Measuring Systemic Risk☆

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Systemic risk VS. Systematic Risk

- Systemic risk can be described as a risk caused by an event at the firm level that is severe enough to cause instability in the financial system.

- Systematic risk is sometimes plainly called market risk, the risk inherent in the aggregate market that cannot be solved by diversification. A portfolio's systematic risk is usually measured by CAPM's beta.

Motivation

- Widespread failures and losses of financial institutions can impose an externality on the rest of the economy.
- However, current financial regulations, such as Basel capital requirements, are not sufficiently focused on systemic risk.

- The goal of this paper is to propose and apply a useful and model-based measure of systemic risk.

We first develop a framework for formalizing and measuring systemic risk and derive an optimal policy for managing systemic risk.

Our ex ante measure of systemic risk can predict the ex post losses during the financial crisis of 2007–2009 as well as the regulators' "stress test" in the spring of 2009.

Literature Review

- One strand of recent papers on systemic risk takes a structural approach using contingent claims analysis of the financial institutions' assets (Lehar 2005; Gray, Merton, and Bodie 2008; Gray and Jobst Forthcoming).

  Disadvantage: strong assumptions about the liability structure.

- As an alternative, some researchers have used market data to back out reduced-form measures of systemic risk.

  Huang, Zhou, and Zhu (2009) use data on credit default swaps (CDSs) of financial firms and stock return correlations across these firms to estimate expected credit losses above a given share of the financial sector's total liabilities.

  Adrian and Brunnermeier (Forthcoming) measure the financial sector's VaR given that a bank has had a VaR loss, which they denote *CoVaR*, using quantile regressions. Their measure uses data on market equity and book value of the debt to construct the underlying asset.

Contribution

- We “bridge the gap” between the structural and reduced-form approaches by considering a simple economic model that gives rise to a measure of systemic risk contribution that depends on observable data and statistical techniques that are related to those in the reduced-form approaches and easily applicable by regulators.
- Our theoretical model potentially also provides an economic foundation for the systemic risk measures proposed by de Jonghe (2010), Goodhart and Segoviano (2009) and Huang, Zhou, and Zhu (2009).

Contribution

- *CoVaR* measure is conceptually different from our measure in that it examines the system's stress conditional on an individual firm's stress, whereas we examine a financial firm's stress conditional on systemic stress.
- As a way of ranking the systemic risk of firms, our measure has the advantage that the conditioning set is held constant for all firms (i.e., the existence of a financial crisis), whereas this is not the case with *CoVaR* (i.e., conditional on a given firm's stress, which varies cross-sectionally). This can lead to some undesirable properties in the rankings.

Article contents

1. Systemic Risk in an Economic Model

- 1.1 Definitions and preliminary analysis

  2 standard measures of firm-level risk

- Value-at-risk(VaR)

  VaR is the most that the bank loses with confidence 1-α:

$$Pr(R < -VaR_{\alpha}) = \alpha.$$

- Expected shortfall(ES)

  ES is the expected loss conditional on the loss being greater than the VaR:

$$ES_{\alpha} = -E[R|R \leq -VaR_{\alpha}]$$

  We focus on ES.

1. Systemic Risk in an Economic Model

- 1.1 Definitions and preliminary analysis

$$ES_{\alpha} = -E[R|R \leq -VaR_{\alpha}]$$

Decompose the bank's return R into the sum of each group's return r_i, that is, $R = \sum_i y_i r_i$, where y_i is the weight of group i in the portfolio.

$$ES_{\alpha} = -\sum_i y_i E[r_i|R \leq -VaR_{\alpha}]$$

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

MES^i is group i's marginal expected shortfall. It measures how group i's risk taking adds to the bank's overall risk.

1. Systemic Risk in an Economic Model

- 1.2 Bank's incentives
- The economy has N financial firms, which we denote as banks, indexed by $i = 1,..N$ and two time periods $t=0,1$.
- Each bank i chooses how much x_j^i to invest in each of the available assets $j = 1,..J$, acquiring total asset a^i of

$$a^i = \sum_{j=1}^{J} x_j^i$$

- Budget constraint

$$w_0^i + b^i = a^i$$

w_0^i: equity; b^i:debt.

1. Systemic Risk in an Economic Model

- 1.2 Bank's incentives
- At time 1, asset *j* pays off r_j^i per dollar invested for bank i, then the pre-distress income is:

$$\hat{y}^i = \sum_{j=1}^{J} r_j^i x_j^i$$

- The total market value of the bank asset at time 1 is:

$$y^i = \hat{y}^i - \phi^i$$

- ϕ^i captures the costs of financial distress:

$$\phi^i = \Phi(\hat{y}^i, f^i)$$

It depends on the market value of bank assets $\hat{y}^i$ and on the face value f^i of outstanding debt.

1. Systemic Risk in an Economic Model

- 1.2 Bank's incentives
- We assume that a fraction α^i of the debt is guaranteed by the government, then the face value of the debt is:

$$b^i = \alpha^i f^i + \left(1 - \alpha^i\right) E\left[\min\left(f^i, y^i\right)\right]$$

- The net worth of the bank, w_1^i, at time 1 is:

$$w_1^i = \hat{y}^i - \phi^i - f^i$$

- The owner of the bank equity is protected by limited liability so it receives $1_{[w_1^i > 0]} w_1^i$ and, hence, solves the following program:

$$\max_{w_0^i, b^i, \left\{x_j^i\right\}_j} \; c \times \left(\bar{w}_0^i - w_0^i - \tau^i\right) + E\left(u\left(1_{\left[w_1^i > 0\right]} \times w_1^i\right)\right)$$

1. Systemic Risk in an Economic Model

- 1.3 Welfare, externalities, and the planner's problem
- The regulator wants to maximize the welfare function $P^1 + P^2 + P^3$.
- The first part is the sum of the utilities of all the bank owners:

$$P^1 = \sum_{i=1}^{N} c \times \left(\bar{w}_0^i - w_0^i - \tau^i\right) + E\left[\sum_{i=1}^{N} u^i \left(1_{\left[w_1^i > 0\right]} \times w_1^i\right)\right]$$

- The second part is the expected cost of the debt insurance program:

$$P^2 = E\left[g \sum_{i=1}^{N} 1_{\left[w_1^i < 0\right]} \alpha^i w_1^i\right]$$

Parameter g captures administrative costs and costs of tax collection.

