



Università
Ca' Foscari
Venezia

Econometric Measures of Systemic Risk in the Finance and Insurance Sectors

Monica Billio, Mila Getmansky,
Andrew W. Lo, Lorian Pelizzon

Scuola Normale di Pisa

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Motivation

- Increased **interconnectedness** of financial institutions (banks, hedge funds, brokers, and insurance companies) amplified systemic problems and served as a major factor in the Financial Crisis of 2007-2009
- Study the degree of **interconnectedness** between these financial institutions
- Develop **econometric measures** of systemic risk to capture linkages and **vulnerabilities** of the entire financial system
- Identify **systemically important** institutions
- Capture the **build-up** of systemic risk prior to a crisis

Our contribution

- Several measures of systemic risk in the finance and insurance sectors based on the **statistical properties of aggregate market returns**.
- In the absence of direct information concerning leverage and linkages among financial institutions, **statistical relationships can yield valuable indirect information** about the build-up of systemic risk.
- Moreover, even if regulatory reforms impose the disclosure for such information, an econometric approach may still provide more immediate and actionable measures of systemic risk.

Literature Review: Theoretical Framework

Interconnectedness:

- Negative externalities
- Fundamental shocks
- Liquidity and volatility spirals
- Network effects
- Uniform risk management practices (i.e., VAR)
 - Negative externalities
 - Inverted asset demand and supply
 - Leverage pro-cyclicality

Transmission channels:

Bhattacharya and Gale (1987), Allen and Gale (1998, 2000), Diamond and Rajan (2005), Danielsson and Zigrand (2008), Adrian and Shin (2008), Brunnermeier and Pedersen (2009), Brunnermeier (2009), Danielsson, Shin, and Zigrand (2009), Battiston et al. (2009), and Castiglionesi, Periozzi, and Lorenzoni (2009)

As a result, we might observe autocorrelation, correlation, and causality between the asset returns of financial institutions
sort of “symptoms of systemic risk”

Literature Review – Other Measures

1. **CoVaR** (Adrian and Brunnermeier, 2009)
 - Systemic risk measure that captures VaR of a financial sector conditional on institution i being in distress
 2. **Systemic Expected Shortfall (SES) and Marginal Expected Shortfall (MES)** (Acharya, Pedersen, Philippon, and Richardson, 2010)
 - SES measures each financial institution's contribution to systemic risk, i.e., its propensity to be undercapitalized when the system as a whole is undercapitalized
 - MES measures institution's losses in the tail of the system's loss distribution
 3. **Distress Insurance Premium** (Huang, Zhou, and Zhu, 2010)
 - Insurance premium to cover distressed losses in a banking system
 4. **Rare Outcomes** (Duggey, 2009)
 - Set of measures based on rare and unknown outcomes and information entropy
 5. **Conditional Marginal Expected Shortfall** (Brownlees and Engle, (2010))
 - Marginal ES of institution I conditional on the market declining of a given percentage
 6. **Absorption Ratio** (Kritzman, Li, Page, and Rigobon (2010))
 - Absorption ratio is based on principal components analysis
-



Literature Review: Other Measures

1. CoVaR (Adrian and Brunnermeier, 2009)

- Systemic risk measured by VaR of financial institutions conditional on other institutions being in distress

$$\alpha = \text{Prob}\left(X^i \leq \text{VaR}_\alpha^i\right)$$

$$\alpha = \text{Prob}\left(X^j \leq \text{CoVaR}_\alpha^{j|i} \mid X^i = \text{VaR}_\alpha^i\right)$$

- VaR of institution j conditional on institution i being at its VaR level
- It allows to study spillover effects across a whole financial network.

Literature Review: Other Measures

2. Systemic Expected Shortfall (SES) and Marginal Expected Shortfall (MES) (Acharya, Pedersen, Philippon, and Richardson, 2010)

- SES measures each financial institution's contribution to systemic risk, i.e., its propensity to be undercapitalized when the system as a whole is undercapitalized
- MES measures institution's losses in the tail of the system's loss distribution

$$ES_{\alpha} \equiv -E[R|R < VaR_{\alpha}] \quad , \quad R = \sum_{i=1}^n \omega_i R_i$$

$$MES_{\alpha}^i \equiv \frac{\partial ES_{\alpha}}{\partial \omega_i} = -E[R_i|R < VaR_{\alpha}]$$

Systemic Risk Measures

Construct Systemic Risk Measures Based On:

1. Principal components
 - Captures increasing commonality
2. Linear Granger causality tests
 - Captures directionality of commonality & signals market dis-functioning
3. Nonlinear Granger causality tests
 - Captures directionality and nonlinearity of commonality

