

The Capital and Loss Assessment Under Stress Scenarios (CLASS) Model

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Measuring systemic risk using top-down stress testing models

- Supervisory stress testing on the rise as a financial stability tool:
 - DFAST/CCAR stress testing framework in US
 - EBA EU-wide stress tests in Europe
 - Prudential Regulatory Authority stress testing in UK
- Also an increasing number of simpler “top-down” stress testing models developed by academics and policy researchers.
- Today:
 1. Outline one such framework: the **C**apital and **L**oss **A**ssessment under **S**tress **S**cenarios (CLASS) model.
 2. Use CLASS to study evolution of the “capital vulnerability” of US banking system over time, as well as variation across firms.



Background: Supervisory Stress Testing



Background: Bank Capital

- In banking, “capital” refers to common and preferred equity and (sometimes) long-term subordinated debt
- Key function is that capital can absorb losses and protect the bank from failure
 - A bank is (technically) solvent as long as capital (common equity) is positive
 - Same as for other firms, but particularly important in banking due to high leverage
- “Failure” when equity gets too small for creditors and counterparties to be certain that their debts will be repaid
 - Can lead to a run -- illiquidity
 - Likely occurs before common equity is completely gone



Background: Regulatory Capital Ratios

- The Federal Reserve specifies a series of regulatory capital ratios.
 - BHCs are required to have current capital ratios that exceed minimum required levels
- Regulatory capital ratios have different measures of “capital” in the numerator and different measures of “assets” in the denominator:
 - Capital measures: common equity (minus deductions); Tier 1 capital (common equity plus preferred); Total regulatory capital (Tier 1 capital plus (some) subordinated debt).
 - Asset measures: risk-weighted assets (different positions weighted according to risk) and average assets (equal weights for all positions).
 - Risk-weighted assets account for off-balance sheet positions; new definition of average assets will also.
- In the U.S., these ratios are now transitioning to the new “Basel III” definitions and required minimum levels

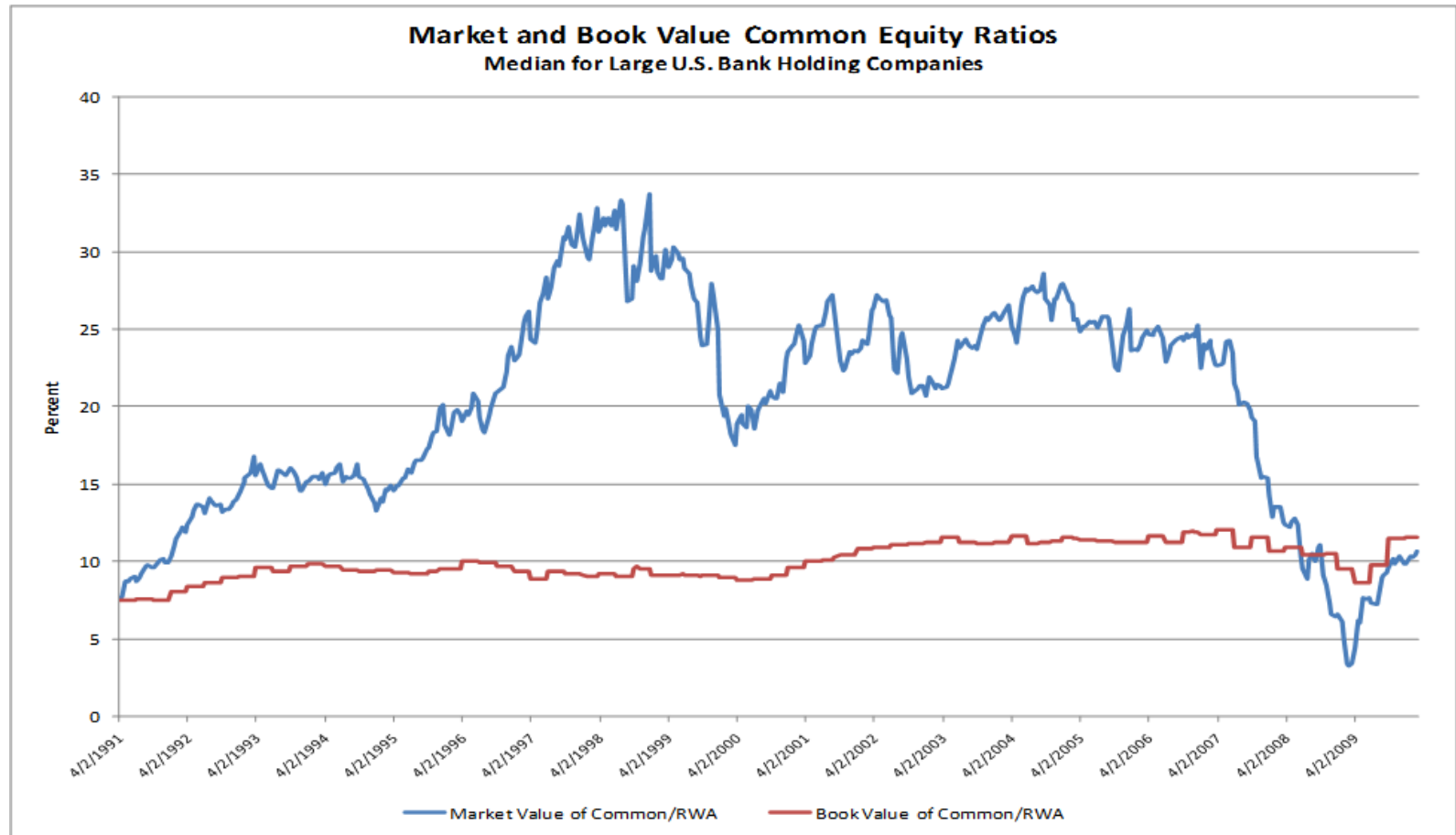


Lessons from the Financial Crisis

- Significant uncertainty about the extent of losses at individual banking companies and in the banking system as a whole
 - Uncertainty because many assets were opaque and difficult to value
 - Uncertainty because of accounting
 - Uncertainty about how bad it might get
- Regulatory capital ratios are backward looking
 - Based on book values of equity, rather than market values
 - Do not incorporate losses not yet recognized under accounting rules
 - Market values incorporate these losses, or at least market expectations of these losses
- Common equity is what matters
 - Other forms of “capital” were significantly discounted by market participants
 - Regulatory capital ratios did not focus on common equity – no regulatory capital ratio based on common equity alone

