Measuring Systemic Risk

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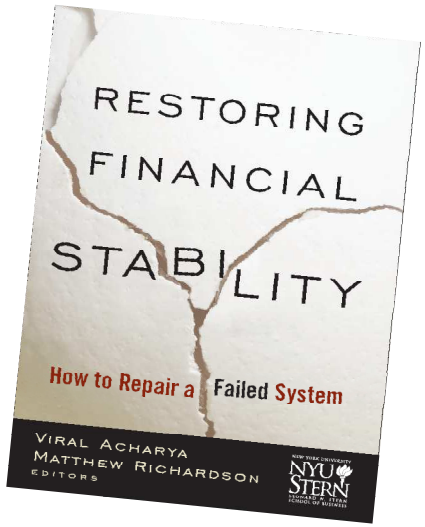
Motivation

- Systemic risk can be defined as:
  - When the distress of financial institutions has externalities that disrupt the real economy

- The challenge is:
  - To use economic theory to find a measure of systemic risk
  - That is useful in managing the systemic risk
  - And asses its empirical success



Systemic Risk vs. Total Risk

- Traditional regulation of financial sector: Firm-level risk management
  - Goal: Limit risk of collapse of each bank seen in isolation
  - Requirement: Detailed knowledge of activities inside the firm

- We advocate in addition: Systemic approach
  - Goal: Limit risk of collapse of the system
  - Requirement: Understand risks and externalities across firms

Main Results: Theory

- Each financial institution's *contribution* to systemic crisis can measured as its systemic expected shortfall (SES):
  - SES = expected capital shortfall, conditional on a future crisis

- A financial institution's SES increases in:
  - its own leverage and risk
  - the system's leverage and risk
  - the tail dependence between the institution and the system
  - the severity of the externality from a systemic crisis

- Managing systemic risk:
  - Incentives can be aligned by imposing a tax or mandatory insurance based SES, adjusted for the cost of capital

Main Results: Empirical

- Empirical methodology:
  - we provide a very simple way of estimating SES

- Institutions' ex-ante SESs
  - predict their losses during the subprime crisis
  - with more explanatory power than measures of idiosyncratic risk

- SES in the cross-section:
  - higher for securities dealers and brokers – every year 1963-2008
  - higher for larger institutions that tend to be more levered

- SES in the time series:
  - higher during periods of macroeconomic stress, especially for securities dealers and brokers

Comparison to Other Measures of Systemic Risk: I

- Conventional wisdom (e.g., most other papers):

  Systemic risk = what would happen if bank X failed?

  – E.g., what crucial infrastructure is operated by bank X? (triparty repo, payment system, etc.)

- Our view:

  Systemic risk = too little aggregate capital in the financial system

  – Too little capital inhibits intermediation and credit provision

  – A failed bank with crucial infrastructure **can be taken over if there is enough capital in the system**

  – Example: Lehman vs. Barings

Comparison to Other Measures of Systemic Risk: II

- How to regulate based on the systemic risk measure?
  - ☑ We show that taxing based on SES implies that banks internalize externalities
  - ☒ Taxing based on "crucial infrastructure" does not work since infrastructure crucial no matter how well capitalized

- In case of tax, how to translate into right units? E.g., how to scale wrt. size of institution?
  - ☑ We show that SES is scaled in meaningful units

  Example, consider these three firms:

  Firm A = Citibank

  Firm B = 1 share of Citibank

  Firm C = 1 share of Citibank + $1 Trillion worth of Treasuries

  - ☑ We show that SES taxes each case consistently
  - ☒ Other measure of systemic risk (e.g. based on "connections") get this wrong
    - ☒ Same tax in dollars for A and B, or
    - ☒ Much higher tax for C than B

- How to handle if institutions merge or split up?
  - ☑ We show that SES handles this immediately

Related Literature

- Incentive to take correlated risk
  - Acharya (2001, 2009), Acharya and Yorulmazer (2007)
- Externalities
  - Liquidity spirals (Brunnermeier and Pedersen (2009), Pedersen (2009))
  - Bank runs (Diamond and Dybvig (1983), Allen and Gale)
  - Debt market freezes (Acharya, Gale, and Yorulmazer (08), He and Xiong (2009))
  - Tightening risk management (Garleanu and Pedersen (2007))
- Contingent claims analysis
  - Lehar (2005), Gray, Merton, and Bodie (2008), Gray and Jobst (2009)
- Statistical measures:
  - Huang, Zhou, and Zhu (2009), Adrian and Brunnermeier (2009)
- Other proposals
  - Kashyap, Rajan, and Stein (2008), Wall (1989), Doherty and Harrington (1997), Flannery (2005), squam lake, NYU book (chapter 13), …