**Measures of the “four L’s” of systemic risk—
leverage, liquidity, linkages, and losses—indirectly via
econometric estimators**



Financial Institutions and Data

- Focus on **hedge funds, banks, brokers, and insurers** (new business ties within last decade)
- Insurance companies now engage in many financial products and non-core activities (derivatives trading, credit-default swaps, and investment management); new business units compete directly with banks, hedge funds, and broker/dealers
- Banking industry has been transformed because financial innovations, like securitization, have blurred the distinction between loans, bank deposits, securities, and trading strategies
- **CRSP**: Monthly equity returns for individual brokers, banks, and insurance companies are obtained from CRSP.
- **TASS**: Monthly reported net-of fee fund returns for hedge funds.



PCA Systemic Risk Measures

- PCAS captures both contribution and the exposure of the i -th institution to the overall risk of the system given a strong commonality across returns of institutions (over H)

$$PCAS_{i,x} = \frac{1}{2} \frac{\sigma_i^2}{\sigma_S^2} \frac{\partial^2}{\partial \sigma_i^2} \sigma_S^2 \Big|_{h_x \geq H} = \sum_{k=1}^{Nx} \sigma_i^2 L_{ik}^2 \frac{\lambda_k}{\sigma_S^2} \Big|_{h_x \geq H}$$

where σ_i^2 is variance of institution i .

σ_S^2 is variance of the whole system.

L_{ik} is the loading (eigenvector) of institution i on k -th PC, and

λ_k is the k -th eigenvalue.

Cumulative Risk Explained

Cumulative Risk Fraction			
Sample Period	PC 1	PC 1-10	PC 1-20
Hedge Funds, Brokers, Banks, Insurers			
1994 to 1996	27%	71%	91%
1996 to 1998	34%	83%	95%
1999 to 2001	27%	85%	96%
2002 to 2004	41%	80%	94%
2006 to 2008	37%	89%	97%

PCAS – Systemic Risk Measure Based on PCA

PCAS				
Index	PC1	PC2-10	PC11-20	PC21-100
Jan1994-Dec1996				
Hedge Funds	0.04	0.02	0.01	0.01
Brokers	0.12	0.04	0.02	0.01
Banks	0.10	0.03	0.02	0.01
Insurers	0.09	0.03	0.02	0.01
Jan1996-Dec1998				
Hedge Funds	0.04	0.02	0.01	0.00
Brokers	0.13	0.05	0.01	0.00
Banks	0.09	0.03	0.01	0.00
Insurers	0.08	0.03	0.01	0.00
Jan1999-Dec2001				
Hedge Funds	0.02	0.01	0.00	0.00
Brokers	0.14	0.06	0.01	0.00
Banks	0.02	0.04	0.01	0.00
Insurers	0.02	0.05	0.01	0.00
Jan2002-Dec2004				
Hedge Funds	0.02	0.01	0.00	0.00
Brokers	0.14	0.04	0.01	0.01
Banks	0.09	0.02	0.01	0.01
Insurers	0.08	0.03	0.01	0.01
Jan2006-Dec2008				
Hedge Funds	0.02	0.01	0.00	0.00
Brokers	0.11	0.04	0.01	0.00
Banks	0.07	0.04	0.01	0.00
Insurers	0.12	0.03	0.01	0.00

Linear Granger Causality Tests

$$X_t = \sum_{j=1}^m a_j X_{t-j} + \sum_{j=1}^m b_j Y_{t-j} + \epsilon_t$$

$$Y_t = \sum_{j=1}^m c_j X_{t-j} + \sum_{j=1}^m d_j Y_{t-j} + \eta_t$$

- $Y \Rightarrow_G X$ if $\{b_j\}$ is different from 0
- $X \Rightarrow_G Y$ if $\{c_j\}$ is different from 0
- If both $\{b_j\}$ and $\{c_j\}$ are different from 0, feedback relation
- Consider causality among monthly returns of hedge funds, banks, brokers, and insurance companies to capture the build-up of systemic risk

Granger Causality Tests

- Dynamic propagation of systemic risk involves **causal relationships** between financial institutions
- Informationally efficient markets should not exhibit Granger causality. **It is a signal of predictability, i.e. market dis-functioning**
- Potential sources of Granger Causality:
 - VaR constraints, network effects, or other market frictions
 - Degree of Granger causality may be a proxy for **spillover effects**, e.g., Danielsson, Shin, and Zigrand (2009), Battiston et al. (2009).

