

# Measuring Systemic Risk

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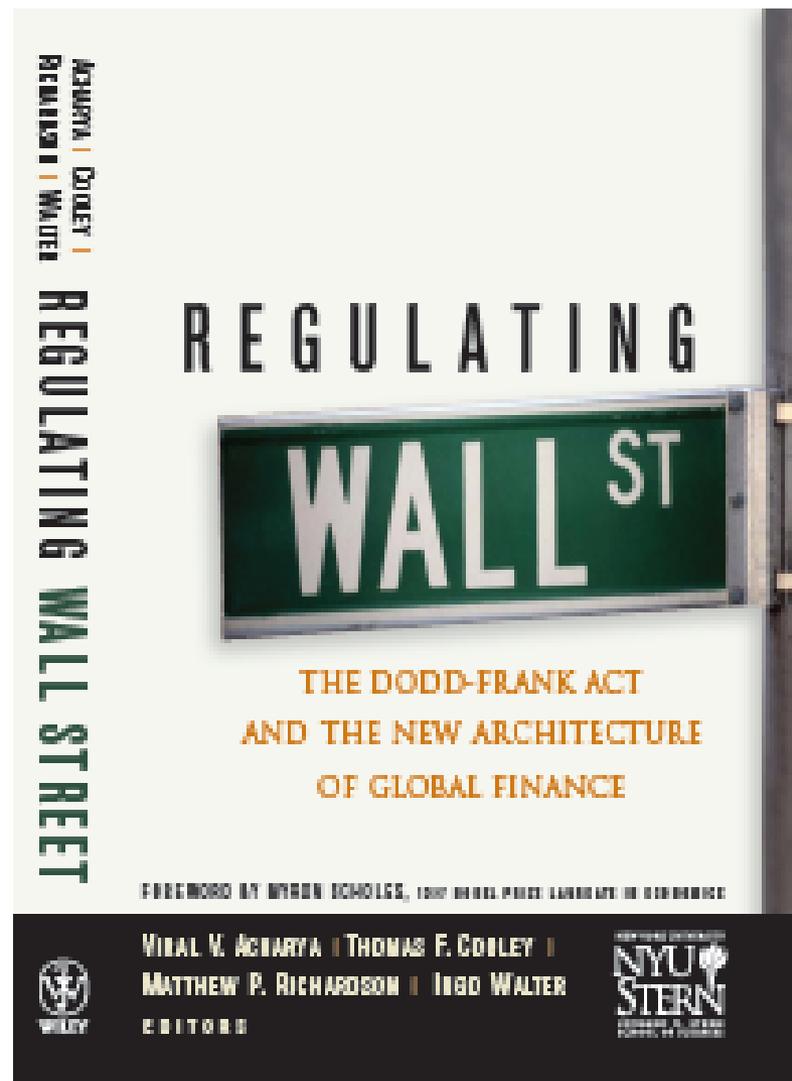
*NBER, CEPR*



# Regulating Wall Street:

The Dodd-Frank Act and the  
New Architecture of Global  
Finance

November 2010



# Idea behind the book

- Joint effort of 40 faculty members and students at NYU Stern
- Edited by Viral V Acharya, Thomas Cooley, Matthew Richardson and Ingo Walter
  - Following up on NYU-Stern's earlier effort "*Restoring Financial Stability: How to Repair a Failed System*", John Wiley & Sons, Mar 2009

## 1. **Bird's Eye-view of the Dodd-Frank:**

- Encore: Causes of the financial crisis of 2007-09
- Assessment of the Dodd-Frank Act from first principles
- Comparative evaluation relative to financial reforms of the 1930's
- What-if analysis for the Dodd-Frank Act during 2003-2008

# 2. Worm's Eye-view of the Dodd-Frank

## I. Financial Architecture

1. The Architecture of Financial Regulation
2. Central Bank Independence and the Role of the Fed
3. Consumer Financial Protection Agency

## II. Systemic Risk

4. Measuring Systemic Risk
5. Taxing Systemic Risk
6. Capital, Contingent Capital and Liquidity Requirements
7. Large Banks and the Volcker Rule
8. Resolution Authority
9. Systemic Risk and the Regulation of Insurance Companies

## III. Shadow Banking

10. Money Market Funds
11. The Repurchase Agreement (Repo) Market
12. Hedge Funds, Mutual Funds and ETFs
13. Regulating OTC Derivatives

## IV. Credit Markets

14. The GSEs
15. Regulation of Rating Agencies
16. Securitization Reform

## V. Corporate Control

17. Compensation
18. Accounting Issues

# Systemic Risk

- What is systemic risk?
  - Widespread failure of financial institutions or freezing of capital markets that impair financial intermediation – payments system and lending to corporations/households.
- When does it emerge?
  - Financial sector has too little capital to cover its liabilities.
- In this crisis,
  - In early Fall of 08, the GSEs, Lehman, Merrill Lynch, Wamu, Wachovia, Citigroup, ... effectively failed. Markets were already or began to freeze.
  - Outcome of systemic risk in the Fall of '08 and Winter '09:
    - Stock Markets: US -42%, UK -46%, Europe -49%, Japan -35%, Latin America -50%
    - GDP: Advanced economies -3.2%, Global -0.8%
    - International Trade -12%

# Traditional regulation

- Traditional approach: Firm-level risk
  - Goal: Limit risk of individual bank
  - Challenge: Detailed knowledge of activities of firm, impose VaR limits...
- Traditional approach ignores systemic risk
  - Distress of entire system with negative externalities on the real economy
- Regulation of *systemic risk* of financial firms is needed
- But how do we measure this risk? What causes such risk?
- Could we have predicted most systemic firms before the crisis?
- What data are needed? Can market data give early warnings?

