MES_{it}$, with $h = 24$ (6 months in weeks).





Outline

Outline

Predictive regressions

We estimate the following specification to predict market outcomes of banks and non-banks during a stress episode:

$$\begin{aligned} y_{ie} \quad = \quad & \beta_1 Measure_{ie} \times bank_i + \beta_2 Measure_{ie} \times (1 - bank_i) \\ & + (\beta_3 bank_i + \beta_4 (1 - bank_i)) \times book\_eq_{ie} \\ & + (\delta_1 bank_i + \delta_2 (1 - bank_i)) \times control_{ie} + \alpha\, bank_i + \alpha_e + \varepsilon_{ie} \end{aligned} \tag{10}$$

where y_{ie} is the average market outcome of firm i during stress episode e (11 "modern" episodes), and α_e are episode fixed effects.

The systemic risk measure, $Measure_{ie}$, the ratio of book equity to total assets $book\_eq_{ie}$, and the variable $control_{ie}$ controlling for firm size are all measured the quarter before the episode starts.

Predictive regressions: realized volatility

Panel A: Realized volatility during stress episodes						
Measure:	baseline		ΔCoVaR		eΔCoVaR	
	(1)	(2)	(3)	(4)	(5)	(6)
Measure×bank			0.32	0.63**	0.78***	0.72***
			(1.01)	(2.04)	(3.66)	(3.54)
Measure×nonbank			-0.64***	-0.56**	1.29***	1.11***
			(-2.78)	(-2.10)	(7.77)	(6.77)
book_eq×bank	-0.03	-0.26**	-0.03	-0.28**	-0.05	-0.27**
	(-0.40)	(-2.51)	(-0.48)	(-2.56)	(-0.69)	(-2.54)
book_eq×nonbank	-0.01*	-0.01**	-0.01*	-0.01**	-0.00*	-0.01**
	(-1.68)	(-2.34)	(-1.67)	(-2.33)	(-1.71)	(-2.22)
Observations	6,436	6,436	6,436	6,436	6,436	6,436
Adj. R-squared	0.032	0.262	0.033	0.264	0.058	0.280
Episode FE	N	Y	N	Y	N	Y
Measure:	MES		SRISK/ME		MES (+Lvg)	
	(7)	(8)	(9)	(10)	(11)	(12)
Measure×bank	0.37***	0.75***	2.65***	3.18***	0.09	0.46***
	(2.59)	(5.40)	(6.47)	(6.64)	(0.70)	(3.69)
Measure×nonbank	0.68***	0.94***	0.34***	0.26	0.68***	0.96***
	(7.82)	(9.33)	(2.70)	(1.35)	(7.71)	(9.54)
Lvg×bank					0.21***	0.26***
					(6.38)	(6.33)
Lvg×nonbank					0.02*	0.01
					(1.94)	(0.59)
book_eq×bank	-0.03	-0.28***	0.15**	-0.04	0.16**	-0.05
	(-0.50)	(-2.65)	(2.06)	(-0.66)	(2.06)	(-0.85)
book_eq×nonbank	-0.01**	-0.01***	-0.00	-0.01*	-0.00*	-0.01***
	(-2.34)	(-3.27)	(-1.30)	(-1.86)	(-1.95)	(-2.99)
Observations	6,436	6,436	6,436	6,436	6,436	6,436
Adj. R-squared	0.050	0.295	0.047	0.280	0.062	0.310
Episode FE	N	Y	N	Y	N	Y