Granger Causality Networks

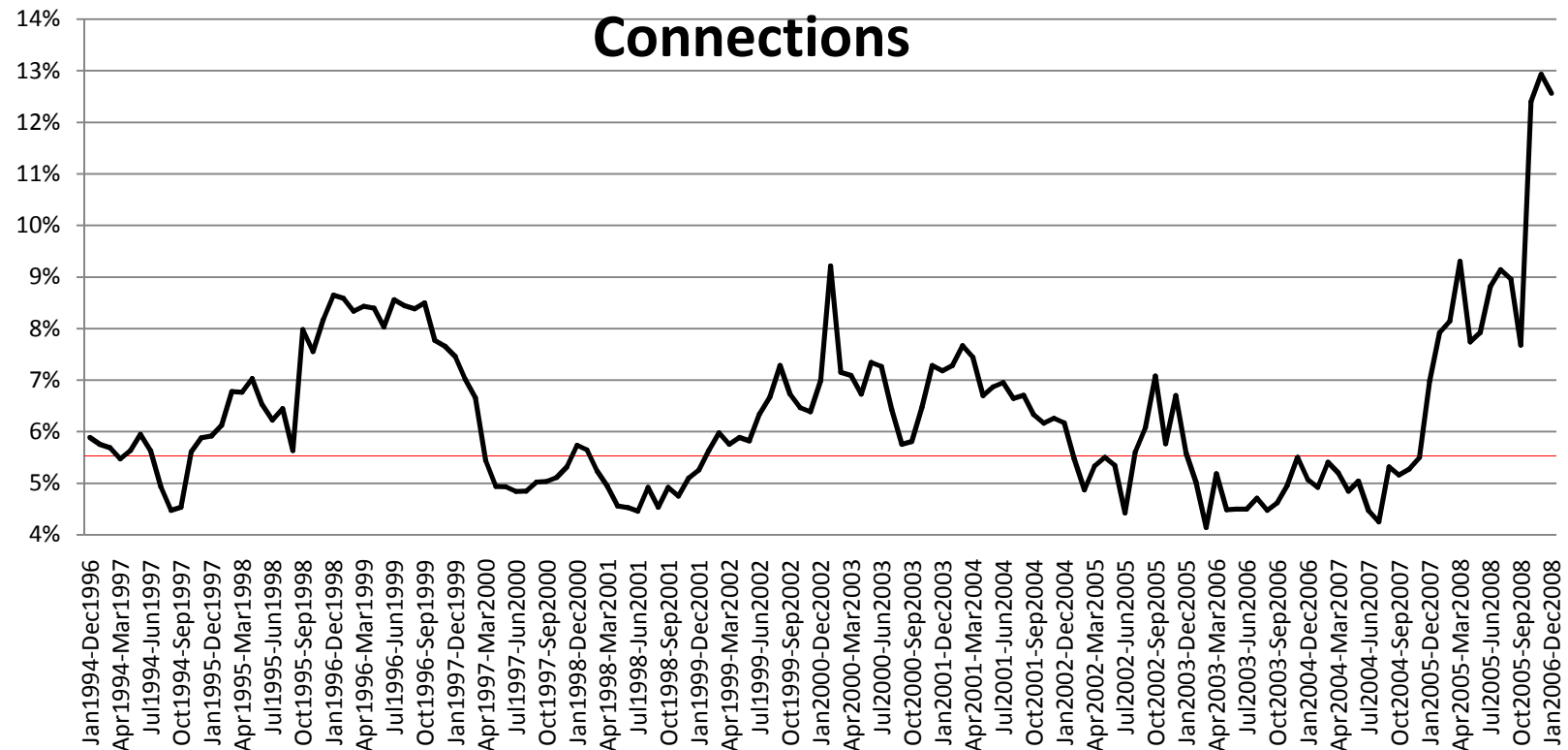
- Granger-causal relationships among 100 largest (by AUM) banks, hedge funds, insurers, and brokers for 36-month rolling sub-periods
- Each financial and insurance sector is represented by the 25 largest (by AUM) individual institutions.