# Systemic regulation: Theoretical motivation

- Goal: Limit risk of collapse of the system
- Regulation needed: firms will not manage their systemic risk
  - Incentive to take correlated risk
    - Acharya (2001, 2009), Acharya and Yorulmazer (2007), Farhi and Tirole (2009)
  - Externalities
    - Liquidity spirals (Brunnermeier and Pedersen (2009), Pedersen (2009))
    - Bank runs (Diamond and Dybvig (1983), Allen and Gale (1998))
    - Debt market freezes (Acharya, Gale, and Yorulmazer (08), He and Xiong (2009))
    - Tightening risk management (Garleanu and Pedersen (2007))

# Challenges for Systemic Regulation

- Identify ex-ante the firms that pose greater systemic risk
- Make firms internalize external costs of systemic risk
- Outline of our work
  - Start from simple economic theory
  - Identify sensible measure of systemic risk: Marginal Expected Shortfall

$$ES_{\alpha} = - \sum_i y_i E[r_i | R \leq -VaR_{\alpha}], \quad \frac{\partial ES_{\alpha}}{\partial y_i} = -E[r_i | R \leq -VaR_{\alpha}] \equiv MES_{\alpha}^i$$

- Provide empirical evidence of its usefulness: (i) stress tests of Spring 2009; (ii) Equity decline in 2007-08; (iii) CDS widening in 2007-08
- NYU Stern VLAB Implementation of systemic risk of financial firms

# Simple Motivation: Stress Tests of 2009

- Time line
  - Feb 25: Fed, FDIC, OCC to examine 19 largest Bk. Hold. Cos. Capital Assistance Program (CAP) as backstop.
  - May 7: Results: Overall losses of 19 banks for 2009-2010 estimated as \$600B under adverse scenario. 9 of 19 have enough capital and future earnings to withstand losses. Other 10 need to raise a total of \$75B.
- Two key points
  - **Aggregate shortfall** of \$75 billion
  - Not all banks are undercapitalized → **need to differentiate**

## EXTERNALITIES DUE HIGH BETA AND LEVERAGE

- Highly levered firms have a greater risk of default.
- The default of a firm is far more dangerous if the economy is weak at the same time (beta) as there are no buyers to assume the liabilities.
- Thus systemically risky firms are those that face capital shortages (“losses”) just when the financial sector as a whole is capital constrained (“in a crisis”).

# LOSSES IN A CRISIS

- In a financial crisis, investors in most firms experience severe losses. The sum of these losses approximate the aggregate loss to society.
- We seek to decompose these losses in any future crisis into losses attributable to each of a collection of firms.
- The firms that lose the most, are the biggest contributors to the systemic cost. These are considered the systemically most risky firms.

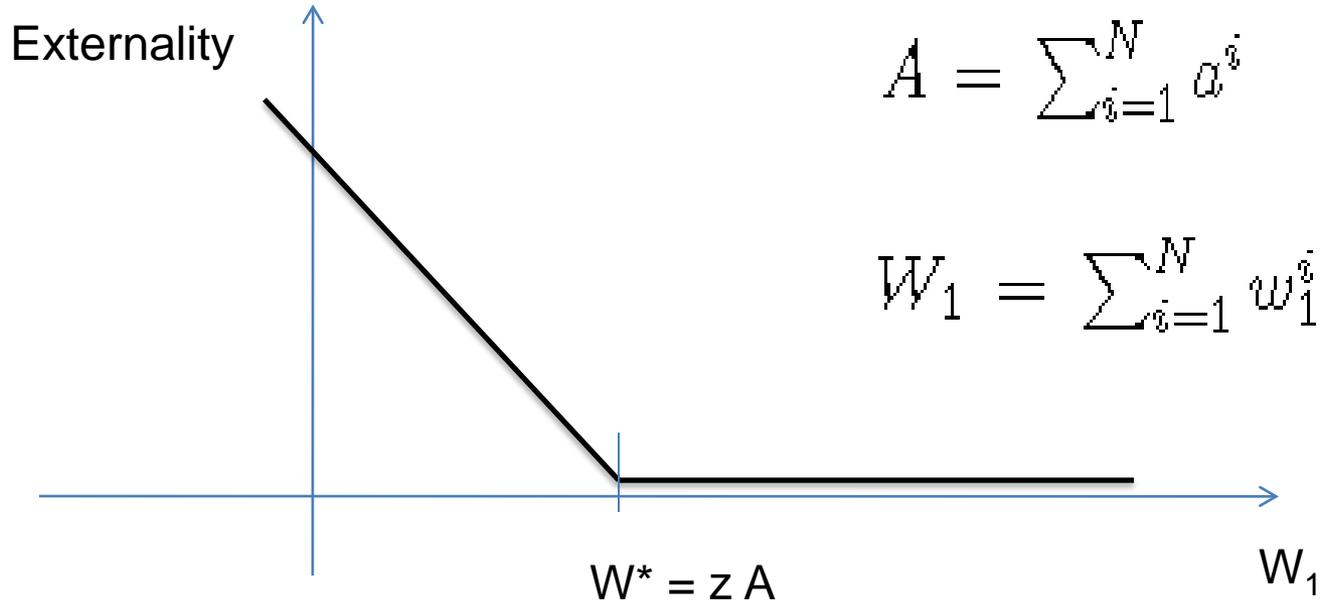
# Our model

- Many banks  $i=1,\dots,N$  and two dates
- Time 0: Choice of investments & leverage
  - Each bank has given initial level of capital  $w_{i,0}$
  - Issue debt  $b_i$  at face value  $f_i$  : a fraction  $\alpha_i$  can be insured by govt
  - Assets:  $a_i = w_{i,0} + b_i$
  - Allocate investments among  $j=1\dots J$  risky assets and cash
- Time 1: Returns are realized
  - Limited liability if insolvent, but govt out insured depositors