1. Systemic Risk in an Economic Model

- 1.3 Welfare, externalities, and the planner's problem
- The third part of the welfare function is the main focus of our analysis since

$$P^3 = E\left[e \times 1_{[W_1 < zA]} \times (zA - W_1)\right]$$

- It captures the externality of financial crisis.

  $A = \sum_{i=1}^{N} a^i$: the aggregate assets in the system.

  $W_1 = \sum_{i=1}^{N} w^i$: the aggregate banking capital at time 1.

  Parameter e measures the severity of the externality imposed on the economy when the financial sector is in distress.

1. Systemic Risk in an Economic Model

- 1.4 Optimal taxation
- The planner's problem is to choose a tax system τ^i that maximizes the welfare function $P^1 + P^2 + P^3$
- Subject to the same technological constraints as the private agents.
- This ex-ante (time 0) regulation is relevant for the systemic risk debate, and this is the one we focus on.
- We assume $\sum_i \tau^i = \bar{\tau}$.

Proposition 1. The efficient outcome is obtained by a tax

$$\tau^i = \frac{\alpha^i g}{c} \times Pr(w_1^i < 0) \times ES^i + \frac{e}{c} \times Pr(W_1 < zA) \times SES^i + \tau_0$$

1. Systemic Risk in an Economic Model

Proposition 1. The efficient outcome is obtained by a tax

$$\tau^i = \frac{\alpha^i g}{c} \times Pr(w_1^i < 0) \times ES^i + \frac{e}{c} \times Pr(W_1 < zA) \times SES^i + \tau_0$$

- Our optimal taxation policy depends on institution-specific expected shortfall:

$$ES^i \equiv -E[w_1^i | w_1^i < 0]$$

- It also depends on systemic expected shortfall:

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

A bank that has positive SES is expected to contribute to a future systemic crisis in the sense of failing to meet this requirement during a future crisis.

SES is the key measure of each bank's expected contribution to a systemic crisis.

2.Measuring Systemic Risk

Proposition 1. The efficient outcome is obtained by a tax

$$\tau^i = \frac{\alpha^i g}{c} \times Pr(w_1^i < 0) \times ES^i + \frac{e}{c} \times Pr(W_1 < zA) \times SES^i + \tau_0$$

An institution-risk component, that is, the expected loss on its guaranteed liabilities.

A systemic-risk component, namely, the expected systemic costs in a crisis times the financial institution's percentage contribution to this undercapitalization.

2.Measuring Systemic Risk

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

- The systemic events in our model ($W_1 < zA$) as extreme tail events that happen once or twice a decade (or less), say.

- We observe more “normal” tail events.
- Define these events as the worst 5% market outcomes at daily frequency, which we denote by $I_{5\%}$.
- Define a marginal expected shortfall (MES):

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

2.Measuring Systemic Risk

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

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

- Use extreme value theory to establish a connection between the moderately bad and the extreme tail, we have

$$\frac{SES^i}{w_0^i} = \frac{za^i - w_0^i}{w_0^i} + kMES_{5\%}^i + \Delta^i$$

where $\Delta^i \equiv \frac{E[\phi^i | W_1 < zA] - k \times E[\phi^i | I_{5\%}]}{w_0^i} - \frac{(k-1)(f^i - b^i)}{w_0^i}$.

- We expect *MES* and leverage to be predictors of *SES*.

3.Empirical Analysis of the Crisis of 2007-2009

- 3.1 The stress test: Supervisory Capital Assessment Program
- In late February 2009, the government announced a series of stress tests were to be performed on the 19 largest banks over a two-month period, known as SCAP.
- Goal: provide a consistent assessment of the capital held by the banks.
- This stress test is in the spirit of SES since it aims at estimating each bank's capital shortfall in a common potential crisis.
- Tier 1 capital: core capital including common shares, preferred shares and deferred tax assets.

3.Empirical Analysis of the Crisis of 2007-2009

- 3.1 The stress test: Supervisory Capital Assessment Program
- MES is marginal expected shortfall of a stock given that the market return is below its 5th percentile.

$$MES^b_{5\%} = \frac{1}{\#days}\sum_{t:\, system\ is\ in\ its\ 5\%\ tail} R^b_t$$

- Leverage (LVG) is measured as quasi-market value of assets divided by market value of equity.

$$LVG^b = \frac{book\ assets - book\ equity + market\ equity}{market\ value\ of\ equity}$$

- Data Source: Center for Research in Security Prices (CRSP) and CRSP-Compustat merged dataset.

Table 1
Banks included in the stress test, descriptive statistics

Panel A

Bank Name	SCAP	Tier1	Tier1 Comm	SCAP/ Tier1	SCAP/Tier1 Comm	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

Panel B: Correlation matrix

	SCAP/Tier1	SCAP/Tier1Comm	MES	LVG
SCAP/Tier1	100.00%			
SCAP/Tier1Comm	95.42%	100.00%		
MES	59.48%	61.47%	100.00%	
LVG	31.58%	48.20%	53.70%	100.00%