Predictive regressions: realized returns

Panel B: Realized returns during stress episodes						
Measure:	baseline		ΔCoVaR		eΔCoVaR	
	(1)	(2)	(3)	(4)	(5)	(6)
Measure×bank			-7.83***	-4.22***	-2.31***	-1.57***
			(-7.86)	(-4.41)	(-3.99)	(-3.40)
Measure×nonbank			-2.72***	-0.40	-0.06	-0.06
			(-2.92)	(-0.45)	(-0.12)	(-0.12)
book_eq×bank	-1.82***	-0.18	-1.68***	-0.14	-1.77***	-0.15
	(-5.58)	(-0.96)	(-5.35)	(-0.72)	(-5.60)	(-0.82)
book_eq×nonbank	-0.01	0.01	-0.01	0.01	-0.01	0.01
	(-0.45)	(0.77)	(-0.46)	(0.71)	(-0.45)	(0.75)
Observations	6,436	6,436	6,436	6,436	6,436	6,436
Adj. R-squared	0.006	0.245	0.011	0.246	0.007	0.246
Episode FE	N	Y	N	Y	N	Y
Measure:	MES		SRISK/ME		MES (+Lvg)	
	(7)	(8)	(9)	(10)	(11)	(12)
Measure×bank	-1.36***	-1.13***	-5.21***	-4.84***	-0.87**	-0.72**
	(-3.25)	(-3.24)	(-5.77)	(-5.27)	(-2.07)	(-2.06)
Measure×nonbank	0.60	-0.14	-0.08	0.58**	0.61	-0.21
	(1.29)	(-0.38)	(-0.40)	(2.54)	(1.30)	(-0.57)
Lvg×bank					-0.37***	-0.36***
					(-5.01)	(-5.06)
Lvg×nonbank					-0.02	0.05**
					(-1.04)	(2.51)
book_eq×bank	-1.80***	-0.17	-2.18***	-0.51***	-2.13***	-0.48**
	(-5.50)	(-0.91)	(-5.54)	(-2.72)	(-5.47)	(-2.57)
book_eq×nonbank	-0.01	0.01	-0.01	0.01	-0.01	0.01
	(-0.44)	(0.76)	(-0.46)	(0.91)	(-0.45)	(0.94)
Observations	6,436	6,436	6,436	6,436	6,436	6,436
Adj. R-squared	0.007	0.246	0.008	0.247	0.009	0.247
Episode FE	N	Y	N	Y	N	Y

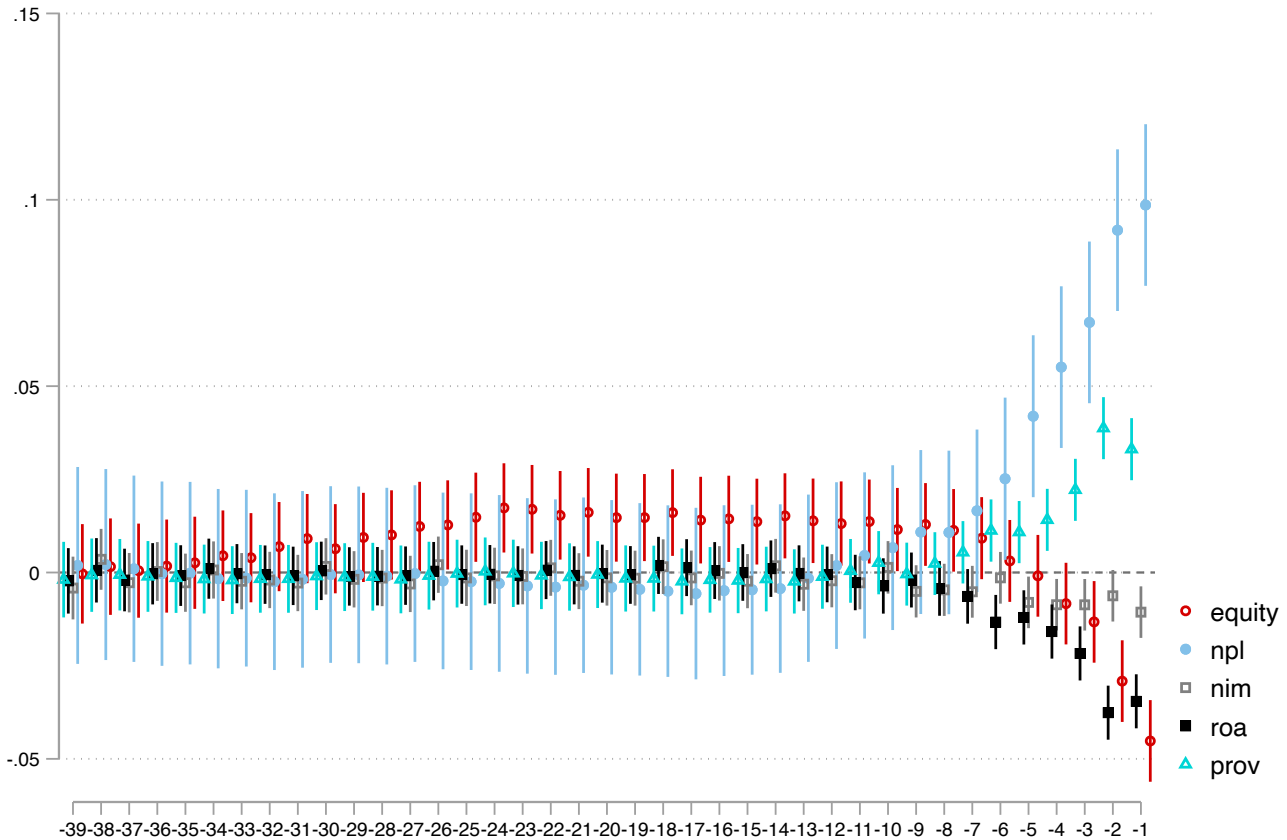
Outline

Balance sheet trends before failure

We estimate:

$$y_{it} = \alpha_i + \sum_{j=-40}^{-1} \beta_j \times 1_{j=t} + \varepsilon_{it}$$

where y_{it} is a balance sheet indicator of a failing bank, j measures the number of quarters before failure, and α_i are bank fixed effects.



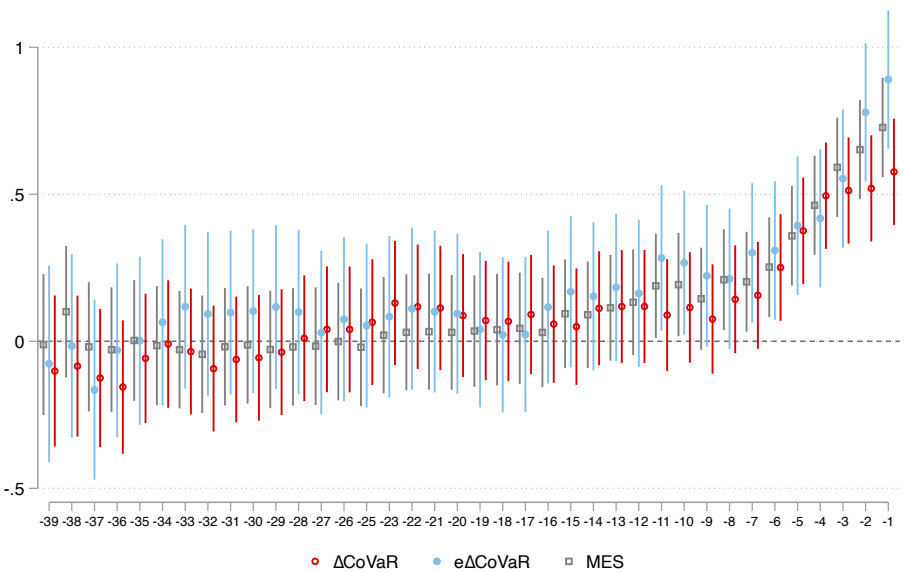
Replica of Figure 2 in Correia, Luck and Verner (2024) at the parent bank level. The sample is restricted to banks that failed from 1959 through 2023, and the ten years before they fail.

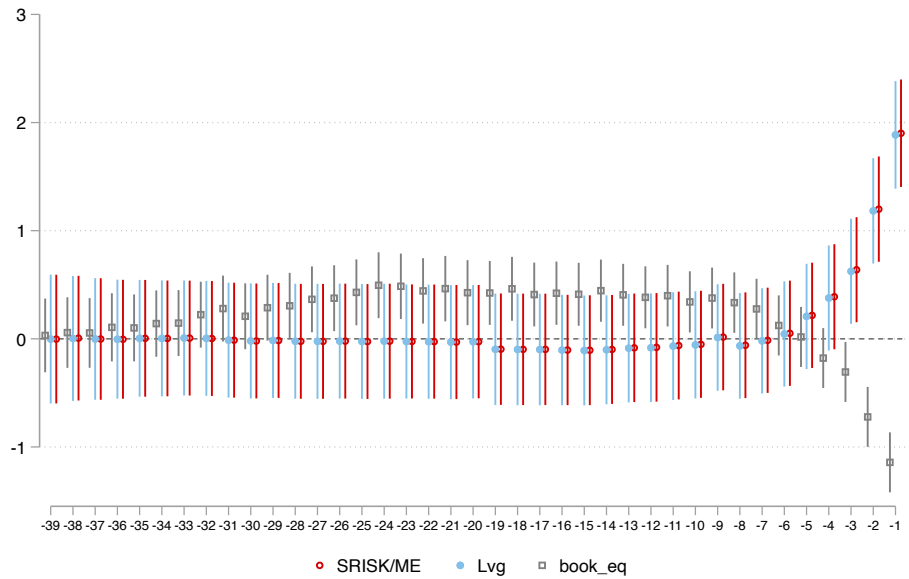
Systemic risk trends before failure

We estimate:

$$y_{it} = \alpha_i + \sum_{j=-40}^{-1} \beta_j \times 1_{j=t} + \varepsilon_{it}$$

where y_{it} is a systemic risk indicator or a capitalization measure of a failing bank, j measures the number of quarters before failure, and α_i are bank fixed effects.