Managing Risk Within and Across Banks

- Standard measures of risk within banks:
  - Value at risk: $Pr\,(\,R \leq -\,VaR\,) = \alpha$
  - Expected shortfall: $ES = -\,E(\,R \mid R \leq -\,VaR\,)$
- Banks consists of several units i=1,…, I of size y_i :
  - Return of bank is: $R = \sum_i y_i\, r_i$
  - Expected shortfall: $ES = -\sum_i y_i\, E(\,r_i \mid R \leq -\,VaR\,)$
- Risk <u>contribution</u> of unit i: Marginal expected shortfall (MES)

$$MES^i := \frac{\partial ES}{\partial y_i} = -E\left[r_i \mid R \leq -VaR\right]$$

- We can re-interpret this as each bank's contributions to the risk of overall banking system: The loss of bank i when overall banking is in trouble
- Question: what is the <u>economic rationale</u> for looking at these measures?

Economic Model

- "Banks" $b=1,\ldots,B$ choose at time 0
  - initial capital w_0
  - exposures $x=(x_1,\ldots,x_S)$ to all assets, which yield returns $r=(r_1,\ldots,r_S)$

- Maximize their objective function

$$E_0\left(u(w_1^b \cdot 1_{(w_1^b>0)})\right) - c(w_0^b + t^b - \bar{w}_0^b)$$

- Given
  - cost of raising capital c
  - tax t^b
  - the evolution of capital

$$w_1^b = w_0^b + r \cdot x^b$$

Economic Model, continued

- Regulator cares about
  - aggregate outcome, including
  - externality, proportional to *e*
    - times the aggregate bank capital shortfall below cutoff
  - insured default losses with the government cost of capital c^g

$$E_0 \sum_{b=1}^{B} \{u(w_1^b \cdot 1_{(w_1^b>0)}) - c(w_0^b + t^b - \bar{w}_0^b) + c^g (w_1^b \cdot 1_{(w_1^b<0)} + t^b)\} + eE_0 \left[(W_1 - \bar{W}) \cdot 1_{(w_1<\bar{w})} \right]$$

Economic Model - Results

- Without government intervention,
  - Banks choose leverage level and exposures $x=(x_1,\ldots,x_S)$ with a risk level higher than socially optimal.

- To correct this, government can charge a tax based on two components:

$$ES^i \equiv -E\left[w_1^i \,\middle|\, w_1^i < 0\right] \qquad SES^i \equiv E\left[za^i - w_1^i \,\middle|\, W_1 < zA\right]$$

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

- In our model, 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 under-capitalization 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 *($Pr[W_1 < W^*]$)*
  - the bank takes a larger exposure (x_s) in an asset *s* that experiences loses when other banks are in trouble
  - the bank is more leveraged (w_0)