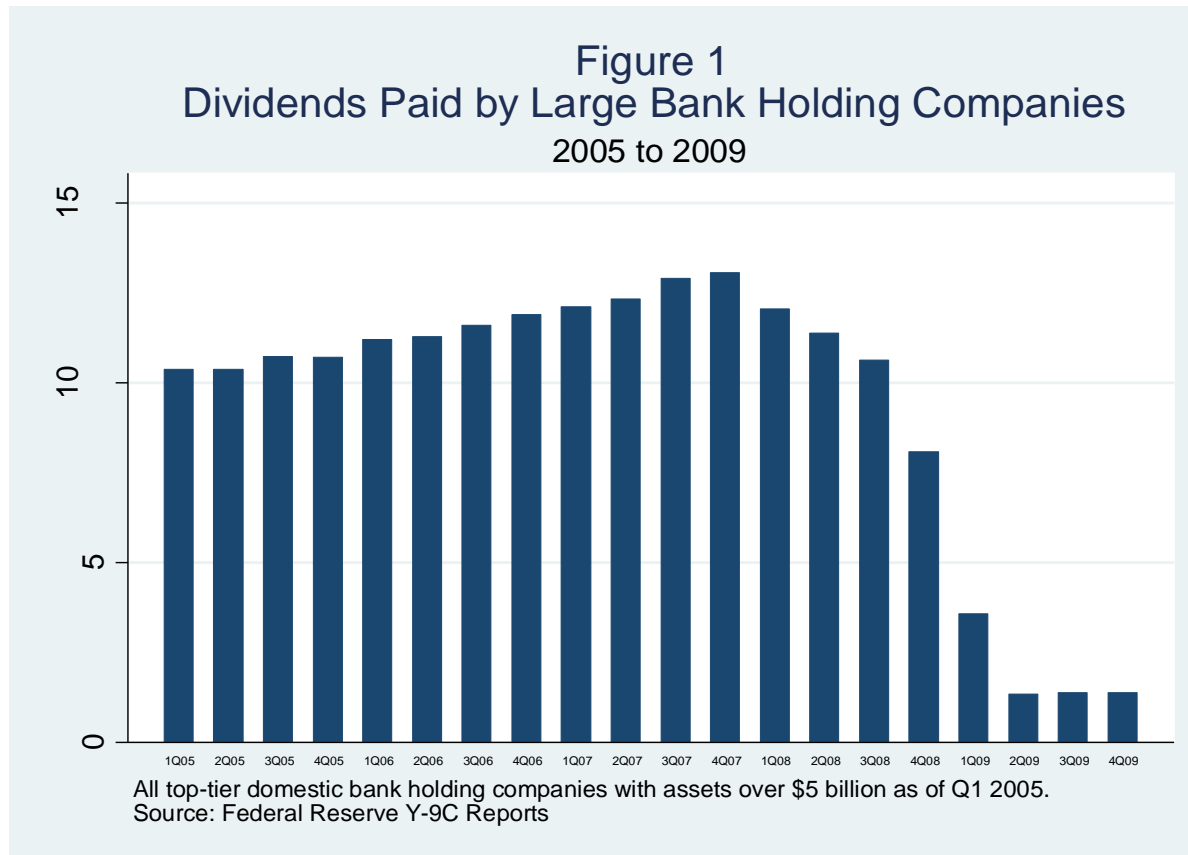


Market and Book Values of Common Equity



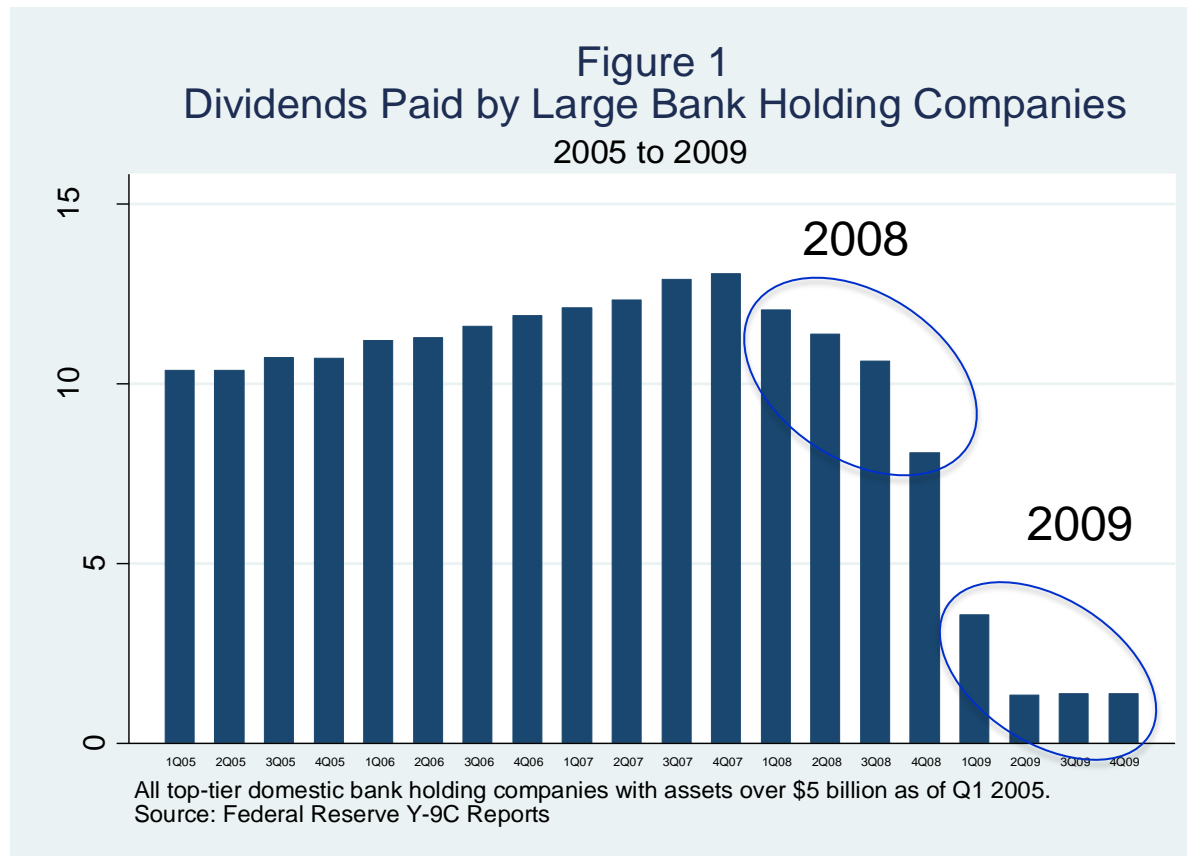
What were the banks doing?

- Most did not reduce dividends until relatively late in the crisis



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- Further reductions in capital, even as conditions deteriorated



Why stress tests?

- A stress test measures what might happen to a bank's capital if the economy deteriorates
 - A hypothetical exercise based on a particular economic scenario
- Stress tests are a way to bring a forward-looking perspective to assessing whether a bank has sufficient capital
- Stress testing many banks at once provides information not just about individual banks, but about the banking system as a whole
 - This was critical during the financial crisis
- Stress tests do not tell us what losses currently are or might be under all circumstances, but they do provide a kind of upper bound if the scenario is severe enough
 - Can help address uncertainty about individual banks and the banking system

History of U.S. Stress Testing

- 2009: Supervisory Capital Assessment Program (SCAP)
 - performed during the height of the financial crisis
 - focus on 19 largest individual BHCs – 2/3 of the assets of the banking system
 - banks had to raise capital to meet any shortfall relative to target
 - **published individual BHC results – a big innovation**
 - **banks raised \$100 billion in new common equity following the SCAP**

- 2011: Comprehensive Capital Analysis and Review (CCAR)
 - supervisory assessment of capital adequacy; initially 19 largest BHCs, now 31 largest
 - assessment of both quantity of capital and of BHCs' internal management processes
 - both BHC-run and supervisory stress test projections are inputs
 - disclosure of supervisory results starting in 2012

- 2013: Dodd-Frank Act Stress Tests (DFAST)
 - requires BHC-run and supervisory stress test projections; initially 18 largest BHCs, now 31 largest
 - disclosure of supervisory and BHC results starting in 2013



What do U.S. bank stress tests do?

- Calculate what happens to regulatory capital under hypothetical stressed economic and financial market conditions (“scenarios”)
- Final outputs are “stressed” regulatory capital ratios
 - Book value, following GAAP accounting and regulatory capital rules
- Key equation in the stress test:
$$\text{Capital}_t = \text{Capital}_{t-1} + \text{Net Income}_t - \text{Dividends}_t$$
- Project net income and components under stressed conditions
 - Revenues, operating expenses, and losses
- Dividends and other capital actions (share repurchases or issuance) are assumptions about future actions
- Also need to project the denominators of the capital ratios – assets and risk-weighted assets



How are the stress tests calculated?