The sample is restricted to banks that failed from 1959 through 2023, and the ten years before they fail. All measures are scaled by their standard deviations.

Predicting bank failures

We estimate the following specification to predict a bank failure in the next year:

$$Failure_{i,t+1\to t+h} = \alpha + \beta\, Measure_{it} + \varepsilon_{i,t+1\to t+h} \tag{11}$$

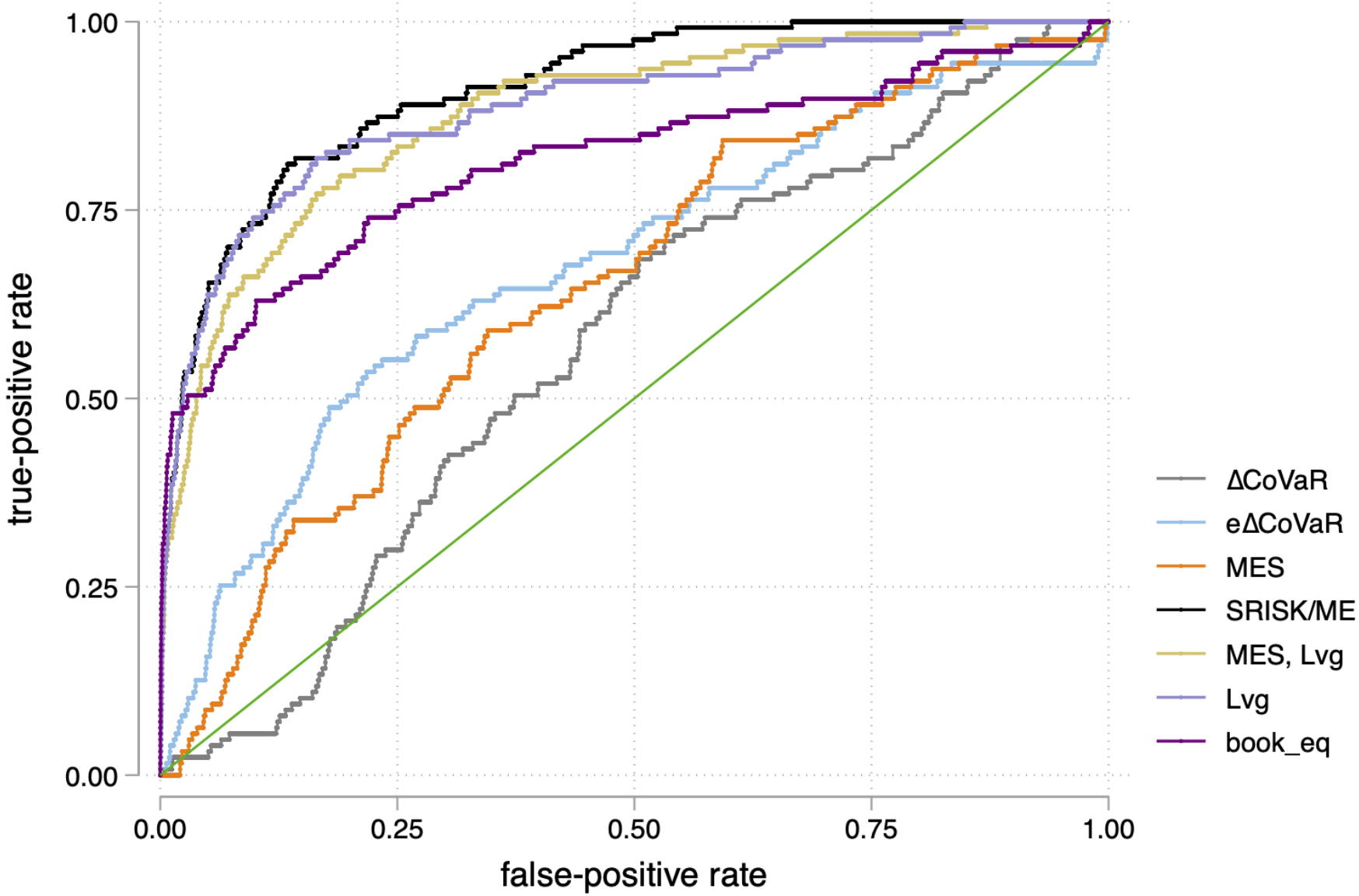
where $Failure_{i,t+1\to t+h} = 1$ if a bank fails in the next h quarters and is equal to zero otherwise, and $h = 4$ (one year).