Granger Causality Networks

Sector	Asset Weighted AutoCorr	Asset Weighted Corr	Asset Weighted σ	# of Connections as % of All Possible Connections				# of Connections			
				Hedge Funds	Brokers	Banks	Insurers	Hedge Funds	Brokers	Banks	Insurers
January 1994 to December 1996											
All	-0.07	0.30	0.04	6%				583			
Hedge Funds	0.03	0.31	0.03	7%	3%	6%	6%	41	21	36	37
Brokers	-0.15	0.54	0.06	3%	5%	6%	4%	18	29	36	24
Banks	-0.03	0.38	0.04	6%	7%	9%	7%	40	46	54	44
Insurers	-0.10	0.25	0.04	5%	6%	6%	9%	33	38	35	51
January 1996 to December 1998											
All	-0.03	0.43	0.06	9%				856			
Hedge Funds	0.08	0.36	0.04	14%	6%	5%	3%	82	38	30	20
Brokers	-0.04	0.54	0.10	13%	9%	9%	9%	81	53	54	57
Banks	-0.09	0.54	0.06	11%	8%	11%	10%	71	52	65	64
Insurers	0.02	0.40	0.05	9%	9%	7%	6%	57	54	44	34
January 1999 to December 2001											
All	-0.09	0.35	0.06	5%				520			
Hedge Funds	0.17	0.18	0.02	5%	5%	5%	9%	32	32	33	58
Brokers	0.03	0.63	0.12	8%	9%	3%	5%	53	52	19	29
Banks	-0.09	0.48	0.07	5%	3%	4%	7%	30	17	25	42
Insurers	-0.20	0.53	0.08	5%	3%	2%	6%	32	16	14	36
January 2002 to December 2004											
All	-0.08	0.38	0.04	6%				611			
Hedge Funds	0.20	0.15	0.01	10%	3%	9%	5%	61	20	56	29
Brokers	-0.09	0.66	0.07	8%	4%	4%	6%	53	23	26	39
Banks	-0.14	0.49	0.04	9%	3%	4%	5%	55	16	24	30
Insurers	0.00	0.32	0.04	8%	6%	9%	6%	48	40	55	36
January 2006 to December 2008											
All	0.08	0.36	0.06	13%				1244			
Hedge Funds	0.23	0.33	0.02	10%	13%	5%	13%	57	82	31	83
Brokers	0.23	0.54	0.08	12%	17%	9%	12%	78	102	55	73
Banks	0.02	0.46	0.07	23%	12%	10%	9%	142	74	58	54
Insurers	0.12	0.37	0.07	15%	16%	12%	16%	84	102	73	96