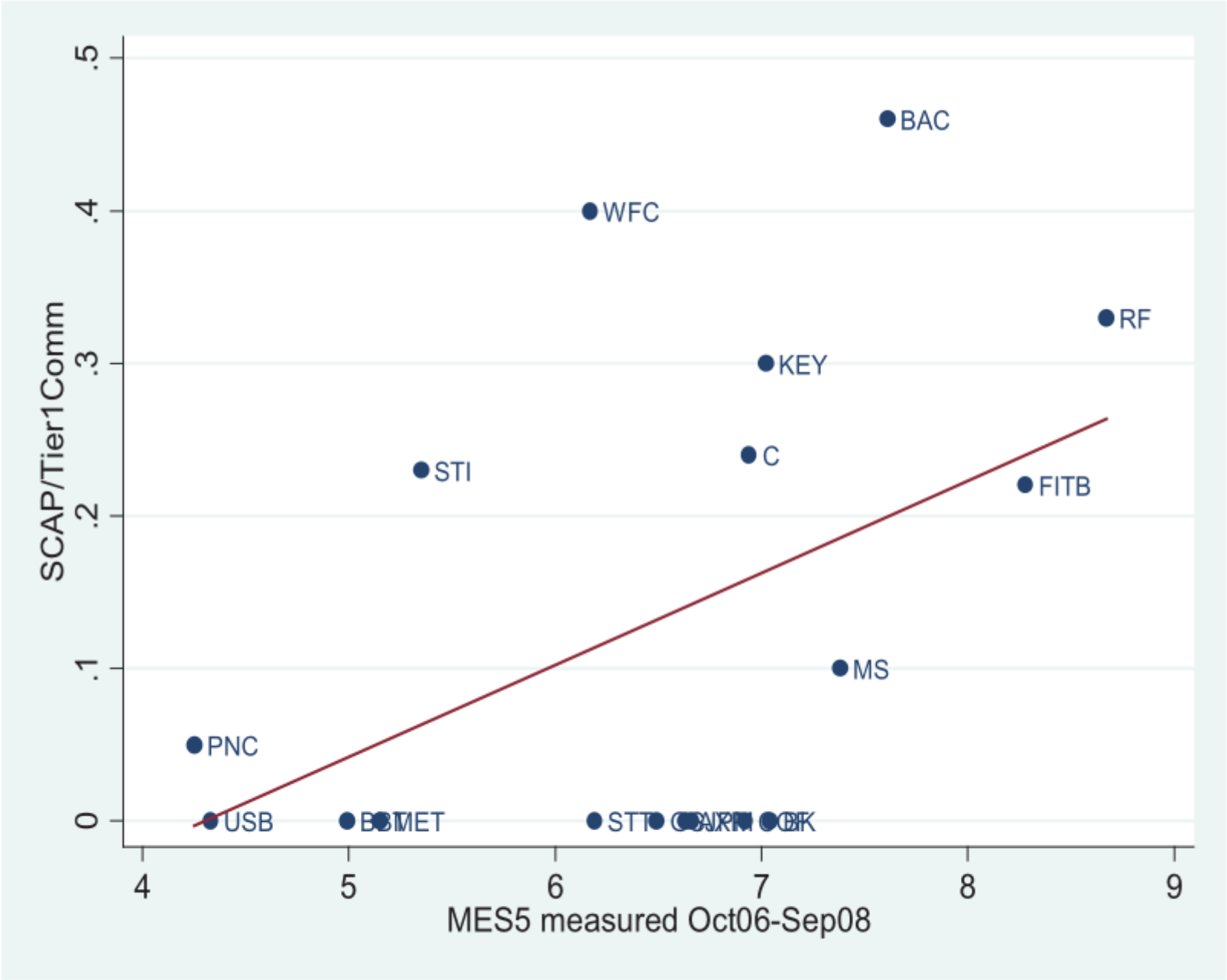

Figure 1
MES predicts the stress tests

Table 2
OLS regression and probit regression analyses

Panel A: Dependent variable is SCAP Shortfall/Tier1

	April 2008–March 2009						October 2007–September 2008					
	OLS			Probit			OLS			Probit		
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
Intercept	−17.29	3.14	−17.33	−5.44	−2.43	−6.04	−13.46	3.94	−14.19	−2.4	−0.95	−2.03
	(−2.2)	(1.16)	(−2.00)	(−2.72)	(−2.26)	(−2.24)	(−1.50)	(1.12)	(−1.50)	(−1.37)	(−1.40)	(−1.14)
MES	1.91		1.91	0.45		0.34	3		3.29	0.37		0.21
	(3.00)		(2.46)	(2.72)		(1.65)	(2.19)		(2.04)	(1.40)		(0.67)
LVG		0.09	−0.001		0.10	0.09		0.15	−0.09		0.08	0.06
		(1.35)	(−0.01)		(2.16)	(1.61)		(0.66)	(−0.37)		(1.50)	(1.05)
Adj. R^2	32.03%	4.65%	27.5%	40.68%	45.09%	53.22%	18.27%	−3.46%	13.61%	11.06%	15.17%	17.3%
No. obs	18	18	18	18	18	18	18	18	18	18	18	18

Panel B: Dependent variable is SCAP Shortfall/Tier1Comm

	April 2008-March 2009			October 2007-September 2008		
	OLS			OLS		
	(I)	(II)	(III)	(VII)	(VIII)	(IX)
Intercept	−36.24	4.41	−30.86	−25.72	9.02	27.13
	(−2.25)	(0.85)	(−1.79)	(−1.37)	(1.24)	(−1.37)
	4.05		3.29	6.00		6.57
	(3.12)		(2.13)	(2.09)		(1.94)
		0.27	0.12		0.31	−0.17
		(2.20)	(0.90)		(0.64)	(−0.34)
Adj. R^2	33.19%	18.44%	33.17%	16.57%	−3.56%	11.69%
No. obs	18	18	18	18	18	18

3.Empirical Analysis of the Crisis of 2007-2009

- 3.2 The financial crisis: July 2007 to December 2008
- We next consider how MES and leverage estimated using data from the year prior to the crisis (June 2006 through June 2007) explain the cross-sectional variation in equity performance Realized SES during the crisis (July 2007 through December 2008).
- *Realized SES*: the ex-post return of financial firms during the crisis.