	Failure probability (fail in next year)						
Measure:	ΔCoVaR	eΔCoVaR	MES	SRISK/ME	MES (+Lvg)	Lvg	book_eq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Measure	0.06**	0.11***	0.06***	0.87***	0.05***	0.07***	-0.15***
	(2.06)	(6.80)	(5.45)	(43.49)	(4.94)	(43.21)	(-13.99)
Lvg					0.07***		
					(43.15)		
Observations	33,250	33,250	33,250	33,250	33,250	33,250	33,250
Adj. R-squared	0.000	0.001	0.001	0.054	0.054	0.053	0.006
Pseudo R2 (logit)	0.002	0.025	0.017	0.117	0.127	0.115	0.195
AUC	0.571	0.676	0.647	0.911	0.880	0.887	0.815

Pseudo R-squared are obtained from corresponding logit regressions. AUC is the area under the receiver operating characteristic (ROC) curve.

Receiver-operating characteristic curve (ROC)

$$Failure_{i,t+1\to t+h} = \alpha + \beta\, Measure_{it} + \varepsilon_{i,t+1\to t+h}$$



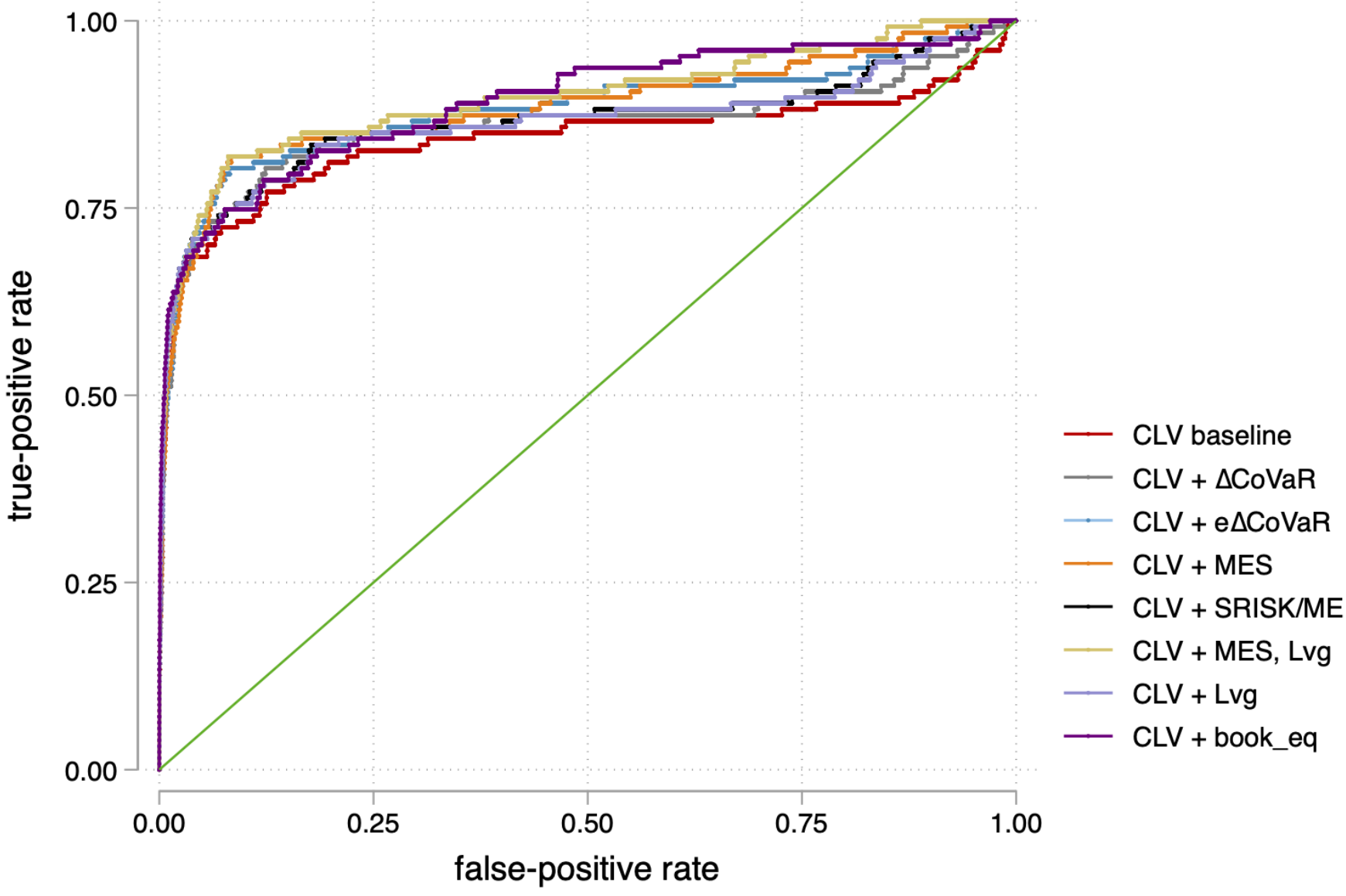
Predicting bank failures

To compare the predictive performance of the systemic risk measures with the results of Correia et al. (2024):

$$\begin{aligned} Failure_{i,t+1\to t+h} \quad = \quad & \alpha + \beta_1 Solvency_{it} + \beta_2 Funding_{it} + \beta_3 Solvency_{it} \times Funding_{it} \\ & + \beta_4 Growth_{it} + \beta_5 AggregateConditions_t + \beta_6 Measure_{it} + \varepsilon_{i,t+1\to t+h} \end{aligned} \tag{12}$$

	Failure probability (fail in next year)							
Measure:	CLV	ΔCoVaR	eΔCoVaR	MES	SRISK/ME	MES(+Lvg)	Lvg	book_eq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
solvency	0.48***	0.49***	0.49***	0.49***	0.49***	0.50***	0.49***	0.46***