Three step process:

- Define the hypothetical scenarios
- Collect data from the banks
- Use the data in models to project net income and capital



Step One: *Baseline and Stress Scenarios*

- Federal Reserve develops three economic and financial market scenarios
 - Baseline, Adverse, Severely Adverse
 - Scenarios made public in November of each year

- Severely Adverse scenario in 2015:
 - A deep recession and sharp fall in asset prices
 - U.S. and international variables
 - Sharp rise in credit spreads, especially in the corporate sector, and financial market volatility
 - Trading positions at largest BHCs also subject to global market shock (big moves in spreads, rates, prices)
 - Default of largest counterparty at 8 large BHCs, after global market shock

- Adverse scenario for 2015:
 - Milder recession than severely adverse
 - Growth slowdown in all country groups
 - Rise in interest rates along the yield curve
 - Includes milder version of global market shock to trading and counterparty default

- Stress scenario horizon runs from Q4 2014 to Q4 2016 (nine quarters)



Step Two: Collect Data from the Banks

- To generate stress test results that accurately reflect each bank, need information about each bank's assets, liabilities, income and expenses
- Banks provide extensive data on their loan, securities, and trading portfolios; business activities; revenue and expenses; and balance sheet on regulatory reports
 - FR 14-M, FR 14-Q and FR 14-A regulatory reports
- Firm-specific risk attributes, loss protection/mitigation, revenue and expense drivers, portfolio composition
- Millions of data elements per bank

Step Three: Models and Output

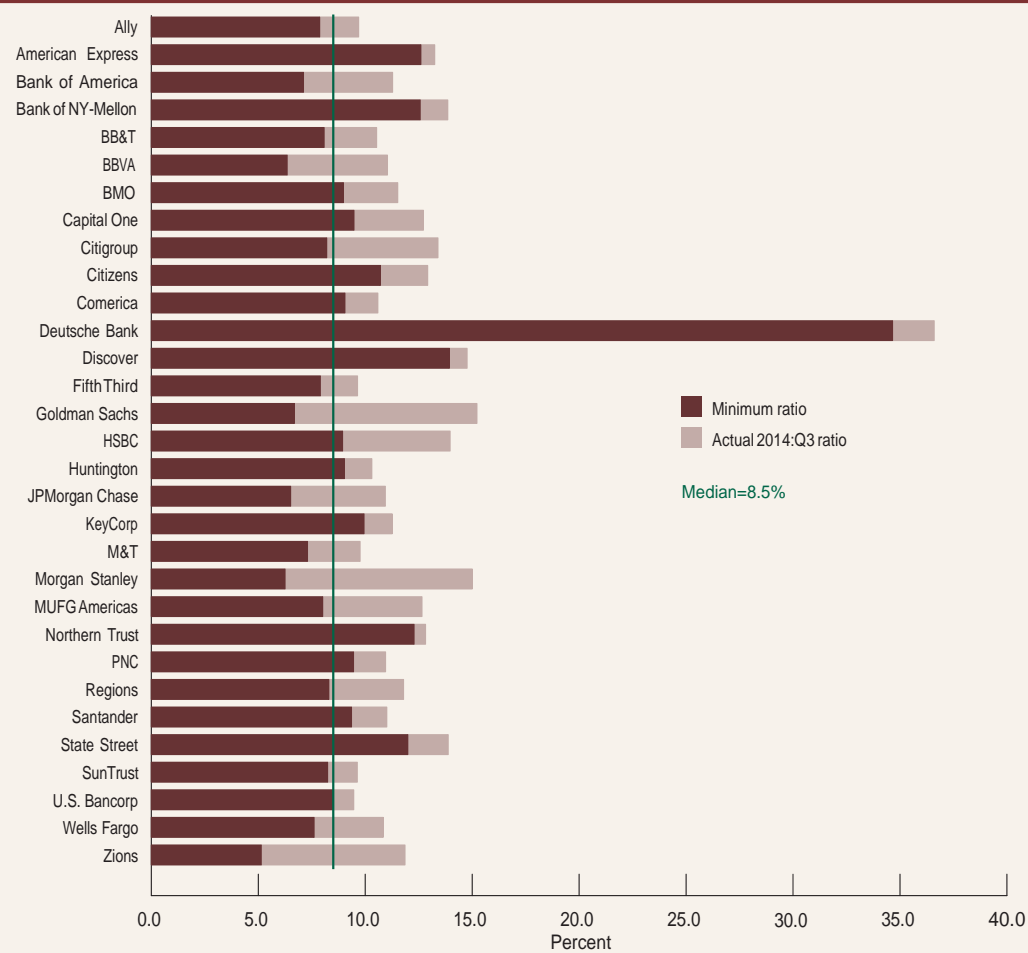
- The Federal Reserve uses bank data and the scenario variables as inputs to models developed or selected by the Federal Reserve to project losses, revenues, expenses, the balance sheet, risk-weighted assets, and capital
 - Federal Reserve models with bank input data
 - With few exceptions, independent estimates, not adjustments to bank projections
- Federal Reserve models capture “typical” bank behavior
 - Models calibrated using industry-wide data
 - No firm-specific adjustments, just firm-specific input data
 - Very limited use of “fixed effects”
 - Consistent assumptions across banks
 - Results therefore vary, perhaps significantly, from what the banks themselves would project
- Key objective is consistency across banks

DFAST/CCAR 2015 Stress Test Results

- Severely Adverse Scenario:
 - Aggregate net income (loss) for the 31 participating BHCs of -\$222B
 - Pre-provision net revenue of \$310B
 - Projected loan loss provisions of \$382B
 - Projected trading/counterparty losses of \$103B
 - Other losses of \$47B
 - Aggregate capital ratios fall 300 to 500 basis points to minimum values
 - Range among individual BHCs is wide, from ~0 to more than 1000 basis points

Change in Tier 1 Common Capital Ratio: DFAST 2015, Severely Adverse Scenario

Figure 10. Change from 2014:Q3 to minimum tier 1 common ratio in the severely adverse scenario

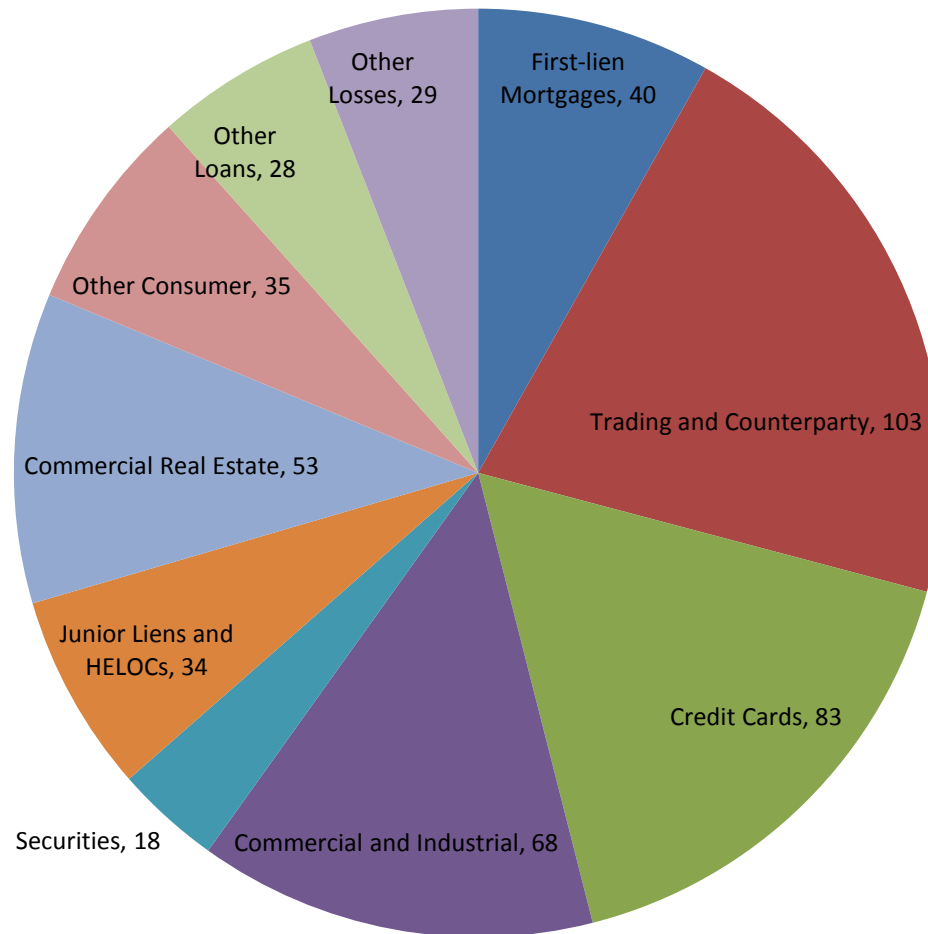


Note: Estimates are for the nine-quarter period from 2014:Q4–2016:Q4 as a percent of average assets.

Projected Losses in the Severely Adverse Scenario

DFAST/CCAR 2015, Billions of Dollar

Total Losses: \$490 Billion



How are the stress test results used?