MES ranking	Name of company	Realized SES	MES
1.	INTERCONTINENTAL EXCHANGE INC	−44.24%	3.36%
2.	E TRADE FINANCIAL CORP	−94.79%	3.29%
3.	BEAR STEARNS COMPANIES INC	−93.28%	3.15%
4.	N Y S E EURONEXT	−61.48%	3.05%
5.	C B RICHARD ELLIS GROUP INC	−88.16%	2.84%
6.	LEHMAN BROTHERS HOLDINGS INC	−99.82%	2.83%
7.	MORGAN STANLEY DEAN WITTER & CO	−76.21%	2.72%
8.	AMERIPRISE FINANCIAL INC	−62.41%	2.68%
9.	GOLDMAN SACHS GROUP INC	−60.59%	2.64%
10.	MERRILL LYNCH & CO INC	−85.21%	2.64%
11.	SCHWAB CHARLES CORP NEW	−15.95%	2.57%
12.	NYMEX HOLDINGS INC	−34.46%	2.47%
13.	C I T GROUP INC NEW	−91.08%	2.45%
14.	T D AMERITRADE HOLDING CORP	−28.75%	2.43%
15.	T ROWE PRICE GROUP INC	−29.83%	2.27%
16.	EDWARDS A G INC	−0.71%	2.26%
17.	FEDERAL NATIONAL MORTGAGE ASSN	−98.78%	2.25%
18.	JANUS CAP GROUP INC	−71.12%	2.23%
19.	FRANKLIN RESOURCES INC	−51.23%	2.20%
20.	LEGG MASON INC	−76.98%	2.19%
21.	AMERICAN CAPITAL STRATEGIES LTD	−91.08%	2.15%
22.	STATE STREET CORP	−41.07%	2.12%
23.	WESTERN UNION CO	−30.84%	2.10%
24.	COUNTRYWIDE FINANCIAL CORP	−87.46%	2.09%
25.	EATON VANCE CORP	−51.20%	2.09%
26.	S E I INVESTMENTS COMPANY	−45.61%	2.00%
27.	BERKLEY W R CORP	−3.57%	1.95%
28.	SOVEREIGN BANCORP INC	−85.77%	1.95%
29.	JPMORGAN CHASE & CO	−31.48%	1.93%
30.	BANK NEW YORK INC	−29.05%	1.90%
31.	M B I A INC	−93.34%	1.84%
32.	BLACKROCK INC	−12.07%	1.83%
33.	LEUCADIA NATIONAL CORP	−43.54%	1.80%
34.	WASHINGTON MUTUAL INC	−99.61%	1.80%

MES ranking	Name of company	Realized SES	MES
72.	TRAVELERS COMPANIES INC	−12.32%	1.26%
73.	COMMERCE BANCORP INC NJ	−4.42%	1.26%
74.	HUDSON CITY BANCORP INC	35.63%	1.26%
75.	P N C FINANCIAL SERVICES GRP INC	−27.35%	1.24%
76.	C N A FINANCIAL CORP	−64.73%	1.22%
77.	UNIONBANCAL CORP	29.14%	1.22%
78.	AON CORP	9.48%	1.20%
79.	MARSHALL & ILSLEY CORP	−60.34%	1.20%
80.	ASSURANT INC	−47.98%	1.18%
81.	CINCINNATI FINANCIAL CORP	−28.29%	1.17%
82.	PEOPLES UNITED FINANCIAL INC	5.77%	1.16%
83.	COMPASS BANCSHARES INC	−6.70%	1.16%
84.	TORCHMARK CORP	−32.18%	1.15%
85.	SYNOVUS FINANCIAL CORP	−36.53%	1.12%
86.	ALLSTATE CORP	−43.63%	1.10%
87.	FIDELITY NATIONAL FINL INC NEW	−16.80%	1.09%
88.	ALLTEL CORP	5.98%	1.08%
89.	SUNTRUST BANKS INC	−62.60%	1.08%
90.	HEALTH NET INC	−79.37%	1.04%
91.	ZIONS BANCORP	−66.42%	1.02%
92.	COVENTRY HEALTH CARE INC	−74.19%	0.99%
93.	MARSH & MCLENNAN COS INC	−17.94%	0.92%
94.	S L M CORP	−84.54%	0.92%
95.	NEW YORK COMMUNITY BANCORP INC	−23.11%	0.92%
96.	WELLPOINT INC	−47.23%	0.88%
97.	U S BANCORP DEL	−17.56%	0.88%
98.	A F L A C INC	−8.52%	0.85%
99.	UNITEDHEALTH GROUP INC	−47.94%	0.72%
100.	AMERICAN INTERNATIONAL GROUP INC	−97.70%	0.71%
101.	BERKSHIRE HATHAWAY INC DEL(A)	−11.76%	0.41%
102.	BERKSHIRE HATHAWAY INC DEL(B)	−10.85%	0.39%

Table 3
Summary statistics and correlation matrix of stock returns during the crisis, risk of financial firms, their systemic risk and other firm characteristics

Panel A: Descriptive statistics of the measures *Realized SES, ES, MES, Vol, Beta,* LVG, Log-Assets and *ME*

	Realized SES	ES	MES	Vol	Beta	LVG	Log-Assets	ME(blns)
Average	−47%	2.73%	1.63%	21%	1.00	5.25	10.84	31.25
Median	−46%	2.52%	1.47%	19%	0.89	4.54	10.88	15.85
Std. dev.	34%	0.92%	0.62%	8%	0.37	4.40	1.78	42.88
Min	−100%	1.27%	0.39%	10%	0.34	1.01	6.43	5.16
Max	36%	5.82%	3.36%	49%	2.10	25.62	14.61	253.70

Panel B: Sample correlation matrix of the measures *Realized SES, ES, MES, Vol, Beta, LVG,* Log-Assets and *ME*

Realized SES	1.00							
ES	−0.17	1.00						
MES	−0.30	0.71	1.00					
Vol	−0.07	0.95	0.64	1.00				
Beta	−0.25	0.76	0.92	0.72	1.00			
LVG	−0.47	−0.09	0.24	−0.17	0.18	1.00		
Log-Assets	−0.38	−0.32	−0.07	−0.40	−0.07	0.75	1.00	
ME	−0.19	−0.24	−0.08	−0.25	−0.07	0.27	0.65	1.00

Panel C: Descriptive statistics of the average of the measures Realized SES, ES, MES, Vol, Beta, LVG for different industry types

Depository institutions	–42%	2.23%	1.42%	17%	0.87	6.21
Other: Non-depository	—52%	3.35%	1.92%	26%	1.22	3.68
Insurance	–44%	2.44%	1.28%	18%	0.78	4.44
Security dealers	–59%	3.61%	2.68%	27%	1.61	9.58

Table 4
Stock returns during the crisis, risk of financial firms, and their systemic risk