Granger Causality Networks

of Connections as a % of All Possible Connections



Granger Causality Networks

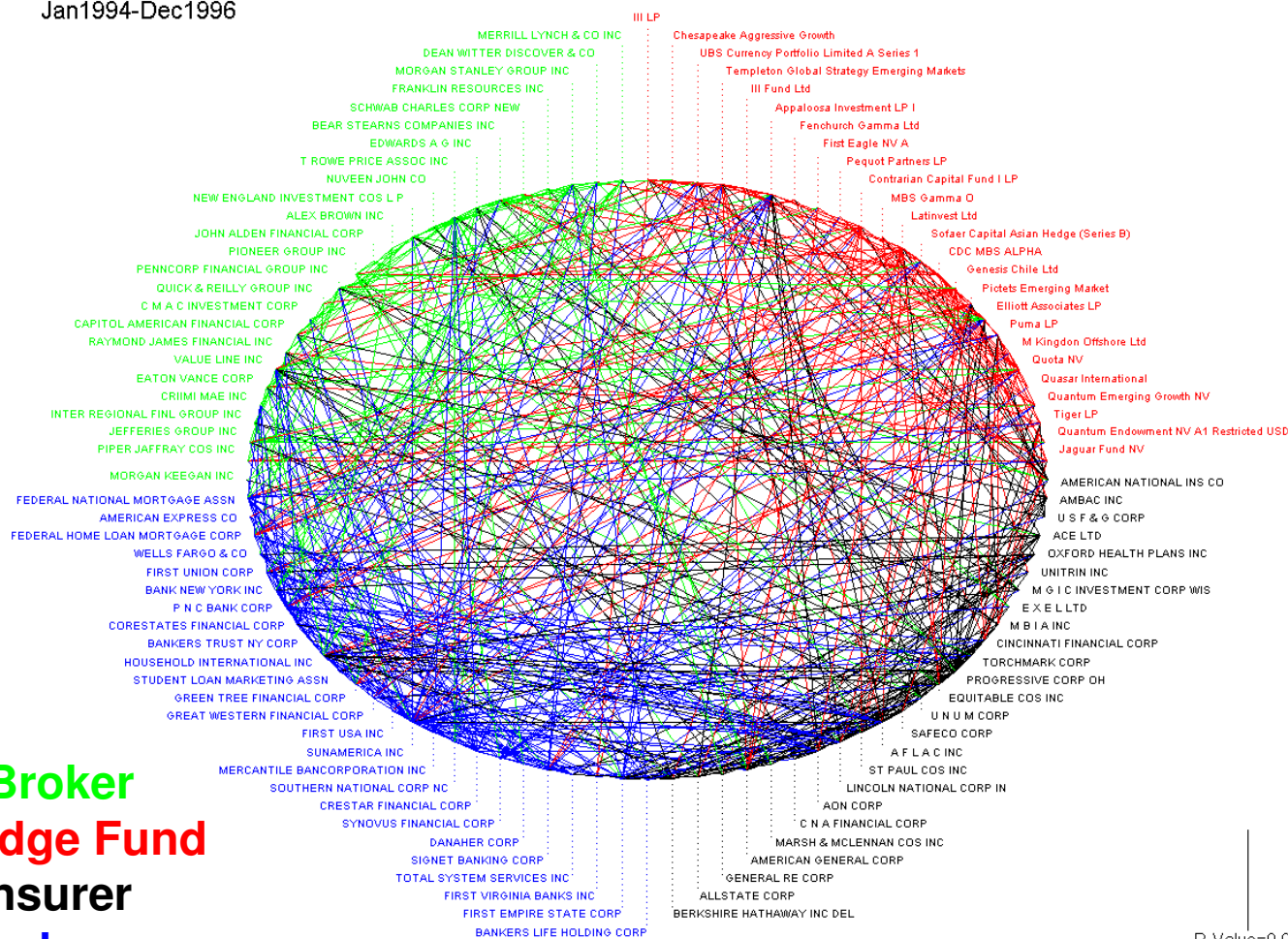
In		Out		In+Out	
PRINCIPAL FINANCIAL GROUP INC	45	WELLS FARGO & CO NEW	26	PRINCIPAL FINANCIAL GROUP INC	51
BERKSHIRE HATHAWAY INC DEL	28	PROGRESSIVE CORP OH	24	STEWART W P & CO LTD	30
INSTINET GROUP INC	24	BANK OF AMERICA CORP	20	INSTINET GROUP INC	29
Cerberus International Ltd	21	CITIGROUP INC	19	BERKSHIRE HATHAWAY INC DEL	29
BERKSHIRE HATHAWAY INC DEL B	21	STEWART W P & CO LTD	18	WELLS FARGO & CO NEW	28
M Kingdon Offshore Ltd	19	FEDERAL NATIONAL MORTGAGE ASSN	17	PROGRESSIVE CORP OH	27
Perry Partners LP	17	U B S AG	16	JEFFERIES GROUP INC NEW	26
LABRANCHE & CO INC	17	UNITEDHEALTH GROUP INC	16	BERKSHIRE HATHAWAY INC DEL B	26
KEYCORP NEW	15	INVESTMENT TECHNOLOGY GP INC NEW	15	U B S AG	25
Sagamore Hill Ltd	14	LEHMAN BROTHERS HOLDINGS INC	14	Cerberus International Ltd	23
EDWARDS A G INC	14	T ROWE PRICE GROUP INC	14	M Kingdon Offshore Ltd	23
JEFFERIES GROUP INC NEW	13	EATON VANCE CORP	14	T ROWE PRICE GROUP INC	23
WADDELL & REED FINANCIAL INC	13	AMERICAN EXPRESS CO	14	LABRANCHE & CO INC	22
BANK MONTREAL QUE	13	M B I A INC	14	M B N A CORP	21
AMERITRADE HOLDING CORP NEW	12	JEFFERIES GROUP INC NEW	13	Graham Global Investment K4D-10	20
INVESTORS FINANCIAL SERV CORP	12	M B N A CORP	13	AMERITRADE HOLDING CORP NEW	20
STEWART W P & CO LTD	12	Graham Global Investment K4D-15	12	EATON VANCE CORP	20
TORONTO DOMINION BANK ONT	12	RAYMOND JAMES FINANCIAL INC	12	CITIGROUP INC	20
MANULIFE FINANCIAL CORP	11	WACHOVIA CORP 2ND NEW	12	BANK OF AMERICA CORP	20
Elliott International Ltd	10	AMBAC FINANCIAL GROUP INC	12	TORONTO DOMINION BANK ONT	20
In from Other		Out to Other		In+Out Other	
PRINCIPAL FINANCIAL GROUP INC	41	WELLS FARGO & CO NEW	23	PRINCIPAL FINANCIAL GROUP INC	45
BERKSHIRE HATHAWAY INC DEL	25	PROGRESSIVE CORP OH	20	STEWART W P & CO LTD	28
INSTINET GROUP INC	20	BANK OF AMERICA CORP	17	BERKSHIRE HATHAWAY INC DEL	26
BERKSHIRE HATHAWAY INC DEL B	20	STEWART W P & CO LTD	16	WELLS FARGO & CO NEW	25
M Kingdon Offshore Ltd	18	UNITEDHEALTH GROUP INC	15	INSTINET GROUP INC	23
Cerberus International Ltd	17	INVESTMENT TECHNOLOGY GP INC NEW	14	U B S AG	23