- Input to the CCAR
 - One part of the assessment of whether a BHC has enough capital to withstand stress and continue to operate
 - A complement to the qualitative assessment of each BHC's internal risk management, risk measurement, and capital adequacy policies and processes
 - CCAR assessment affect BHCs' ability to pay dividends and do share repurchases
- Stress test results published by the Federal Reserve (“Dodd-Frank Act Stress Test” results -- DFAST)
 - Aggregate as well as individual BHC results
 - Results under two scenarios: severely adverse and adverse
 - BHCs also disclose their own stress test results under severely adverse (same scenario, BHC-specific calculations)
 - Most recent results released March 5

Overview of the CLASS Model

Summary of the CLASS model

- **What is CLASS?** A simple “top-down” model for forecasting losses, net income and capital for the US banking system.

Main features:

- Based on public Y-9C and Call report regulatory filings (rather than detailed supervisory data).
- Project net income (revenues, expenses, loan losses, other losses) using simple statistical models + macro projections + assumptions for provisioning, dividends, taxes etc.
- Combine to project capital path by firm. Add up to get an overall industry estimate for capital path and capital “gap”.
 - Individual projections for 200 largest bank holding companies (BHCs) or banks, plus aggregate of rest of industry.

Regression Models

- General structure:

$$\mathbf{ratio}_t = \alpha + \beta_1 \mathbf{ratio}_{t-1} + \beta_2 \mathbf{macro}_t + \beta_3 \mathbf{X}_t + \varepsilon_t$$

ratio : financial ratio of interest (e.g. net interest margin)

macro_t : selected macroeconomic variables

X_t : other controls (e.g., asset portfolio shares, time trend)

- Mix of time-series models and firm-level pooled regression models.
Estimated by OLS using Y-9C and Call data. (See paper for estimates.)
- Forecasts generated dynamically, using autoregressive structure.

Some key assumptions (more details in paper)

- **Balance sheet growth:** Asset balances grow at 1.25% per quarter, consistent with historical average. Liability growth is a residual ($A=L+E$).
 - Model has “toggle” in which asset growth depends on the scenario.
- **Loan loss reserving:** Forward looking provisioning rule. Reserves bounded above next four quarters of projected net chargeoffs (NCOs). Within range, provision expense = NCOs.
- **Taxes:** Firms taxed at 35% statutory rate. Tax losses carried forward, subject to regulatory capital limits on qualifying deferred tax assets.
- **Dividends / distributions:** Firms converge to long-run payout ratio of 45%, or to zero dividends if net income < 0. Net equity issuance = 0.

Benefits and costs of top-down approaches

Benefits:

- No confidential data: Estimated using public data (Y-9C / Call reports).
 - One advantage: consistent data available over much longer historical period.
- Speed: End-to-end run time is a couple of minutes for a given scenario (for 200 individual firms + remainder of system).
- Transparency: Models are pretty simple. Easier to understand what is going on, and what is driving the results.

Limitations:

- Limited data, which misses much of the variation in risk across firms.
 - E.g. no information on loan characteristics for loan portfolios (LTV, FICO etc.).
- Simple models and many auxiliary simplifying assumptions.
- Useful macro-prudential tool, but likely less reliable for individual firms.

Model projections:

Illustrate model properties using two macroeconomic scenarios:

- **Baseline:** central path for economic conditions, asset prices
- **Crisis redux:** repeat of macro conditions from 2007:Q3 onwards.

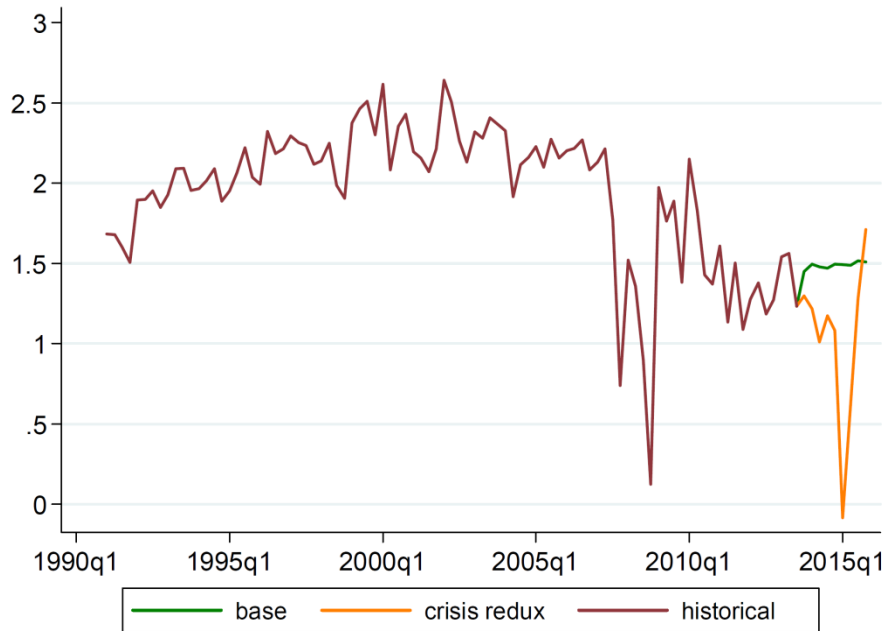
Macro scenarios: Selected variables

	Historical	Baseline			Crisis Redux		
	2013 Q3	First 3Q	Middle 3Q	Last 3Q	First 3Q	Middle 3Q	Last 3Q
Unemployment rate (end)	7.30	7.00	6.70	6.30	7.80	9.70	12.40
GDP growth (% ann)	1.86	2.59	2.89	2.89	0.47	(2.87)	(1.54)
Equity prices (% ch)	19.44	(0.70)	4.00	4.08	(12.39)	(31.82)	19.39
Home price growth (% ch, ar	10.90	2.52	2.64	3.07	(15.40)	(21.73)	(11.74)