Panel A, OLS regression analysis: The dependent variable is Realized SES, the company stock returns during the crisis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ES	−0.05							
	(−1.14)							
Vol		0.04						−0.07
		(0.07)						(−0.12)
MES			−0.21***			−0.15**		−0.17**
			(−2.90)			(−2.25)		(−2.08)
Beta				−0.29**				
				(−2.24)				
LVG					−0.04***	−0.04***		−0.03**
					(−5.73)	(−5.43)		(−2.29)
Log Assets							−0.09***	−0.05*
							(−4.86)	(−1.69)
Industry dummies								
Constant	−0.32***	−0.44***	−0.13	−0.18	−0.18**	0.02	0.61***	0.50
	(−2.71)	(−3.81)	(−1.09)	(−1.42)	(−2.50)	(0.20)	(2.75)	(1.61)
Other	−0.04	−0.09	0.01	0.012	−0.20**	−0.12	−0.25***	−0.15
	(−0.33)	(−0.91)	(0.14)	(0.12)	(−2.44)	(−1.35)	(−2.87)	(−1.61)
Insurance(×100)	0.43	−0.68	−3.63	−2.95	−8.86	−10.17	−0.09	−0.11
	(0.05)	(−0.08)	(−0.45)	(−0.36)	(−1.19)	(−1.39)	(−1.13)	(−1.55)
Broker-dealers	−0.09	−0.16	0.11	0.06	−0.02	0.16	−0.17	0.14
	(−0.65)	(−1.20)	(0.71)	(0.3)	(−0.18)	(1.19)	(−1.56)	(1.02)
Adj. R^2	0%	−1.36%	6.72%	3.62%	24.27%	27.34%	18.46%	28.02%
No. obs.	102	102	102	102	101	101	101	101

Panel B, Tobit Analysis: The dependent variable is *Realized SES*, the company stock returns during the crisis

ES	−0.05							
	(−1.06)							
Vol		0.10						−0.26
		(0.17)						(−0.42)
MES			−0.23***			−0.001**		−0.001*
			(−2.85)			(−2.03)		(−1.69)
Beta				−0.32**				
				(−2.24)				
LVG					−0.07***	−0.06***		−0.05***
					(−6.40)	(−6.14)		(−3.18)
Log Assets							−0.12***	−0.04
							(−5.48)	(−1.18)
Industry dummies								
Constant	−0.35***	−0.48***	−0.14	−0.18	−0.06	0.12	0.87***	0.5
	(−2.66)	(−3.93)	(−1.02)	(−1.02)	(−0.69)	(1.01)	(3.48)	(1.48)
Other	−0.01	−0.08	0.04	0.04	−0.26***	−0.18*	−0.28***	−0.18*
	(−0.10)	(0.70)	(0.41)	(0.40)	(−2.92)	(−1.82)	(−2.90)	(−1.82)
Insurance(×100)	0.03	0.01)	−0.02	−0.01	−0.11	−0.12	−0.09	−0.13
	(0.27)	(0.14)	(−0.21)	(−0.14)	(−1.42)	(−1.58)	(−1.03)	(−1.60)
Broker-dealers	−0.14	−0.22	0.08	0.03	−0.07	0.10	−0.23*	0.10
	(−0.87)	(−1.42)	(0.49)	(0.18)	(−0.58)	(0.68)	(−1.85)	(0.68)
Pseudo R^2	3.95%	2.95%	10.21%	7.49%	43.95%	47.70%	28.87%	49.05%
No. obs.	102	102	102	102	101	101	101	101

This table contains the results of the cross-sectional regression analyses (Panel A) and Tobit analyses (Panel B) of individual company stock returns (*Realized SES*) on risk (*ES, Vol, LVG*) and systemic risk (*MES, Beta*) measures. *Realized SES*, risk measures, and leverage are as described in Table 3. In the tobit regression analyses the following firms were assumed to have a Realized SES of –1: AIG, Bear Stearns, Citi-Group, Countrywide Financial Corp., Freddie Mac, Fannie Mae, Lehman Brothers, Merrill Lynch, National City Corp., Washington Mutual, and Wachovia. All balance sheet data are based on quarterly CRSP-Compustat merged data as of end of