LABRANCHE & CO INC	16	CITIGROUP INC	14	BERKSHIRE HATHAWAY INC DEL B	23
Perry Partners LP	13	U B S AG	14	M Kingdon Offshore Ltd	22
WADDELL & REED FINANCIAL INC	13	FEDERAL NATIONAL MORTGAGE ASSN	12	JEFFERIES GROUP INC NEW	22
KEYCORP NEW	13	AMERICAN EXPRESS CO	12	PROGRESSIVE CORP OH	22
EDWARDS A G INC	12	AMBAC FINANCIAL GROUP INC	12	LABRANCHE & CO INC	20
STEWART W P & CO LTD	12	Kingate Global Ltd USD Shares	11	T ROWE PRICE GROUP INC	19
BANK MONTREAL QUE	12	T ROWE PRICE GROUP INC	11	Cerberus International Ltd	18
AMERITRADE HOLDING CORP NEW	11	JEFFERIES GROUP INC NEW	11	INVESTMENT TECHNOLOGY GP INC NEW	18
INVESTORS FINANCIAL SERV CORP	11	X L CAPITAL LTD	11	BANK OF AMERICA CORP	17
JEFFERIES GROUP INC NEW	11	M B N A CORP	10	KEYCORP NEW	17
Sagamore Hill Ltd	10	M B I A INC	10	EDWARDS A G INC	16
TORONTO DOMINION BANK ONT	10	Graham Global Investment K4D-10	9	UNITEDHEALTH GROUP INC	16
MANULIFE FINANCIAL CORP	10	AMERICAN INTERNATIONAL GROUP INC	9	X L CAPITAL LTD	16
Elliott International Ltd	9	ACE LTD	9	Graham Global Investment K4D-10	15
Closeness		Eigenvector Centrality			
WELLS FARGO & CO NEW	1.74	PROGRESSIVE CORP OH	0.31		
PROGRESSIVE CORP OH	1.76	WELLS FARGO & CO NEW	0.31		
BANK OF AMERICA CORP	1.80	BANK OF AMERICA CORP	0.24		
CITIGROUP INC	1.81	CITIGROUP INC	0.22		
STEWART W P & CO LTD	1.82	STEWART W P & CO LTD	0.21		
FEDERAL NATIONAL MORTGAGE ASSN	1.83	UNITEDHEALTH GROUP INC	0.19		
U B S AG	1.84	FEDERAL NATIONAL MORTGAGE ASSN	0.19		
UNITEDHEALTH GROUP INC	1.84	INVESTMENT TECHNOLOGY GP INC NEW	0.18		
INVESTMENT TECHNOLOGY GP INC NEW	1.85	AMBAC FINANCIAL GROUP INC	0.16		
LEHMAN BROTHERS HOLDINGS INC	1.86	M B N A CORP	0.16		
T ROWE PRICE GROUP INC	1.86	T ROWE PRICE GROUP INC	0.15		
EATON VANCE CORP	1.86	X L CAPITAL LTD	0.15		
AMERICAN EXPRESS CO	1.86	U B S AG	0.14		
M B I A INC	1.86	Kingate Global Ltd USD Shares	0.14		
JEFFERIES GROUP INC NEW	1.87	AMERICAN EXPRESS CO	0.14		
M B N A CORP	1.87	BlackRock Obsidian (Offshore) Fund	0.14		
Graham Global Investment K4D-15	1.88	LEHMAN BROTHERS HOLDINGS INC	0.14		
RAYMOND JAMES FINANCIAL INC	1.88	Crabtree Div Futures(4X composite)	0.13		
WACHOVIA CORP 2ND NEW	1.88	WASHINGTON MUTUAL INC	0.13		
AMBAC FINANCIAL GROUP INC	1.88	M B I A INC	0.12		