$$\hat{y}^i = \sum_{j=1}^J r_j^i x_j^i, \quad \phi^i = \Phi(\hat{y}^i, f^i) \quad w_1^i = \hat{y}^i - \phi^i - f^i$$

# Externality

- Let  $W_1$  be aggregate net worth of financial system at time 1
- Systemic distress happens if  $W_1$  falls below a cutoff  $W^* = zA$
- Imposes negative externality  $e(W^* - W_1)$  on economy



# Economic model - results

- Without government intervention,
  - Banks choose leverage level and exposures  $x=(x_I, \dots, x_S)$  with a risk level higher than socially optimal.

- To correct this, government could charge a tax:

$$ES^i \equiv -E [w_1^i | w_1^i < 0] \quad SES^i \equiv E [za^i - w_1^i | W_1 < zA]$$

$$\tau^i = \frac{\alpha^i g}{c} \cdot Pr(w_1^i < 0) \cdot ES^i + \frac{e}{c} \cdot Pr(W_1 < zA) \cdot SES^i.$$

- We assume sufficient metrics of systemic risk contributions available to design optimal taxation (a normative benchmark)

# Efficient regulation

- Tax system with two components
- Default Expected Shortfall (DES):
  - ***The bank's expected losses upon default***
  - Analogous to the FDIC insurance premium.
  - Justified by government guarantees on deposits and related cost (g).
- Systemic Expected Shortfall (SES):
  - ***The bank's expected losses in a crisis***
  - Expected contribution of bank to the aggregate shortfall of capital during a crisis.
  - Justified by the externality (e).

# Systemic Expected Shortfall

- A bank's SES is larger if
  - the externality is more severe ( $e$ ),
  - systemic under-capitalization is more likely ( $Pr[W_i < W^*]$ )
  - the bank takes a larger exposure ( $x_s$ ) in an asset  $s$  that experiences losses when other banks are in trouble
  - the bank is more leveraged ( $w_0$ )
- In our empirical work, we focus on the cross-sectional part of SES, taking as given (i) the size of externality or the level of tax; (ii) the likelihood of systemic crisis, the time-series part

# Measuring SES

- Analogy with risk management inside firms
  - Banks compute contribution of segment  $s$  (business line, geographical region, etc.) to overall VaR of the bank

$$MVaR_s = \frac{\partial VaR}{\partial v_s}$$

- Define and measure marginal expected shortfall (MES):
  - Choose cutoff (say 5% risk level) for aggregate return
  - Compute bank's equity return on days with market return below cutoff

$$MES_{5\%}^i \equiv -E \left[ \frac{w_1^i}{w_0^i} - 1 \mid I_{5\%} \right]$$

# From MES to SES

- MES in “normal” times, while SES corresponds to the “tail”
  - For example, -40% aggregate return on a 6 month period would imply a Great Recession or a Depression
- Leverage should matter as distress more likely but also because of distress costs in the tail, not captured by normal times (more for OTM option strategies)