	(8.39)	(8.43)	(8.58)	(8.54)	(8.68)	(8.76)	(8.65)	(7.96)
funding	0.04***	0.05***	0.05***	0.05***	0.03***	0.04***	0.03***	0.04***
	(20.95)	(21.90)	(23.35)	(23.51)	(15.62)	(16.85)	(14.64)	(19.45)
solvency×funding	-4.93***	-4.93***	-4.91***	-4.93***	-4.07***	-4.10***	-4.08***	-4.85***
	(-36.18)	(-36.18)	(-36.10)	(-36.19)	(-29.50)	(-29.70)	(-29.56)	(-34.46)
asset_growth	0.02	0.03	0.03	0.04	0.23***	0.23***	0.22***	-0.01
	(0.33)	(0.47)	(0.48)	(0.58)	(3.26)	(3.30)	(3.17)	(-0.12)
aggregate_cond	0.16***	0.14***	0.17***	0.17***	0.20***	0.20***	0.20***	0.17***
	(4.92)	(4.30)	(5.16)	(5.18)	(6.19)	(6.30)	(6.12)	(5.19)
Measure		0.20***	0.18***	0.12***	0.61***	0.10***	0.05***	-0.03**
		(6.74)	(10.75)	(10.87)	(28.75)	(8.72)	(28.10)	(-2.36)
Lvg						0.05***		
						(27.32)		
Observations	33,208	33,208	33,208	33,208	33,208	33,208	33,208	33,208
Adj. R-squared	0.072	0.073	0.075	0.075	0.094	0.095	0.093	0.072
Pseudo R2 (logit)	0.280	0.291	0.312	0.309	0.314	0.335	0.313	0.357
AUC	0.841	0.859	0.882	0.885	0.865	0.898	0.863	0.892

Receiver-operating characteristic curve (ROC)



Predicting bank failures (during stress episodes)

$$Failure_{i,t+1\to t+h} = \alpha + \beta_1 Solvency_{it} + \beta_2 Funding_{it} + \beta_3 Solvency_{it} \times Funding_{it} + \beta_4 Growth_{it} + \beta_5 Measure_{it} + \gamma gz_t + [\delta_1 Solvency_{it} + \delta_2 Funding_{it} + \delta_3 Solvency_{it} \times Funding_{it} + \delta_4 Growth_{it} + \delta_5 Measure_{it}] \times gz_t + \varepsilon_{i,t+1\to t+h} \quad (13)$$