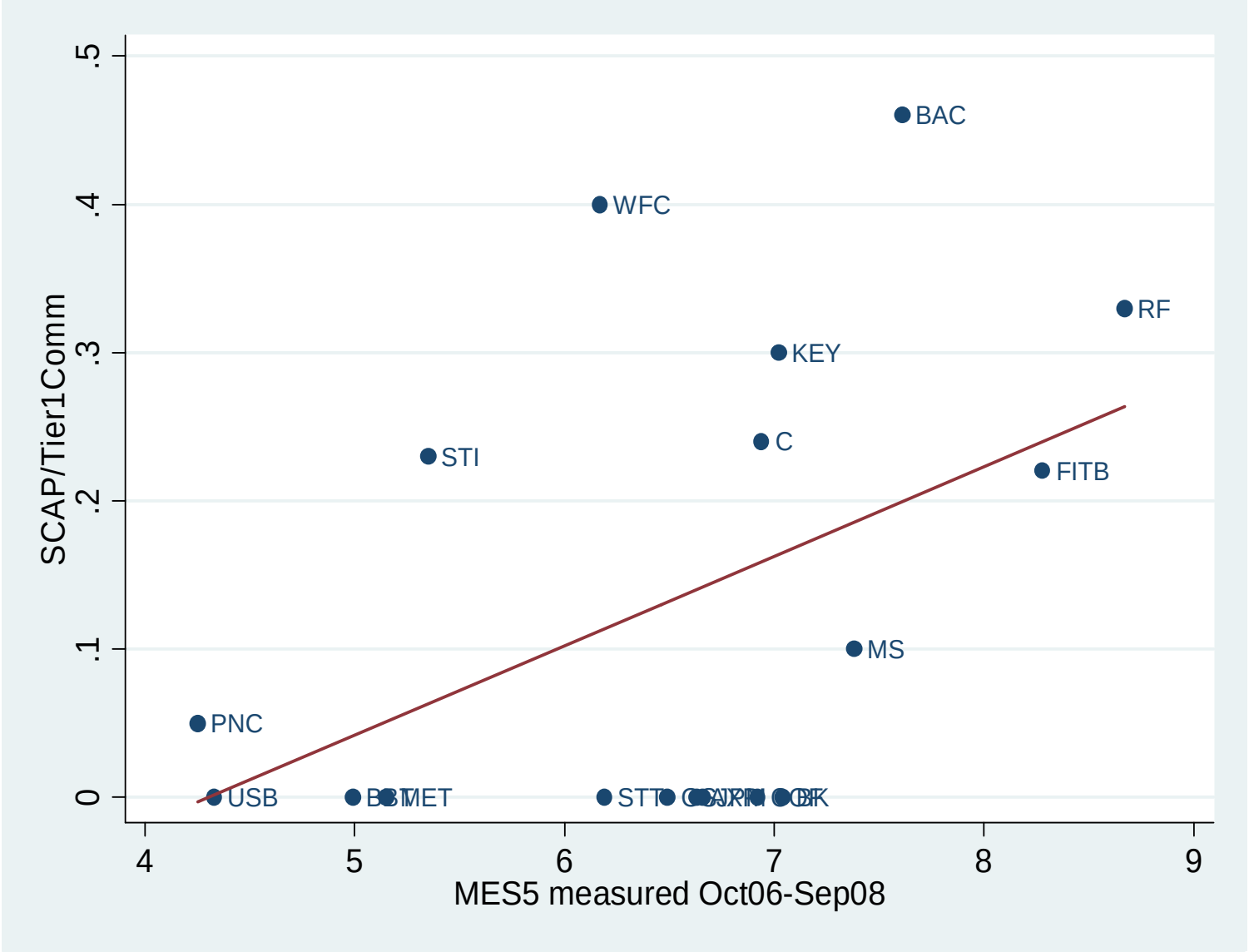
- In our empirical work, we focus on the cross-sectional part of SES, taking as given (i) the size of externality or the level of tax; (ii) the likelihood of systemic crisis, the time-series part

Empirical Methodology

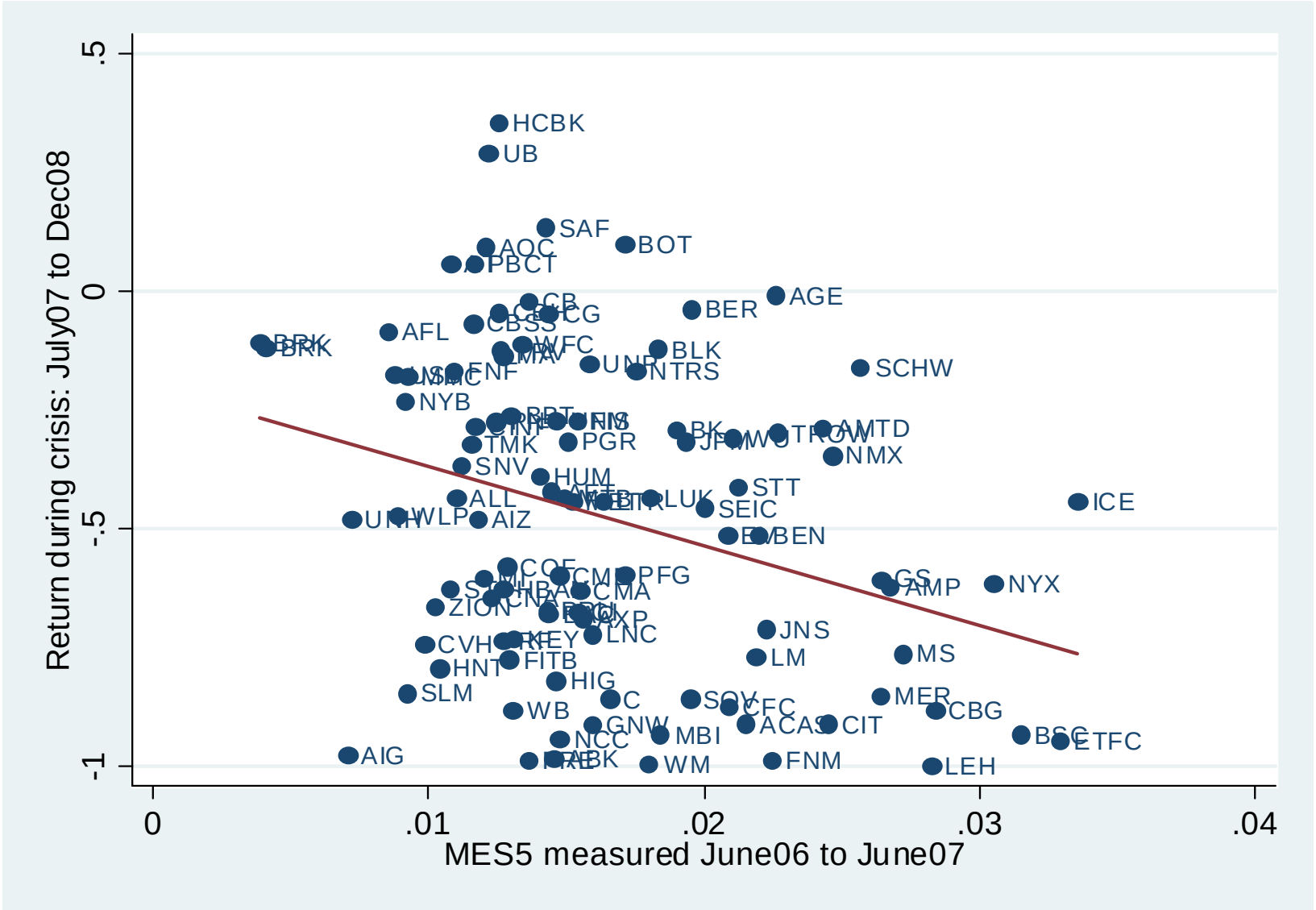
- MES:
  - Very simple non-parametric estimation:
    - find the 5% worst days for the market
    - compute each institution's return on these days
  - Parametric
- SES:
  - Consider both MES and Leverage