Projections: key net income components

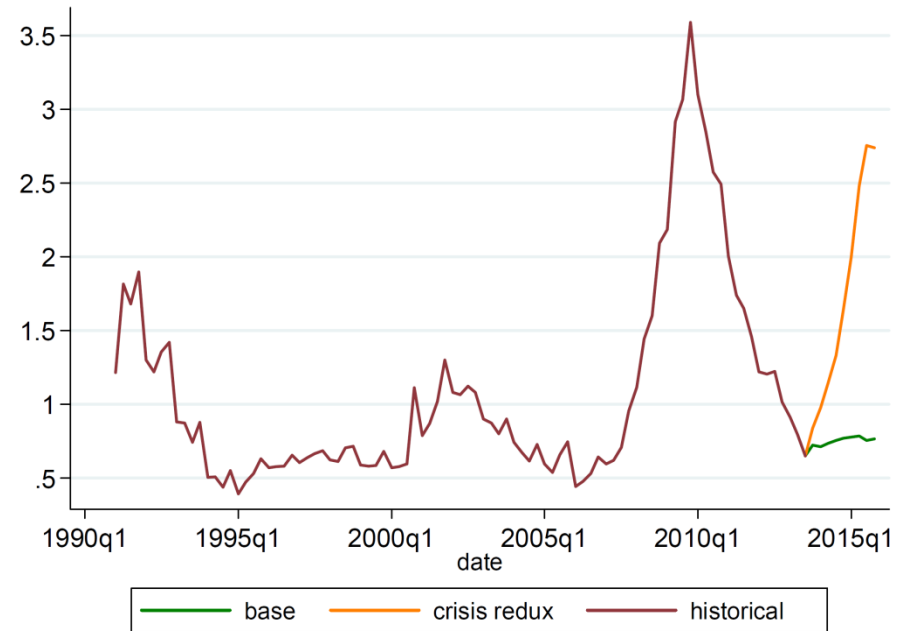
Pre-provision net revenue ratio

PPNR, % total assets, annualized



Net charge-off rate

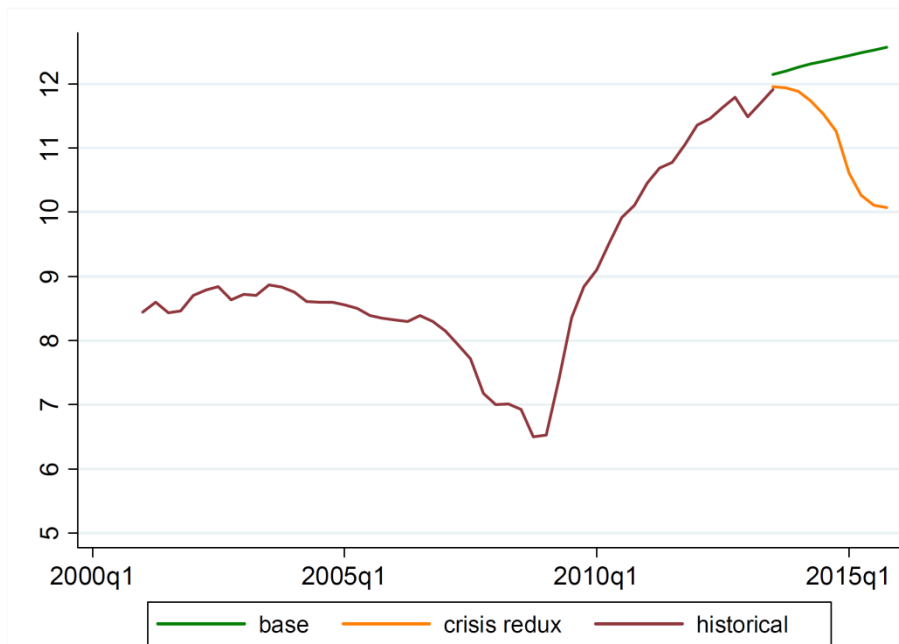
NCOs, % of total loans, annualized



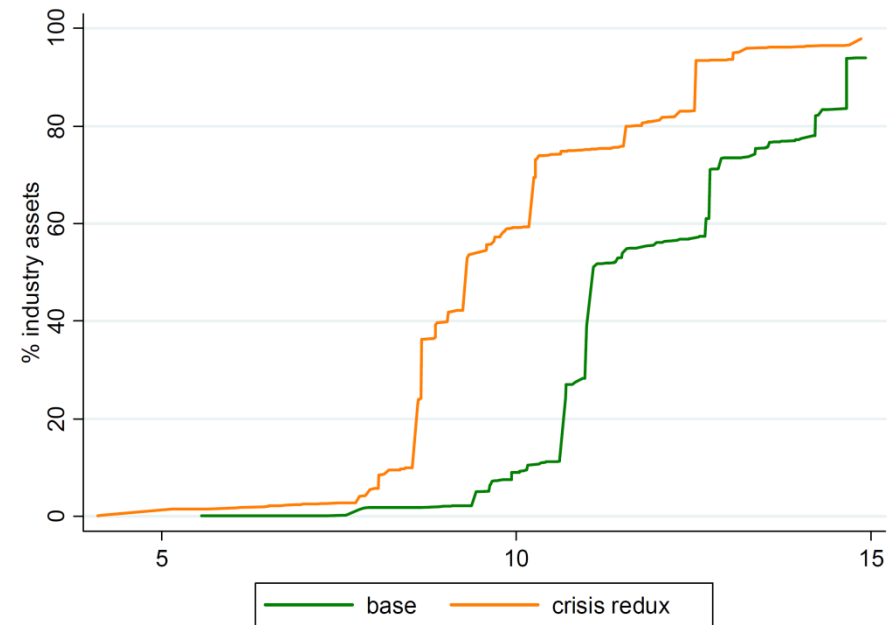
Capital projections

Capital ratio: tier 1 common equity as % of risk-weighted assets

A. Industry aggregate



B. Distribution of capital across firms



CLASS Model and Financial Stability

Top-down models and risk assessment through the cycle

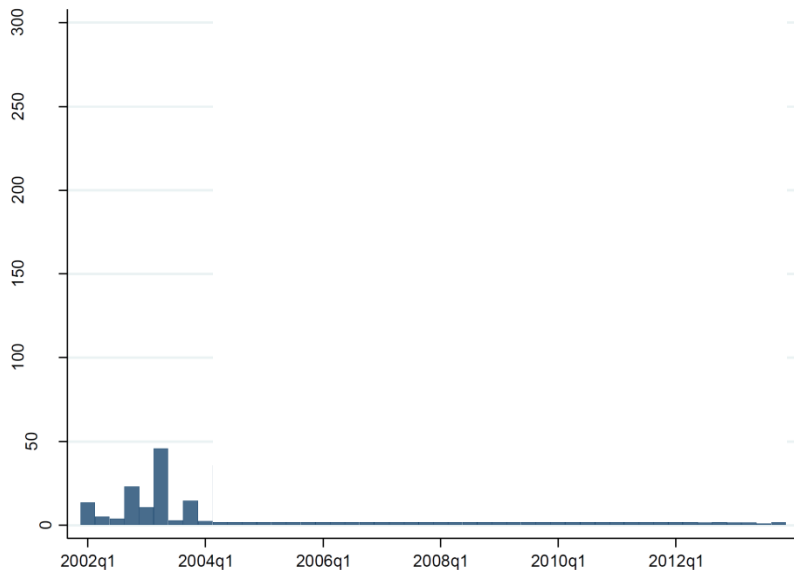
- Top down models can help shed light on how stress testing might perform over longer time horizon – e.g., leading up to the financial crisis.
- Key policy question: is the Fed's supervisory stress testing program built to respond to a build-up of risk in advance?
 - As capital risks increase, would like firms' capital planning to respond (e.g., reduce payout ratio to build up higher capital).
- Concern: Procyclicality. Models often project lower risk in “good times”
 - Adrian and Shin (2012): VAR declined in period before the crisis.
 - Credit loss projections on loan portfolio depend on current performance status. Lower % of delinquent loans during booms.

Time path of industry stress capital gap: CLASS model

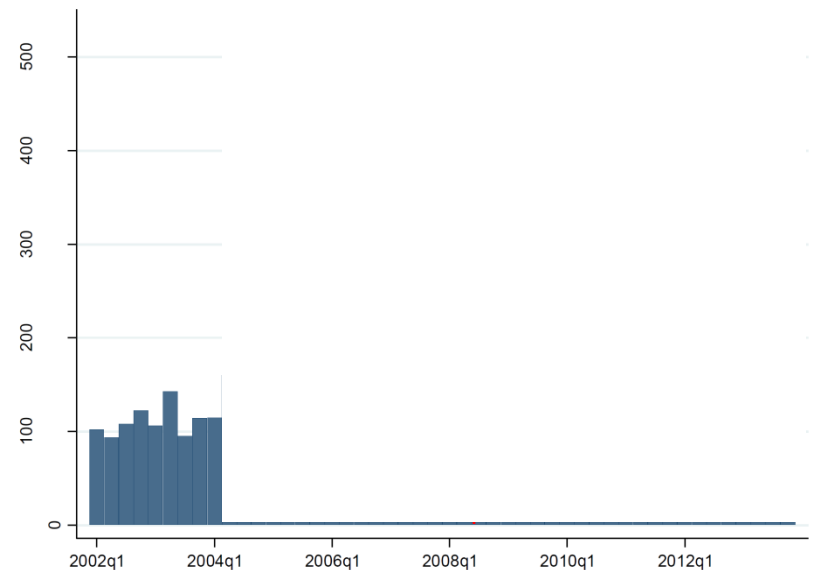
- Graph: Industry capital “gap” estimated at different points in time (i.e. seed model with bank balance sheet data from different quarters).
 - Each run, use the same “crisis redux” scenario, and hold model fixed.
 - Two thresholds: 5% & 8% tier 1 common equity / risk weighted assets.