The top names in the Out and Out-to-Other categories include:

Wells Fargo, Bank of America, Citigroup, Federal National Mortgage Association, UBS, Lehman Brothers Holdings, Wachovia, Bank New York, American International Group, and Washington Mutual

Granger Causality Networks

Jan1994-Dec1996

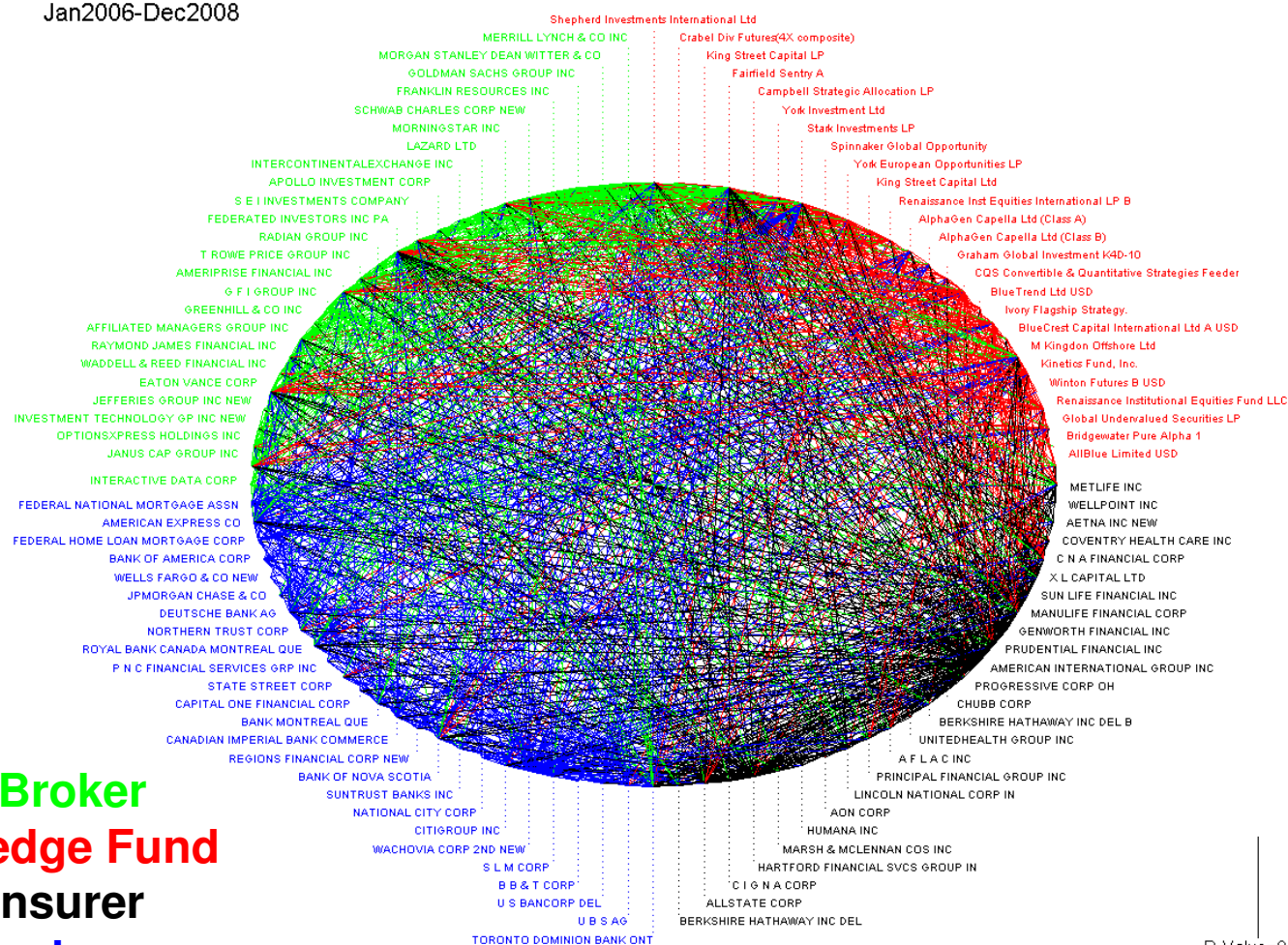


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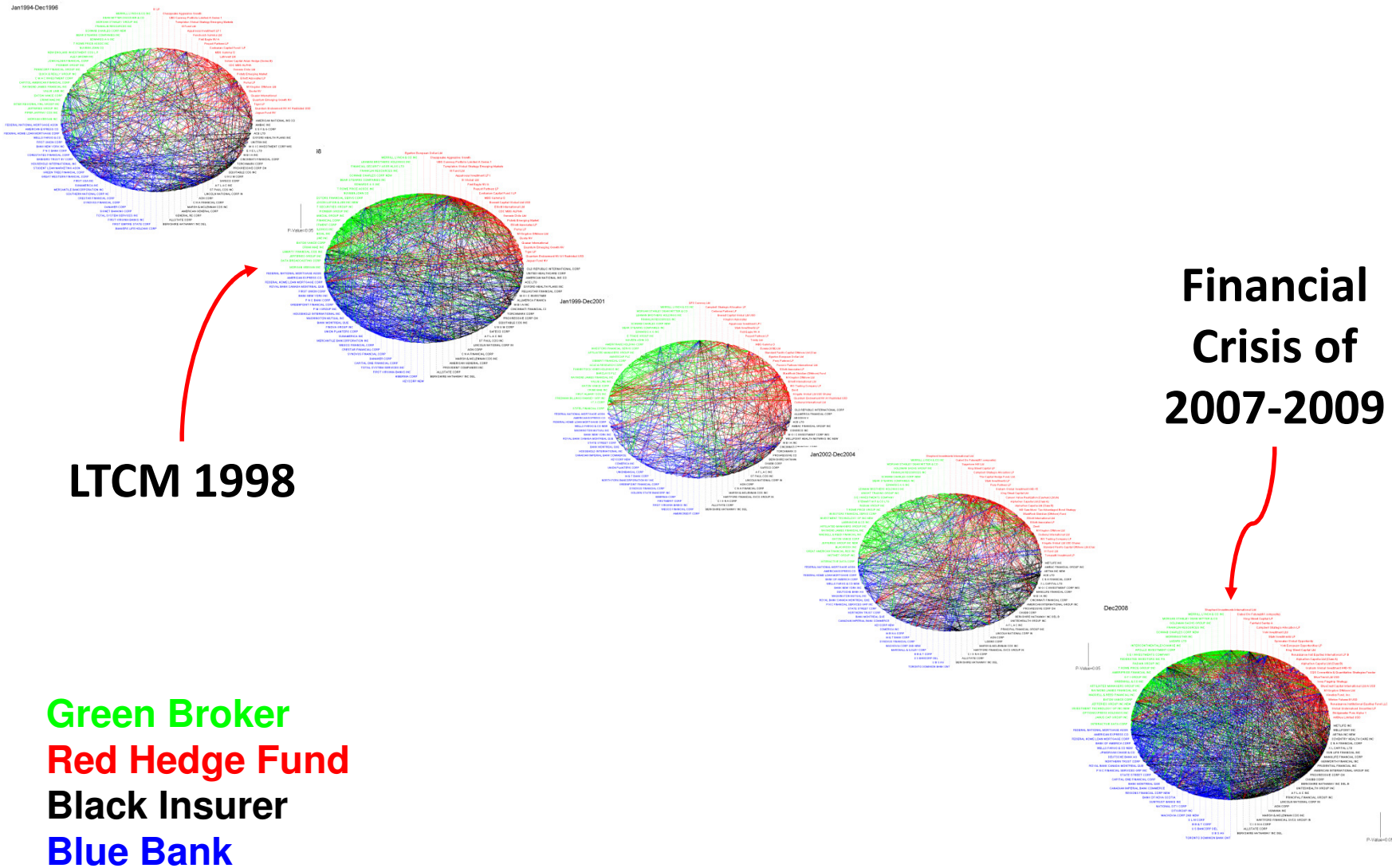


Granger Causality Networks

Jan2006-Dec2008



Granger Causality Networks



Granger Causality Results

- Connections increase during financial crises (LTCM 1998 and Financial Crisis 2007-2009)
- Connections increase before financial crises
- Liquidity decreases during financial crises
- **Results Show Asymmetry in Connections:**
 - Banks and Insurers seem to have a more significant impact—in terms of Granger causality— on Hedge funds and Brokers than vice versa.
 - This suggests that the “**shadow hedge fund system**”, i.e., banks and insurers that take hedge-fund types of risks, may be a better description than the “shadow banking system.”