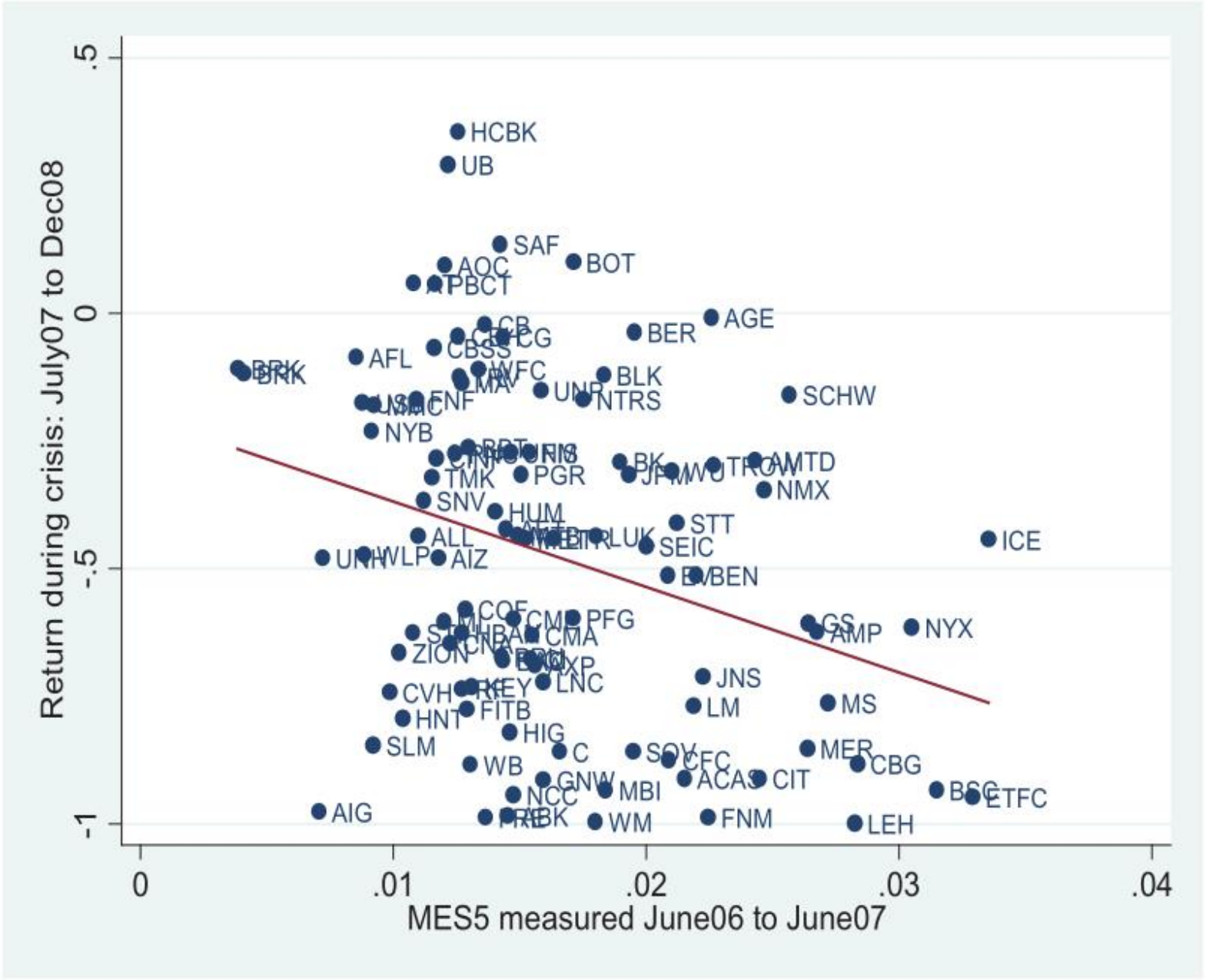

Figure 2
MES predicts realized equity returns during the crisis

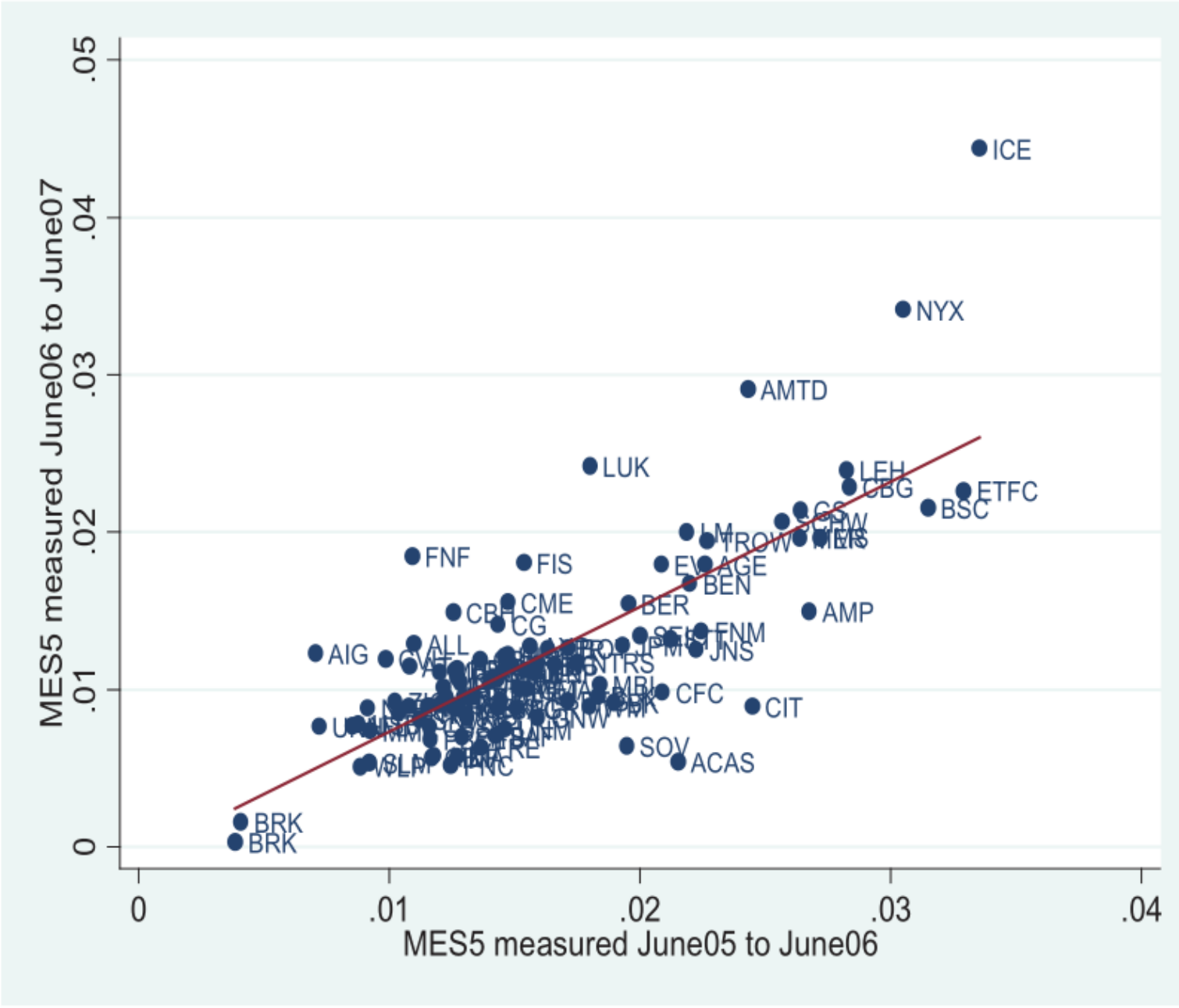

Figure 3
Stability of MES

3.Empirical Analysis of the Crisis of 2007-2009

- 3.3 Using CDS to measure systemic risk
- MES and leverage can predict the outcome of the stress test and the equity performance during the financial crisis.
- We add to this evidence by considering the credit default swaps (CDS) data from Bloomberg for these financial firms.

The CDS premium resembles the spread between risky and riskless floating rate debt.

CDS might better capture estimates of losses of market value of the financial firm's assets, as opposed to just its equity.

CDS data reflects the underlying value of the financial firm's debt, which may be subject to government guarantees.