Vulnerability to undercapitalization index (capital gap, \$bn)

Relative to 5% Tier 1 common / RWA threshold



Relative to 8% Tier 1 common / RWA threshold



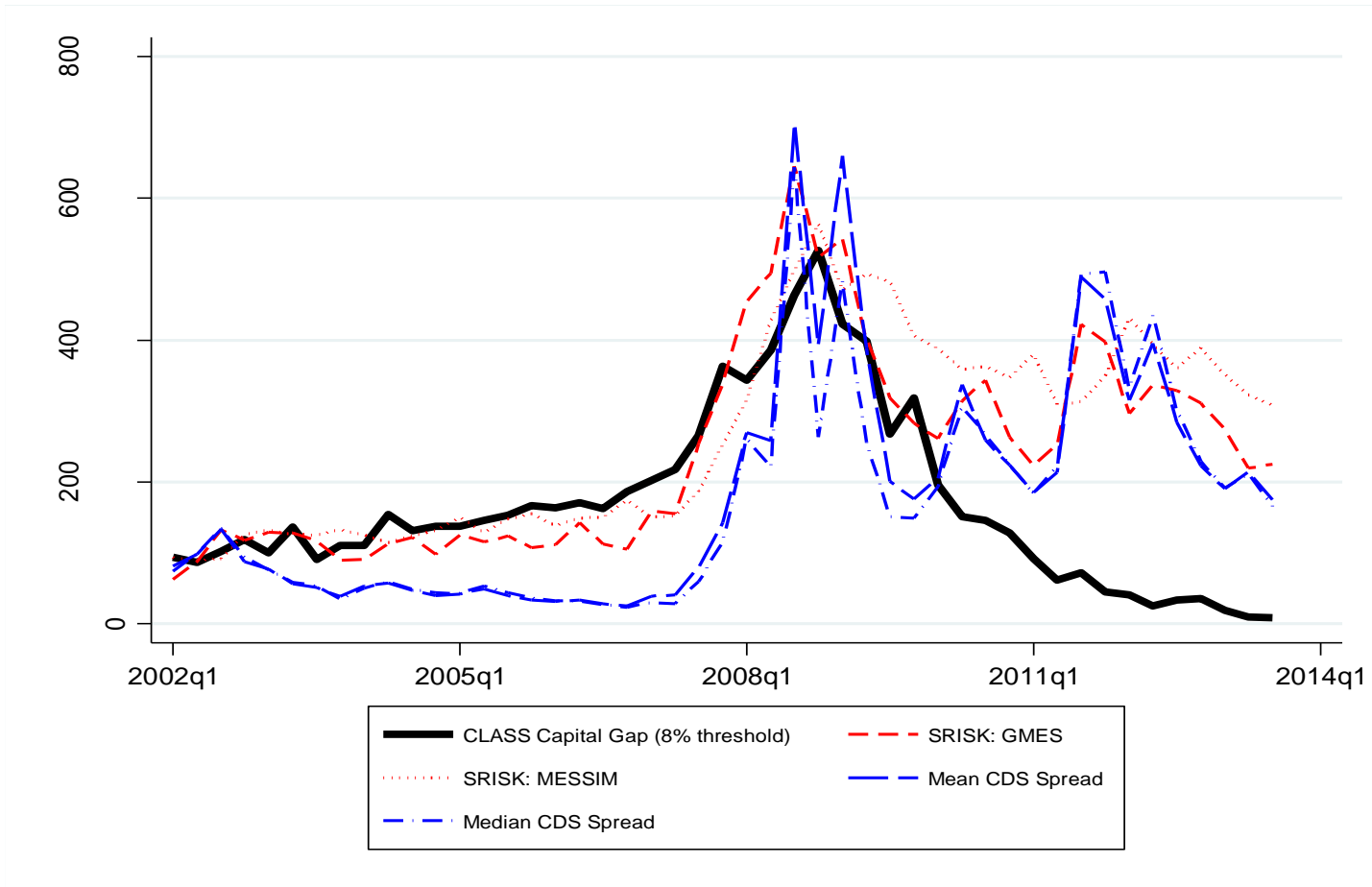
Evolution of the capital gap: key findings

- Industry capital gap today significantly below crisis peak, as well as pre-crisis levels. E.g., relative to 8% T1C/RWA threshold:
 - 2002: Gap = \$100bn
 - 2008: Gap > \$500bn
 - Today: Gap < \$10bn
- CLASS identifies buildup of capital vulnerability several years prior to the crisis, starting around 2004, intensifying in 2007-08.
 - Banks paid high dividends during this period (Acharya et al. 2011, Hirtle 2014).
 - Results suggestive that stress testing program backed by supervisory action could have been very valuable in lead-up to the crisis.
- CLASS identifies rise in risk earlier than market-based measures (e.g., SRISK, CDS spreads etc.). Reason: low risk premia / high valuations.

Comparison to Other Measures of Capital Adequacy

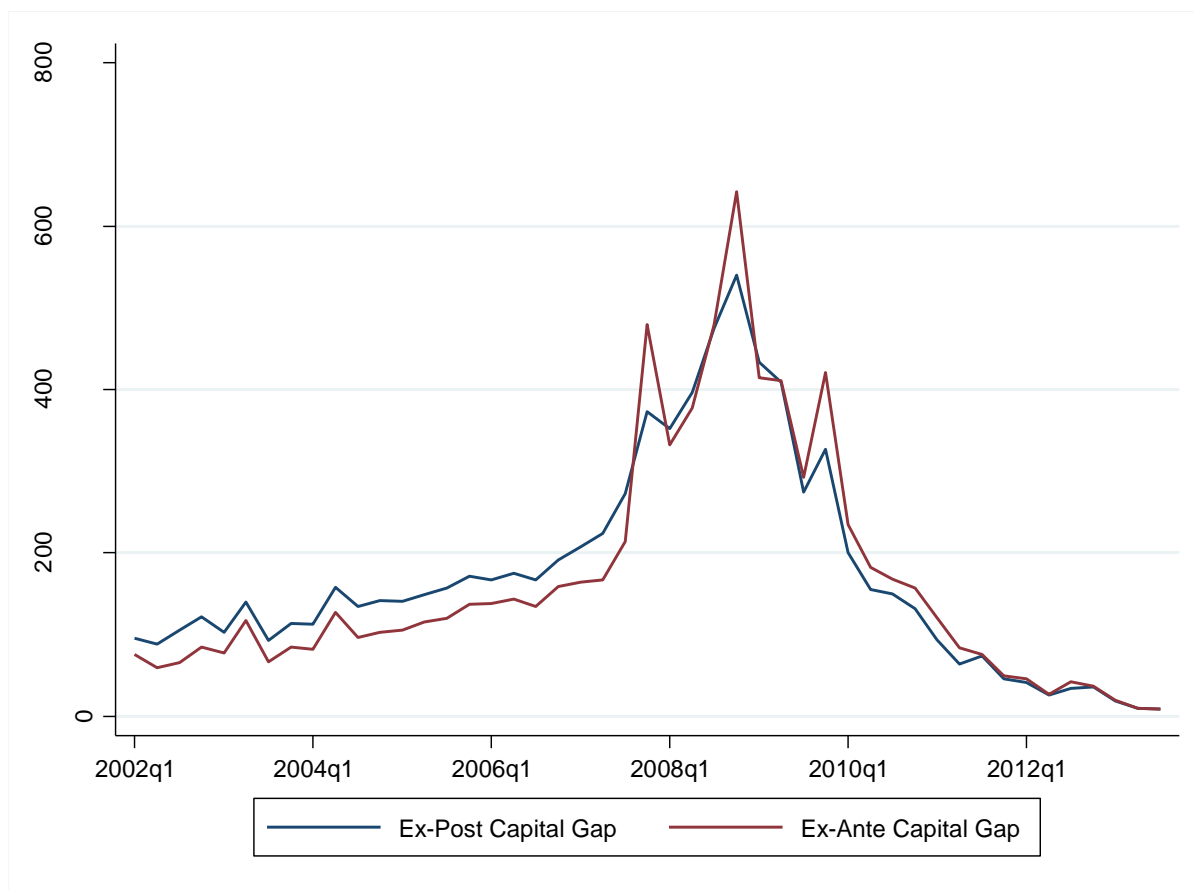
- SRISK: A capital gap measure based on large changes in the market value of common equity.
 - Acharya, Engle and Richardson (2012)
http://vlab.stern.nyu.edu/public/static/capital_shortfall-2012.pdf
- CDS spreads for large U.S. investment and commercial banks