	Failure probability (fail in next year)							
Measure:	CLV	ΔCoVaR	eΔCoVaR	MES	SRISK/ME	MES(+Lvg)	Lvg	book_eq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
solvency×gz	0.30***	0.32***	0.34***	0.34***	0.33***	0.36***	0.33***	0.34***
	(7.04)	(7.51)	(7.99)	(7.95)	(7.88)	(8.69)	(7.82)	(7.64)
funding×gz	2.32***	2.77***	2.69***	2.87***	2.13***	2.84***	2.18***	2.45***
	(11.73)	(13.41)	(13.28)	(14.05)	(10.68)	(13.62)	(10.89)	(12.20)
solvency×funding×gz	-1.37***	-1.35***	-1.34***	-1.33***	-1.58***	-1.57***	-1.59***	-1.49***
	(-14.30)	(-14.14)	(-13.99)	(-13.92)	(-16.56)	(-16.45)	(-16.67)	(-14.70)
asset_growth×gz	-17.04**	-17.46**	-18.69**	-17.47**	-15.11**	-17.12**	-15.68**	-16.47**
	(-2.28)	(-2.34)	(-2.51)	(-2.35)	(-2.04)	(-2.32)	(-2.12)	(-2.18)
Measure		-0.28***	-0.17***	-0.16***	0.65***	-0.20***	0.05***	-0.12***
		(-4.05)	(-4.10)	(-5.98)	(13.73)	(-7.41)	(14.24)	(-4.53)
Measure×gz		21.29***	15.52***	12.63***	-0.30	13.10***	-0.16	3.73***
		(7.34)	(9.16)	(11.10)	(-0.16)	(11.56)	(-1.04)	(3.39)
Lvg						0.06***		
						(15.21)		
Lvg×gz						-0.39**		
						(-2.49)		
Observations	33,208	33,208	33,208	33,208	33,208	33,208	33,208	33,208
Adj. R-squared	0.083	0.086	0.088	0.089	0.108	0.112	0.107	0.084
Pseudo R2 (logit)	0.285	0.298	0.318	0.314	0.319	0.340	0.317	0.366
AUC	0.852	0.875	0.901	0.898	0.890	0.919	0.887	0.907

Outline

Predictive regressions: loan growth

We estimate the following specification to predict bank balance sheet outcomes during a stress episode:

$$y_{ie} = \beta Measure_{ie} + \delta controls_{ie} + \alpha_e + \varepsilon_{ie} \quad (14)$$

where y_{ie} is the average balance sheet outcome of bank i during episode e, and α_e are episode fixed effects.

Measure:	ΔCoVaR		eΔCoVaR		MES		SRISK/ME		MES (+Lvg)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	loan growth									
Measure	-1.43***	-1.19**	-0.46***	-0.31**	-0.39***	-0.28**	-0.77***	-0.44	-0.33**	-0.26**
	(-2.92)	(-2.11)	(-2.81)	(-2.00)	(-3.17)	(-2.14)	(-4.30)	(-1.60)	(-2.48)	(-1.99)
Lvg									-0.05***	-0.03
									(-3.00)	(-1.08)
Observations	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222
Adj. R-squared	0.006	0.005	0.003	0.004	0.004	0.004	0.003	0.004	0.004	0.004
Episode FE	N	Y	N	Y	N	Y	N	Y	N	Y

Predictive regressions: loan growth (C&I and real estate)

Measure:	ΔCoVaR		eΔCoVaR		MES		SRISK/ME		MES (+Lvg)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					C&I loan growth					
Measure	-1.25**	-1.09	-0.61**	-0.49*	-0.71***	-0.59***	-1.40***	-0.90**	-0.59***	-0.55***
	(-2.08)	(-1.22)	(-2.03)	(-1.65)	(-3.72)	(-2.75)	(-4.16)	(-2.47)	(-2.94)	(-2.60)
Lvg									-0.09***	-0.06
									(-3.18)	(-1.64)
Observations	2,202	2,202	2,202	2,202	2,202	2,202	2,202	2,202	2,202	2,202
Adj. R-squared	0.007	0.156	0.006	0.156	0.010	0.159	0.009	0.157	0.012	0.159
					real estate loan growth					
Measure	-1.85***	-1.38**	-0.57***	-0.44***	-0.33	-0.00	-1.25***	-0.46	-0.18	0.03
	(-2.58)	(-1.98)	(-3.35)	(-2.96)	(-1.44)	(-0.01)	(-3.58)	(-1.54)	(-0.74)	(0.08)
Lvg									-0.11***	-0.05**
									(-3.61)	(-2.23)
Observations	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210	2,210
Adj. R-squared	0.010	0.159	0.005	0.158	0.005	0.157	0.007	0.157	0.008	0.157
Episode FE	N	Y	N	Y	N	Y	N	Y	N	Y