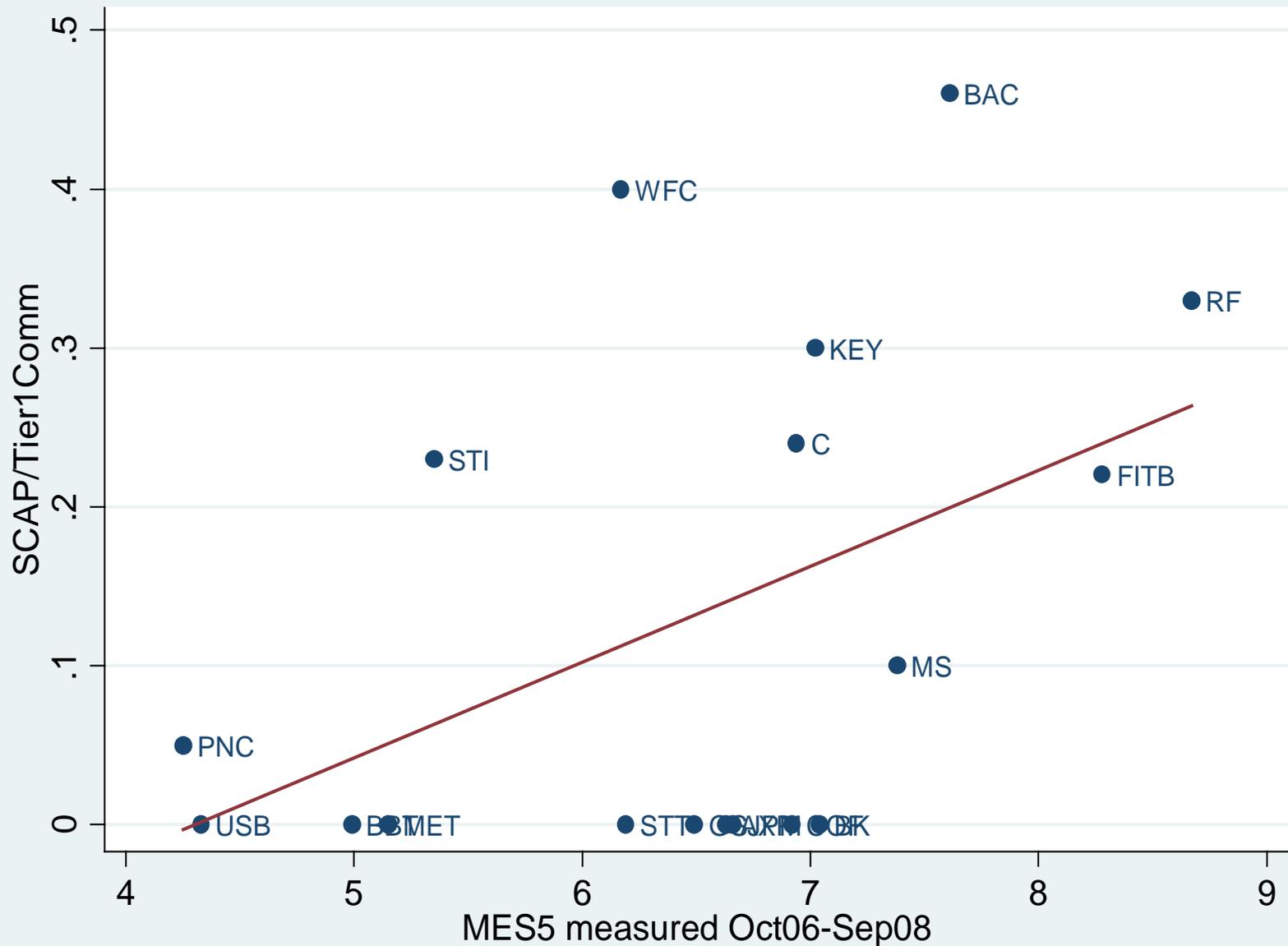
# Some Important Observations about MES

- Intuition: At a first-order approximation, it is about “beta”
  - Volatility of firm’s returns
  - Correlation of firm’s returns with the market
  - BOTH ARE POTENTIALLY IMPORTANT
- Scaling property:
  - If a firm divides itself up into  $n$  clones, does not affect system’s risk
  - MES is *per-unit* measure of systemic risk
- MES by itself, however, is not enough as starting leverage also affects distress likelihood and greater distress costs in the tail