- Data: CRSP and COMPUSTAT

MES Predicts the Stress Tests



MES Predicts Realized Equity Returns During the Crisis 2007-08



NYU Stern VLAB: Real-Time Systemic Risk Rankings

- 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

Systemic Risk Rankings for 2011-04-20 **(MES is equity loss for a 2% daily market decline)**

Institution	SRISK%	RNK	SRISK ($ m)	MES	Beta	Cor	Vol	Lvg	MV
Bank Of America	20.7%	1	122,668	3.57	1.19	0.55	27.4	17.46	124186.6
JP Morgan Chase	16.3%	2	96,512	3.35	1.35	0.70	24.3	12.37	177505.2
Citigroup	12.9%	3	76,697	2.59	0.91	0.58	19.8	14.33	133071.9
Morgan Stanley	7.8%	4	46,069	3.56	1.36	0.70	24.4	19.44	40248.3
MetLife	5.9%	5	35,043	3.01	1.16	0.63	23.0	15.74	46258.0
Wells Fargo	5.2%	6	31,170	3.27	1.19	0.61	24.7	8.31	151878.7
Goldman Sachs	5.1%	7	30,370	2.99	1.12	0.58	24.4	10.74	85493.1
Prudential Financial	4.9%	8	29,048	3.21	1.43	0.72	25.0	18.12	29612.0
American Internation Group	4.8%	9	28,707	3.80	1.07	0.46	29.4	10.80	58123.8
Hartford Financial Services	3.1%	10	18,649	2.96	1.20	0.55	27.2	25.66	12087.9

Did Our Method Predict Well?

- Eight out of top ten failed or nearly failed in the crisis
  - Morgan Stanley, Merrill Lynch, Goldman Sachs, Fannie Mae, Freddie Mac, Citigroup, Lehman Bros, J.P. Morgan Chase, Bear Stearns, Met Life.

Implementation: Our Policy Proposal

- SES signals institutions likely to contribute to aggregate crises

- Three ways to limit systemic risk using our measure

1. **Systemic Capital Requirement**
   - Capital requirement proportional to estimated systemic risk

2. **Systemic Fees** (FDIC-style)
   - Fees proportional to estimated systemic risk
   - Create systemic fund

3. **Private/public systemic insurance**

Our Systemic Insurance Proposal

- Compulsory insurance against own losses during crisis
  - Payment goes to systemic fund, not the bank itself
  - Insurance from government, prices from the market
    - Say 5 cents from private; 95 cents from the government
    - Analogy to terrorism reinsurance by the government (TRIA, 2002)

- Advantages of private/public proposal
  - A market-based estimate of the contribution to crises and externalities
  - Private sector has incentives to be forward looking
  - Gives bank an incentive to be less systemic and more transparent:
    - to lower their insurance payments

Conclusion: Systemic Risk

- Economic model of systemic risk gives rise to SES

- Systemic expected shortfall (SES)
  - Measures each financial institution's *contribution* to systemic crisis
  - Increases in: leverage, risk, comovement, tail dependence
  - An SES tax/insurance incentivizes banks to contribute less to crisis

- Empirically
  - Ex ante SES predicts ex post crisis loses
  - We analyze its cross-sectional and time series properties