CLASS Capital Gap vs. SRISK and CDS Spreads



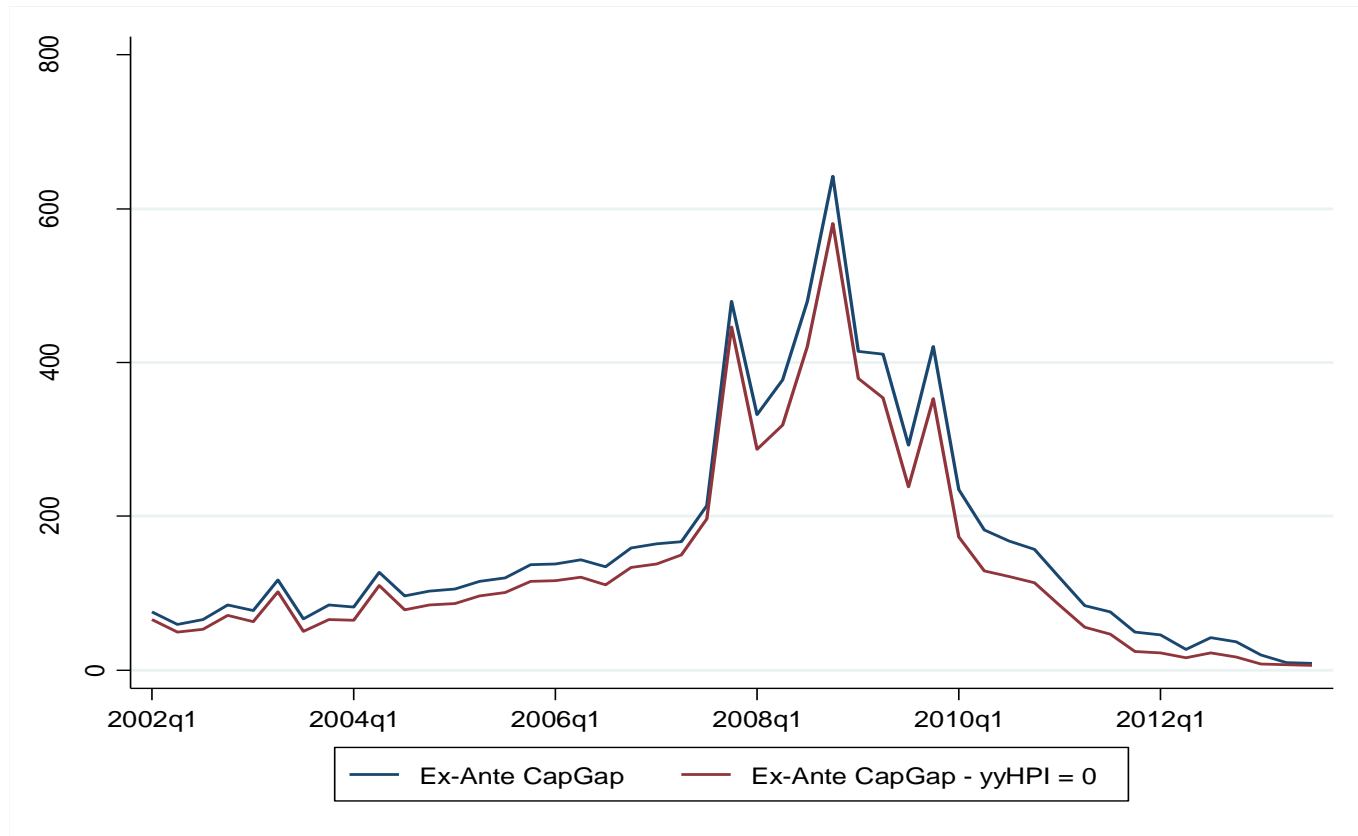
Real-time vs full-sample capital gap

- Alternative calculation: “real time” capital gap based on model estimated only up to time t (rather than full sample)
 - Similar overall results (e.g., buildup of gap from 2004-07).
 - Lower *level* of capital gap prior to financial crisis, however.



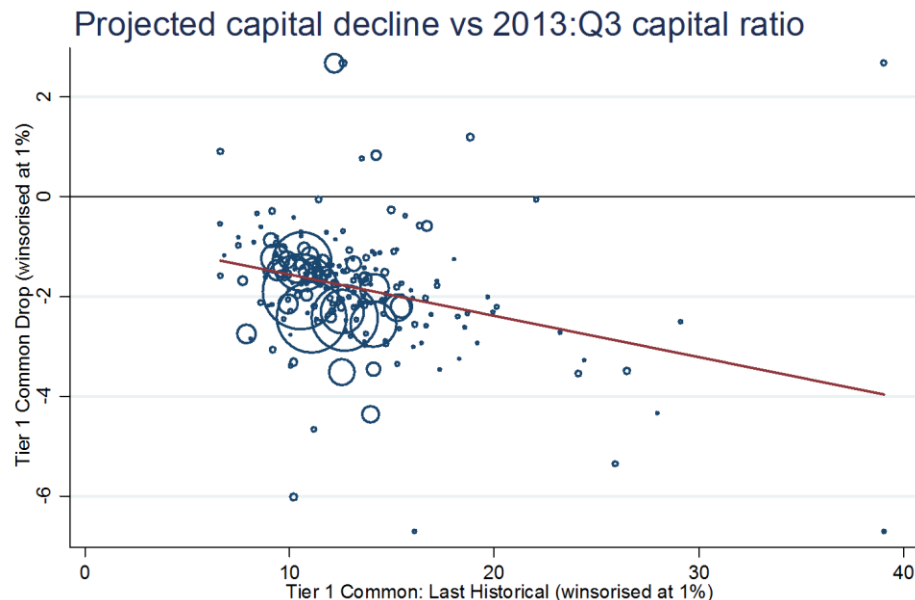
Real-time with and without housing price decline

- Real-time capital gap assuming no housing price decline in crisis redux scenario
 - Similar overall results, though at lower level

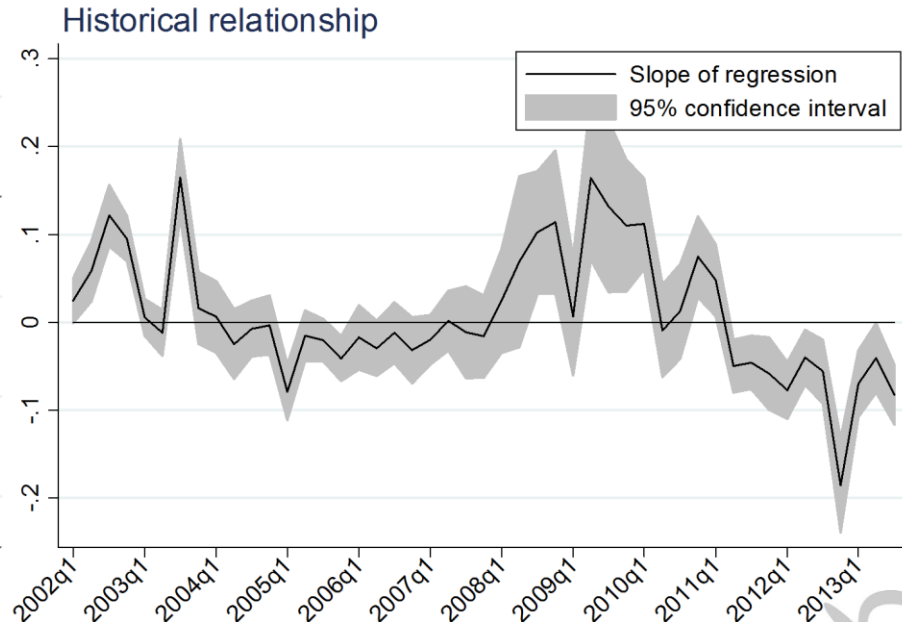


Which firms are vulnerable to macro stress?

- Figure: correlation between **initial capital ratio** (T1C/RWA) and projected **change in capital ratio** during stress scenario.
- Recently: riskier firms hold more capital, consistent with “precautionary” view of bank capital. (Desirable from financial stability perspective).
- Earlier: correlation less negative, sometimes positive!



Note: The regression line is the fitted values of an OLS regression
Note: Marker size represents total assets.



Comparison of projections to benchmarks

- As a specification / “reasonableness” test: compare CLASS projections to two external benchmarks:
 1. Official Federal Reserve stress test projections (DFAST 2014)
 2. BHC / bank performance during the financial crisis.