# Test I: Stress test of Spring 2009

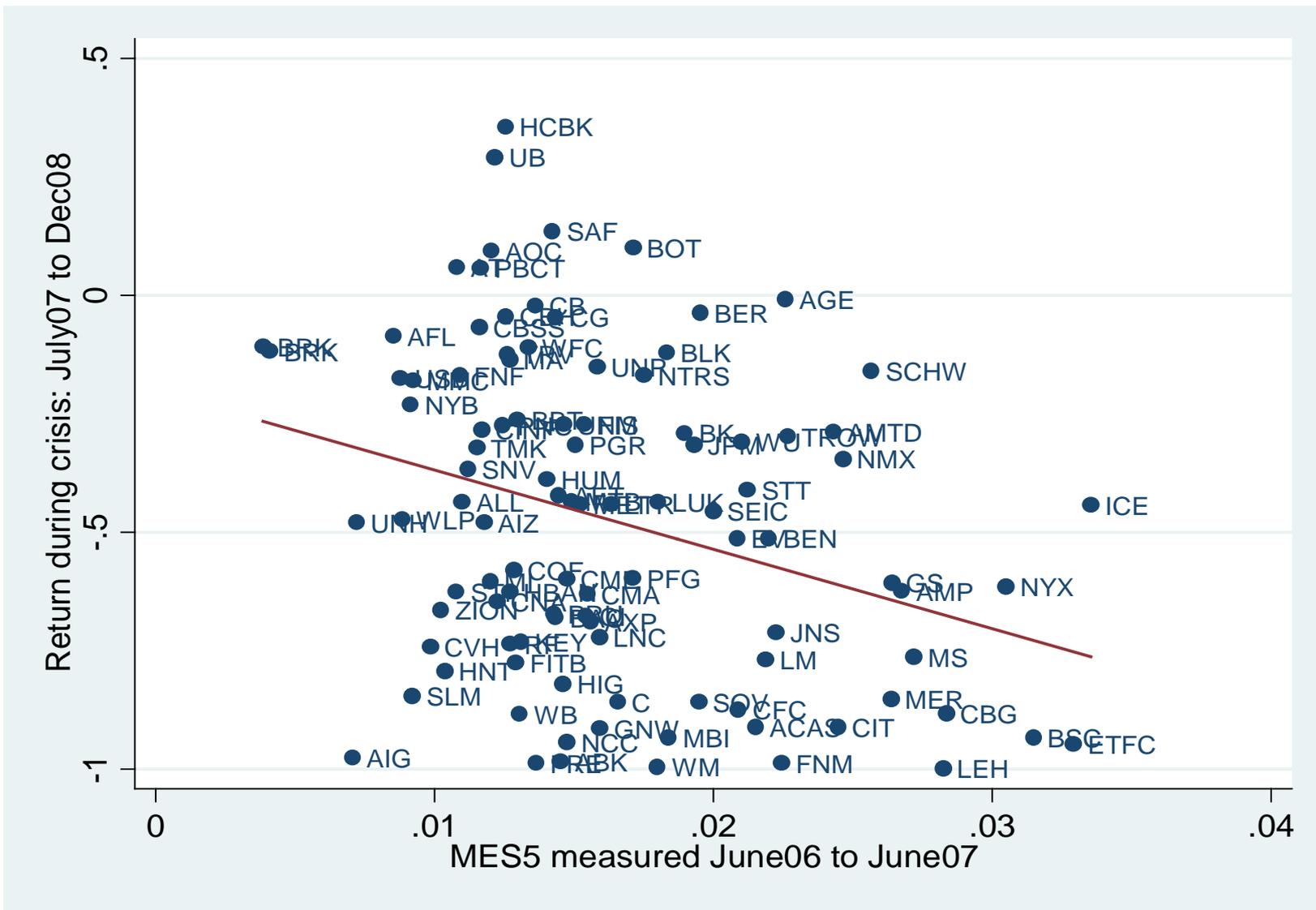
Panel A							
Bank Name	SCAP	Tier1	Tier1Comm	SCAP/Tier1	SCAP/Tier1Comm	MES	LVG
REGIONS FINANCIAL CORP							
NEW	2.5	12.1	7.6	20.66%	32.89%	14.8	44.42
BANK OF AMERICA CORP	33.9	173.2	75	19.57%	45.50%	15.05	50.38
WELLS FARGO & CO NEW	13.7	86.4	34	15.86%	40.41%	10.57	20.58
KEYCORP NEW	1.8	11.6	6	15.52%	30.00%	15.44	24.36
SUNTRUST BANKS INC	2.2	17.6	9.4	12.50%	23.40%	12.91	39.85
FIFTH THIRD BANCORP	1.1	11.9	4.9	9.24%	22.45%	14.39	67.16
CITIGROUP INC	5.5	118.8	23	4.63%	24.02%	14.98	126.7
MORGAN STANLEY DEAN							
WITTER & CO	1.8	47.2	18	3.81%	10.11%	15.17	25.39
P N C FINANCIAL SERVICES							
GRP INC	0.6	24.1	12	2.49%	5.13%	10.55	21.58
AMERICAN EXPRESS CO	0	10.1	10	0.00%	0.00%	9.75	7.8
B B & T CORP	0	13.4	7.8	0.00%	0.00%	9.57	14.78
BANK NEW YORK INC	0	15.4	11	0.00%	0.00%	11.09	6.46
CAPITAL ONE FINANCIAL CORP	0	16.8	12	0.00%	0.00%	10.52	33.06
GOLDMAN SACHS GROUP INC	0	55.9	34	0.00%	0.00%	9.97	18.94
JPMORGAN CHASE & CO	0	136.2	87	0.00%	0.00%	10.45	20.43
METLIFE INC	0	30.1	28	0.00%	0.00%	10.28	26.14
STATE STREET CORP	0	14.1	11	0.00%	0.00%	14.79	10.79
U S BANCORP DEL	0	24.4	12	0.00%	0.00%	8.54	10.53