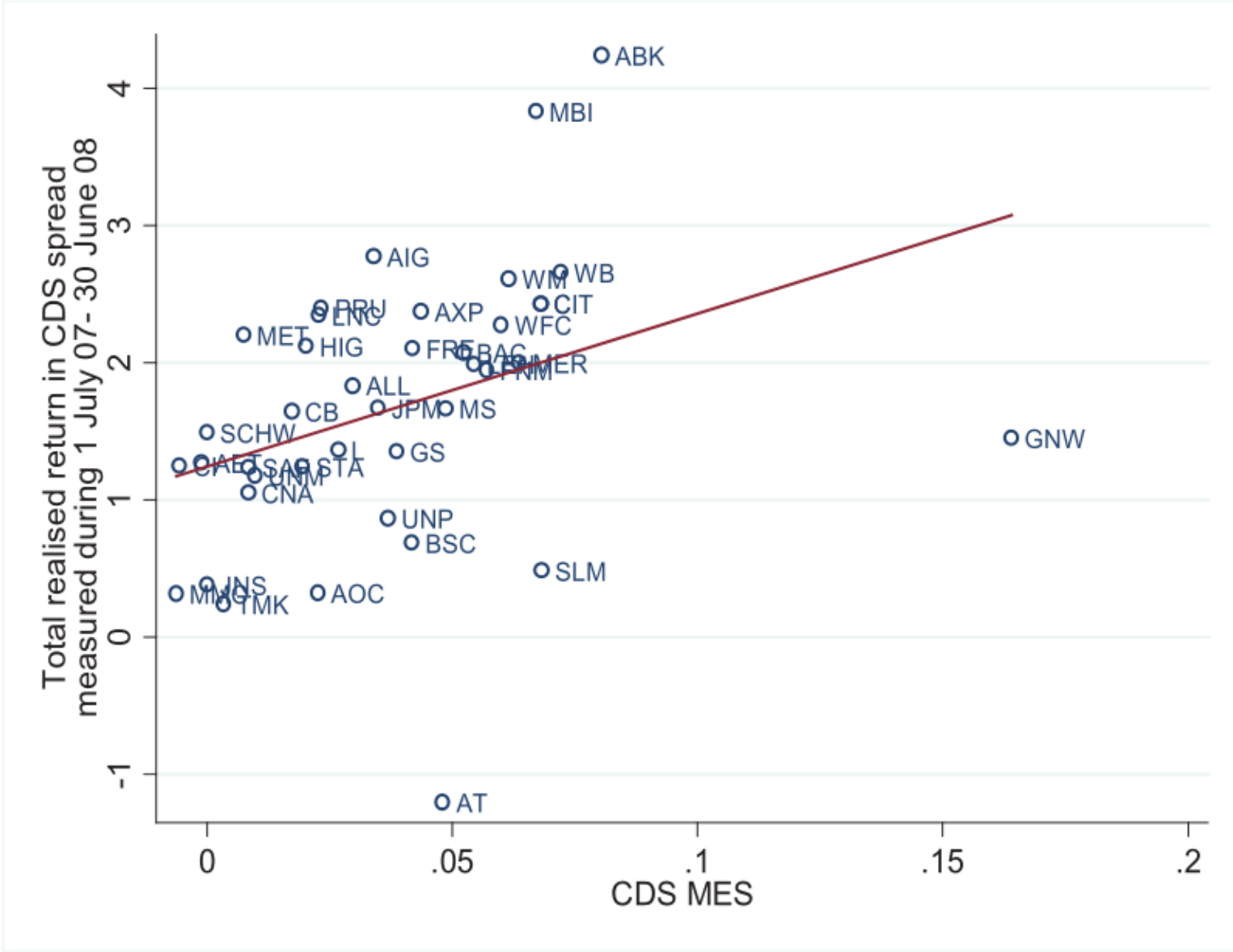

Figure 4
MES predicts realized CDS returns during the crisis
MES estimated ex ante from CDS returns July 2006–June 30, 2007, plotted against the total realized return on CDS spread during July 1, 2007–June 30, 2008.

Table 6
CDS MES vs. realized CDS SES

Panel A: The dependent variable is total realized return on CDS spread during the crisis; CDS MES is measured as log returns

	July 1, 2007–June 30, 2008	July 1, 2007–September 14, 2008	July 1, 2007–September 30, 2008	July 1, 2007–October 10, 2008	July 1, 2007–December 30, 2008
CDS MES	10.21**	9.67*	13.11**	10.72	11.56*
	(2.06)	(1.83)	(2.15)	(1.65)	(2.02)
LVG	0.05	0.05	0.05	0.06	0.03
	(1.43)	(1.41)	(1.33)	(1.45)	(0.81)
Constant	1.34**	1.75**	1.80***	1.90***	1.71***
	(2.68)	(3.28)	(2.93)	(2.91)	(2.96)
Other	−0.95*	−1.29**	−1.22*	−0.97	−1.09*
	(−1.93)	(−2.46)	(−2.02)	(−1.52)	(−1.92)
Insurance	−0.14	−0.48	−0.44	−0.03	0.35
	(−0.32)	(−1.01)	(−0.81)	(−0.04)	(0.68)
Broker dealers	−0.87	−0.91	−0.72	−0.80	−0.63
	(−1.52)	(−1.49)	(−1.02)	(−1.07)	(−0.96)
Adj. R^2	17.86%	19.94%	19.37%	10.80%	19.30%
No. obs.	40	40	40	40	40

Panel B: The dependent variable is total change in CDS spread during the crisis; CDS MES is measured as changes in CDS spreads

CDS MES	90.41**	91.04**	201.35***	239.08**	228.27**
	(2.63)	(2.16)	(2.82)	(3.12)	(2.70)
LVG	−2.07	5.80	12.24	25.50	23.76
	(−0.20)	(0.45)	(0.56)	(1.09)	(0.92)
Constant	46.51	236.00	433.10	289.63	240.62
	(0.30)	(1.24)	(1.35)	(0.84)	(0.63)
Other	−131.56	−387.37*	−693.51*	−573.43	−738.60*
	(−0.78)	(−1.87)	(−1.98)	(−1.52)	(−1.78)
Insurance	104.02	−52.03	−233.95	4.30	77.11
	(0.72)	(−0.29)	(−0.78)	(0.01)	(0.22)
Broker dealers	−25.49	−183.60	−435.61	−489.86	−606.80
	(−0.14)	(−0.80)	(−1.11)	(−1.17)	(−1.31)
Adj. R^2	7.21%	5.13%	11.67%	14.09%	12.45%
No. obs.	40	40	40	40	40