Predictive regressions: ROA and uninsured deposits

Measure:	ΔCoVaR		eΔCoVaR		MES		SRISK/ME		MES (+Lvg)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					return on assets					
Measure	-0.03*	0.01	-0.03***	-0.02***	-0.02***	-0.01**	-0.07**	-0.07**	-0.01*	-0.01*
	(-1.82)	(0.46)	(-3.20)	(-2.84)	(-2.60)	(-2.58)	(-2.27)	(-1.98)	(-1.71)	(-1.96)
Lvg									-0.01***	-0.01***
									(-3.13)	(-3.07)
Observations	2,227	2,227	2,227	2,227	2,227	2,227	2,227	2,227	2,227	2,227
Adj. R-squared	0.184	0.297	0.188	0.301	0.185	0.299	0.192	0.307	0.198	0.312
					uninsured deposit growth					
Measure	-1.17***	-0.31	-0.55**	-0.31	-0.44**	-0.31*	-1.64	-1.23	-0.34**	-0.27
	(-2.90)	(-0.68)	(-2.03)	(-1.10)	(-2.35)	(-1.67)	(-1.27)	(-0.83)	(-2.02)	(-1.56)
Lvg									-0.10	-0.08
									(-0.94)	(-0.69)
Observations	1,726	1,726	1,726	1,726	1,726	1,726	1,726	1,726	1,726	1,726
Adj. R-squared	0.013	0.030	0.012	0.030	0.013	0.031	0.014	0.032	0.015	0.032
Episode FE	N	Y	N	Y	N	Y	N	Y	N	Y

Outline

Predicting market outcomes (1927-1958)

We estimate the following specification to predict market outcomes during the early episodes:

$$y_{ie} = \beta Measure_{ie} + \delta control_{ie} + \alpha_e + \varepsilon_{ie} \quad (15)$$

where y_{ie} is the average market outcome of financial institution i during stress episode e. Sample: 7 banks and 42 non-banks.

Panel A: realized volatility (during stress episodes)									
Measure:		ΔCoVaR			eΔCoVaR			MES	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Measure	2.22***	2.12***	2.21***	1.62***	0.95**	0.64	2.16***	1.45***	1.41***
	(4.25)	(4.83)	(3.35)	(3.02)	(2.21)	(1.26)	(5.94)	(4.54)	(4.09)
Observations	171	171	171	171	171	171	171	171	171
Adj. R-squared	0.103	0.379	0.447	0.178	0.332	0.418	0.227	0.368	0.479
Size control	N	Y	Y	N	Y	Y	N	Y	Y
Episode FE	N	N	Y	N	N	Y	N	N	Y

Panel B: realized returns (during stress episodes)									
Measure:		ΔCoVaR			eΔCoVaR			MES	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Measure	-4.89***	-4.72***	-2.56*	-2.49**	-1.31	0.13	-3.18***	-1.89	-1.60
	(-3.38)	(-3.31)	(-1.81)	(-2.21)	(-1.21)	(0.18)	(-2.94)	(-1.47)	(-1.58)
Observations	171	171	171	171	171	171	171	171	171
Adj. R-squared	0.046	0.117	0.173	0.037	0.079	0.167	0.043	0.084	0.177
Size control	N	Y	Y	N	Y	Y	N	Y	Y
Episode FE	N	N	Y	N	N	Y	N	N	Y

Systemic Risk Measurement Stocktake: key takeaways

Stock-market based systemic risk measures predict realized stress (returns, volatility), conditional on a stress period, especially for banks, over a long time series (1927 - 2023).

The measures predict bank failures, together with other leading fundamental indicators (Correia, Luck, and Verner, 2024).

The measures also predict bank balance sheet outcomes on lending, profitability, and deposit drawdowns, over and above book capital measures of solvency.

Market-based indicators detect financial vulnerability during a stress episode, and can be useful regulatory and supervisory aids.