# Stress tests: Predictive power of MES (equity)



# Test II 2007-08: Predictive power of MES

## (equity)



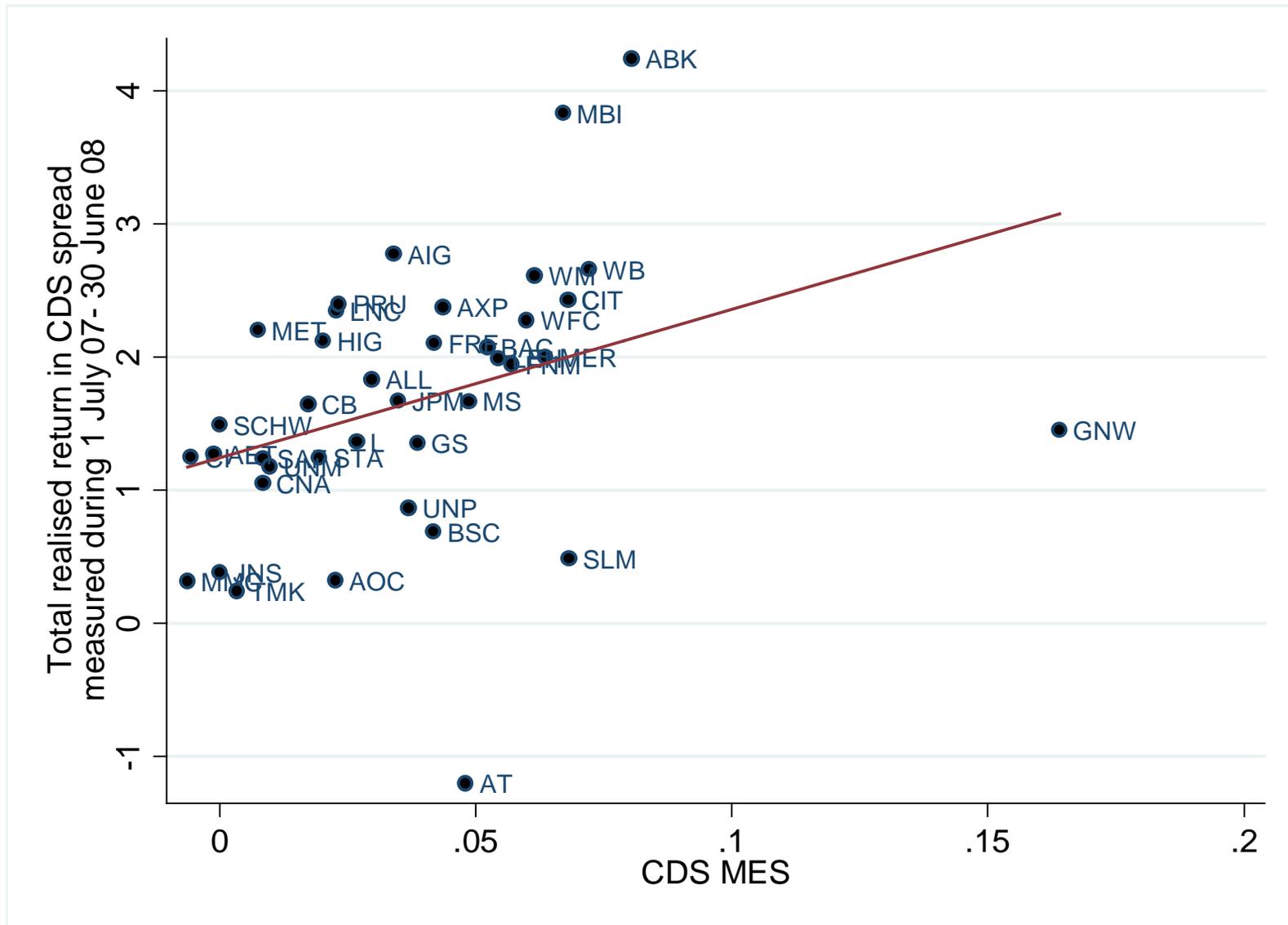


# Fitted (MES, LVG, Industry) rankings

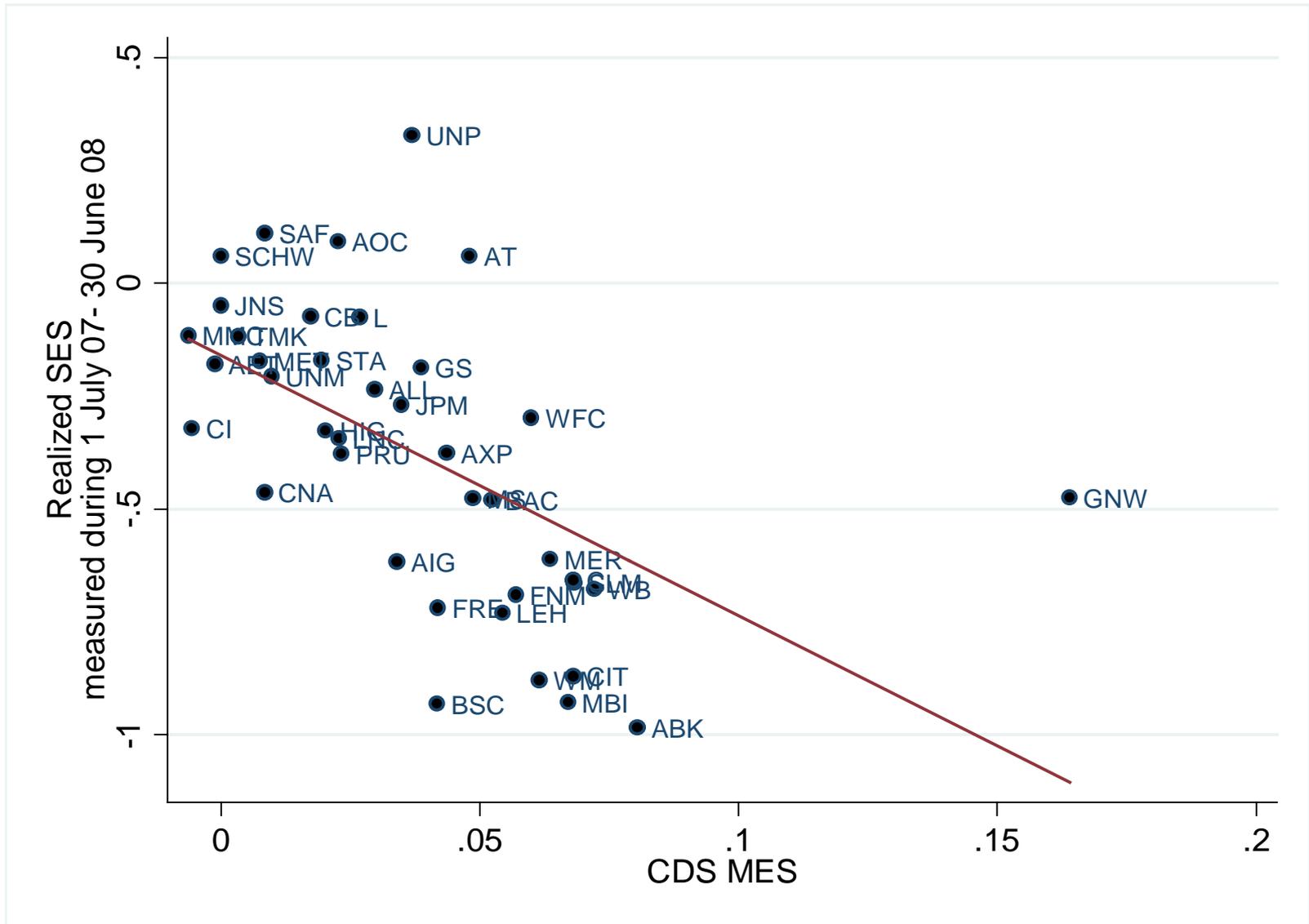
Name of Company	Realized SES	MES	Avg \$Loss(bln)	Avg Contribution	LVG	Fitted Rank	Assets (bln)	ME(bln)
INTERCONTINENTALEXCHANGE INC	-44.24%	3.36%	0.24	0.28%	1.12	16	2.55	10.40
E TRADE FINANCIAL CORP	-94.79%	3.29%	0.33	0.42%	7.24	21	62.98	9.39
BEAR STEARNS COMPANIES INC	-93.28%	3.15%	0.55	0.68%	25.62	1	423.30	16.66
N Y S E EURONEXT	-61.48%	3.05%	0.43	0.53%	1.43	19	16.93	19.44
C B RICHARD ELLIS GROUP INC	-88.16%	2.84%	0.20	0.25%	1.55	24	5.95	8.35
LEHMAN BROTHERS HOLDINGS INC	-99.82%	2.83%	1.08	1.26%	15.83	4	605.86	39.51
MORGAN STANLEY DEAN WITTER & CO	-76.21%	2.72%	2.09	2.51%	14.14	9	1199.99	88.40
AMERIPRISE FINANCIAL INC	-62.41%	2.68%	0.35	0.43%	7.72	7	108.13	14.95
GOLDMAN SACHS GROUP INC	-60.59%	2.64%	2.13	2.41%	11.25	15	943.20	88.54