This table contains the results of the cross-sectional regression analyses of 40 companies' realized CDS SES on CDS MES. Panel A provides the results where CDS MES and realized CDS SES are measured in log return. Panel B provides the results where CDS MES and realized CDS SES are measured using arithmetic changes in CDS spreads. All measures are as described in Table 3 and Table 4, except for CDS MES, which is the average CDS returns on the worst 5% days during July 1, 2006–June 30, 2007, where the average return on CDS spreads of the 40 companies are the highest. Leverage is based on data available at end of each period. All CDS data are from Bloomberg.

Table 7
CDS MES vs. realized stock SES

Panel A: The dependent variable is realized stock return during the crisis; CDS MES is measured as log returns

	July 1, 2007–June 30, 2008	July 1, 2007–September 14, 2008	July 1, 2007–September 30, 2008	July 1, 2007–October 10, 2008	July 1, 2007–December 30, 2008
CDS MES	−4.38***	−5.20***	−6.05***	−4.48***	−4.11***
	(−3.33)	(−3.52)	(−3.83)	(−3.19)	(−2.77)
LVG	−0.03***	−0.04***	−0.04***	−0.04***	−0.03
	(−3.82)	(−4.31)	(−4.13)	(−4.17)	(−3.64)
Constant	−0.03	0.19	0.25	−0.007	−0.14
	(−0.26)	(1.29)	(1.57)	(−0.05)	(−0.91)
Other	0.09	−0.11	−0.16	−0.13	−0.09
	(0.69)	(−0.76)	(−0.99)	(−0.90)	(−0.62)
Insurance	0.03	−0.08	−0.17	−0.19	−0.06
	(0.24)	(−0.62)	(−1.19)	(−1.53)	(−0.44)
Broker dealers	0.19	0.07	0.03	0.03	0.07
	(1.26)	(0.43)	(0.19)	(0.21)	(0.39)
Adj. R^2	46.79%	51.66%	50.94%	45.52%	40.76%
No. obs.	40	40	40	40	40

Panel B: The dependent variable is realized stock return during the crisis; CDS MES is measured as changes in CDS spreads

CDS MES	−0.06**	−0.07*	−0.07*	−0.04	−0.02
	(−2.04)	(−2.00)	(−2.02)	(−1.21)	(−0.71)
LVG	−0.04	−0.05***	−0.05***	−0.05***	−0.04***
	(−4.48)	(−4.90)	(−4.70)	(−4.60)	(−4.04)
Constant	−0.17	0.03	0.06	−0.17	−0.30*
	(−1.26)	(0.19)	(0.35)	(−1.16)	(−1.98)
Other	0.20	0.02	−0.006	−0.03	−0.02
	(1.42)	(0.12)	(−0.03)	(−0.21)	(−0.11)
Insurance	0.12	0.03	−0.04	−0.09	0.04
	(0.96)	(0.19)	(−0.26)	(−0.67)	(0.28)
Broker dealers	0.33**	0.24	0.23	0.17	0.18
	(2.06)	(1.29)	(1.12)	(0.95)	(1.00)
Adj. R^2	37.16%	40.98%	37.31%	32.15%	28.49%
No. obs.	40	40	40	40	40

This table contains the results of the cross-sectional regression analyses of 40 companies' realized stock returns (Realized SES) on CDS MES (measured as log returns in Panel A and changes in CDS spreads in Panel B). All measures are as described in Table 3 and Table 4, except for CDS MES, which is the average CDS returns on the worst 5% days during July 1, 2006–June 30, 2007, where the average changes in CDS spreads of the 40 companies are the highest. Leverage is based on data available at end of each period. All CDS data are from Bloomberg.

t-statistics are given in parentheses. ***, **, and *, indicate significance at 1%, 5%, and 10% levels, respectively.

4.Discussion

- 4.1 Compare our optimal policy to some of the proposals put forward by regulators and policymakers.

Proposition 1. The efficient outcome is obtained by a tax

$$\tau^i = \frac{\alpha^i g}{c} \times Pr(w_1^i < 0) \times ES^i + \frac{e}{c} \times Pr(W_1 < zA) \times SES^i + \tau_0$$

- Resolution fund

It is essentially the institution-risk component and reflects the costs of the government guarantees in the system (e.g., deposit insurance and too-big-to-fail).

However, it doesn't fully address the systemic-risk component.

4.Discussion

- 4.2 Systemic risk

Proposition 1. The efficient outcome is obtained by a tax

$$\tau^i = \frac{\alpha^i g}{c} \times Pr(w_1^i < 0) \times ES^i + \frac{e}{c} \times Pr(W_1 < zA) \times SES^i + \tau_0$$

- Systemic risk has been the size of financial institutions' assets and liabilities.
- The interesting question is what variables help explain the percentage of expected losses (as opposed to losses in dollars).
- The risk of a systemic event $Pr(W_1 < zA)$ can be measured using historical research, as in Reinhart and Rogoff(2008).

4.Discussion

- 4.3 Whether non-banking institutions can be systemically important
- In our model, we didn’t introduce specific features distinguishing banks from non-banking entities.
- Acharya, Philippon, and Richardson (Forthcoming) extend our model where some of the financial firm liabilities are long-term, allowing for a distintion between liquidity and solvency risks.

5. Conclusion

- Current financial regulations seek to limit each institution's risk.
- Financial regulation be focused on limiting systemic risk.
- We provide a simple and intuitive way to measure each bank's contribution to systemic risk, suggesting ways to limit it.

- Extensions of our work in future

Obtain information of systemic risk through prices of out-of-the-money equity options and insurance contracts against losses of individual firms.

The form of leverage that had the most pernicious effect in the crisis of 2007-08 was arguably short-term debt.

It is important to empirically understand how short-term leverage contributes to market-based measures of systemic risk of financial firms.