CLASS vs DFAST

Income Category	Aggregate projections			CLASS vs DFAST: across firms (CLASS = $\alpha + \beta \cdot \text{DFAST} + \epsilon$)	
	CLASS	DFAST	Difference	Slope coefficient (β)	R ²
PPNR/Assets (%)	1.97	1.57	0.39	0.845***	0.869
Provision Expense/Assets (%)	1.94	2.88	-0.94	0.625***	0.685 ^a
Other/Assets (%)	-0.02	-0.26	0.24	-0.044	0.008
Net Income Before Tax / Assets (%)	0.00	-1.57	1.57	0.662***	0.423
Change in T1C / RWA (%)	1.70	-3.63	1.93	0.202**	0.166

Comparison to benchmarks (cont...)

CLASS vs Financial Crisis (2007:q3 to 2008:q4)

Actual vs predicted: across firms (actual = $\alpha + \beta \cdot \text{predicted} + \epsilon$) ⁽¹⁾						
	Industry values		Weighted		Unweighted	
	Model	Actual	Slope coefficient (β)	R ²	Slope coefficient (β)	R ²
<i>Income and loan performance (9 quarter cumulative, annualized):</i>						
PPNR / total assets	1.54	1.47	1.378***	0.507	0.905***	0.155
Net chargeoff rate	1.93	1.99	1.224***	0.606	0.443***	0.067
Return on assets	0.13	-0.05	2.174***	0.317	1.482***	0.075
Change in T1C / RWA (6 qtr)	-1.10	-1.77	0.903***	0.081	0.235	0.010

Summing up: the CLASS model

- Simple model that projects bank income and capital under different macroeconomic scenarios, based on public data.
- Not a substitute for detailed bottom-up stress testing modelling, but has a variety of complementary uses (e.g., “what if” analysis”).
- Projections from the model suggest that the US banking system is less vulnerable to undercapitalization than before or during the 2007-09 financial crisis.
 - Measured capital vulnerability started to increase in 2004, well before crisis.
 - Suggests that this kind of stress-testing framework may help provide useful early warning signals.

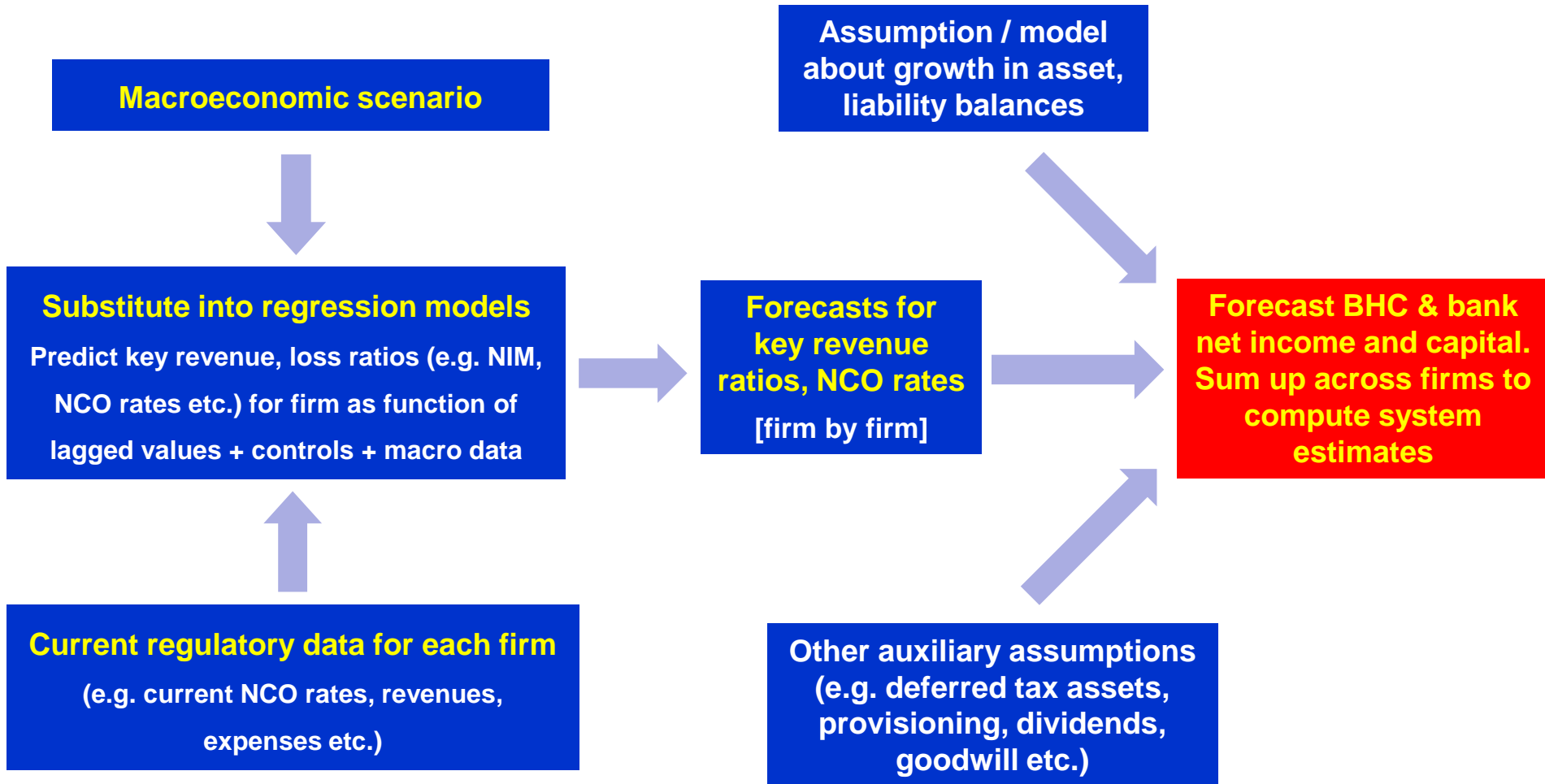
For more details:

- CLASS Model Paper can be found at:

http://www.newyorkfed.org/research/staff_reports/sr663.html

APPENDIX

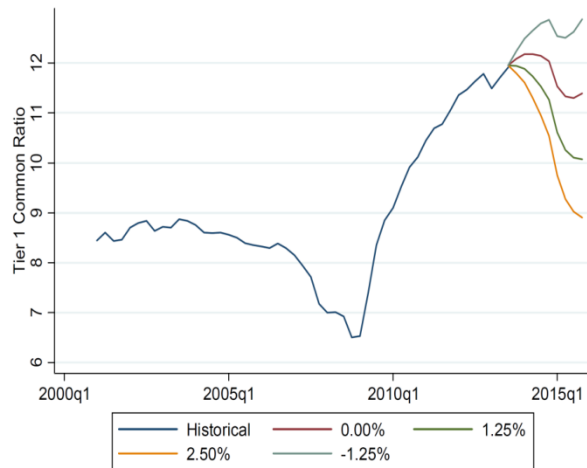
Computing capital projection



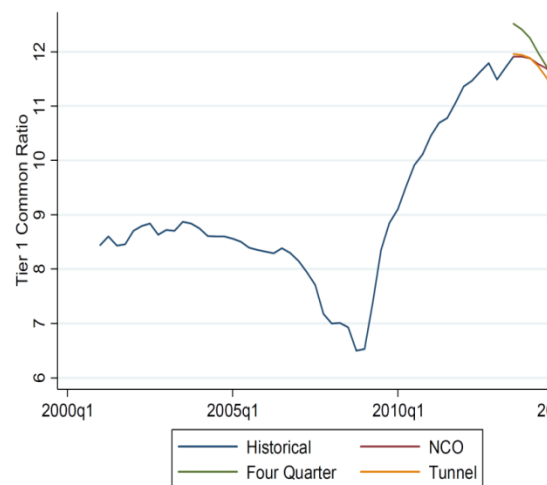
Sensitivity to model assumptions

- Asset growth assumption has very significant effect on projections.
 - Mechanical effect: assets are the denominator of the capital ratio.
 - Key stress testing question: How much should assets grow during scenario?
- Provisioning and payout assumptions also matter, but less critical.

A. Asset growth rate



B. Provisioning assumption



C. Payout rule