MERRILL LYNCH & CO INC	-85.21%	2.64%	1.93	2.25%	15.32	5	1076.32	72.56
SCHWAB CHARLES CORP NEW	-15.95%	2.57%	0.59	0.66%	2.71	88	49.00	25.69
NYMEX HOLDINGS INC	-34.46%	2.47%	0.28	0.33%	1.23	98	3.53	11.57
C I T GROUP INC NEW	-91.08%	2.45%	0.26	0.32%	8.45	8	85.16	10.52
T D AMERITRADE HOLDING CORP	-28.75%	2.43%	0.24	0.30%	2.40	26	18.53	11.92
T ROWE PRICE GROUP INC	-29.83%	2.27%	0.27	0.32%	1.03	101	3.08	13.76
EDWARDS A G INC	-0.71%	2.26%	0.11	0.13%	1.46	100	5.24	6.43
FEDERAL NATIONAL MORTGAGE ASSN	-98.78%	2.25%	1.24	1.51%	14.00	3	857.80	63.57
JANUS CAP GROUP INC	-71.12%	2.23%	0.09	0.10%	1.34	35	3.76	5.16
FRANKLIN RESOURCES INC	-51.23%	2.20%	0.62	0.66%	1.08	40	9.62	33.07
LEGG MASON INC	-76.98%	2.19%	0.29	0.30%	1.25	38	10.08	12.97
AMERICAN CAPITAL STRATEGIES LTD	-91.08%	2.15%	0.15	0.17%	1.73	32	12.15	7.75
STATE STREET CORP	-41.07%	2.12%	0.46	0.52%	5.54	28	112.27	23.01
WESTERN UNION CO	-30.84%	2.10%	0.36	0.42%	1.34	83	5.33	16.09
COUNTRYWIDE FINANCIAL CORP	-87.46%	2.09%	0.48	0.57%	10.39	6	216.82	21.57

# Test III - 2007-08: Predictive power of MES

(cfs)



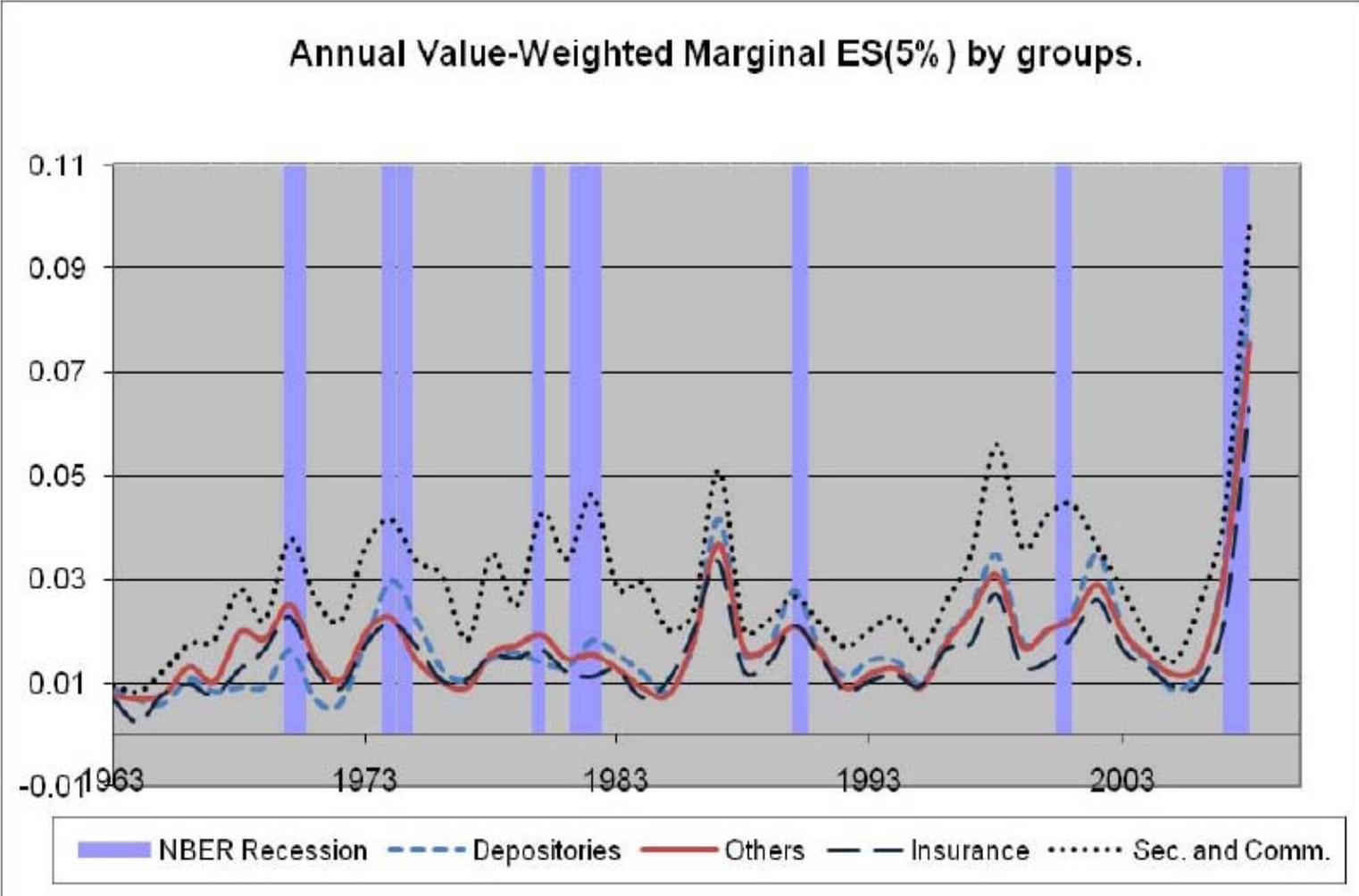
# 2007-08: Predictive power of MES (cds)



# CDS MES rankings

Name of company	Type of institution	CDS MES ranking	Realized CDS SES (July 07-June 08)	Realized CDS SES (July 07-Dec 08)	CDS MES
GENWORTH FINANCIAL INC	Insurance	1	145.38%	403.03%	16.40%
AMBAC FINANCIAL GROUP INC	Insurance	2	424.10%	389.12%	8.05%
WACHOVIA CORP 2ND NEW	Depository	3	266.11%	219.94%	7.21%
S L M CORP	Other	4	48.88%	113.08%	6.82%
CITIGROUP INC	Depository	5	243.16%	278.96%	6.80%
C I T GROUP INC NEW	Other	6	243.16%	278.96%	6.80%
M B I A INC	Insurance	7	383.11%	303.44%	6.71%
MERRILL LYNCH & CO INC	Broker-Dealer	8	200.27%	160.20%	6.37%
WASHINGTON MUTUAL INC	Depository	9	261.19%	436.42%	6.15%
WELLS FARGO & CO NEW	Depository	10	227.79%	233.43%	6.00%
FEDERAL NATIONAL MORTGAGE ASSN	Other	11	194.89%	78.69%	5.70%
LEHMAN BROTHERS HOLDINGS INC	Broker-Dealer	12	199.25%	282.25%	5.44%
BANK OF AMERICA CORP	Depository	13	207.86%	215.70%	5.23%
MORGAN STANLEY DEAN WITTER & CO	Broker-Dealer	14	166.88%	248.96%	4.86%
ALLTEL CORP	Other	15	-119.93%	-103.25%	4.80%
AMERICAN EXPRESS CO	Other	16	237.53%	293.40%	4.36%
FEDERAL HOME LOAN MORTGAGE CORP	Other	17	210.58%	94.57%	4.20%
BEAR STEARNS COMPANIES INC	Broker-Dealer	18	68.72%	84.96%	4.18%
GOLDMAN SACHS GROUP INC	Broker-Dealer	19	135.50%	213.68%	3.87%
UNION PACIFIC CORP	Other	20	86.69%	123.56%	3.69%
JPMORGAN CHASE & CO	Depository	21	166.95%	182.80%	3.49%
AMERICAN INTERNATIONAL GROUP INC	Insurance	22	277.42%	369.20%	3.40%

# Time-series determinants of systemic risk



# Conclusion

- Economic model of systemic risk gives rise to SES
- Systemic expected shortfall (SES)
  - Measures each financial institution's *contribution* to systemic crisis
  - Can be based on public information and well-informed investors
  - Tied to tail-dependence with the economy as a whole and leverage
  - An SES tax/insurance incentivizes banks to contribute less to crisis
- Empirically (Historically)
  - Ex ante SES predicts ex post crisis losses
  - We analyze its cross-sectional properties
  - In different periods, different markets, predicts “worst” systemic firms

# NYU-STERN VLAB'S RISK PAGE

- Directed by Rob Engle
- We have introduced a page providing estimates of risk for the 102 largest US Financial firms.
- *NYU Stern Systemic Risk Ranking*: Risk is estimated both for the firm itself and for its contribution to risk in the system.
- This is updated weekly/daily to allow regulators, practitioners and academics to see early warnings of system risks.
- Extend to European and Australasian firms: Collaboration with Universite de Lausanne and Australian Graduate School in Sydney