Systemic risk measures

Measures of the “structure of the network”:

- Number of “In” connections
- Number of “Out” connections
- Number of “In+Out” connections
- Number of “In-from-Other” connections
- Number of “Out-to-Other” connections
- Number of “In+Out Other” connections
- Closeness
- Eigenvector centrality

Early Warning Signs

$$\text{rank}_{i,\text{loss},t+1} = \alpha + \beta \text{rank}_{i,\text{causality},t} + \epsilon_i$$

	Max % Loss_2005				Max % Loss_2007			
	Coeff	t-stat	p-value	Kendall τ	Coeff	t-stat	p-value	Kendall τ
# of "In" Connections	0.03	0.25	0.80	0.02	-0.01	-0.07	0.94	-0.01
# of "Out" Connections	0.23	2.23	0.03	0.16	0.25	2.53	0.01	0.20
# of "In+Out" Connections	0.16	1.51	0.13	0.11	0.19	1.89	0.06	0.13
# of "In-from-Other" Connections	0.12	1.15	0.25	0.09	-0.02	-0.19	0.85	-0.02
# of "Out-to-Other" Connections	0.32	3.11	0.00	0.22	0.17	1.68	0.10	0.13
# of "In+Out Other" Connections	0.23	2.23	0.03	0.15	0.09	0.84	0.41	0.06
Closeness	0.23	2.23	0.03	0.16	0.25	2.53	0.01	0.20
Eigenvector Centrality	0.24	2.31	0.02	0.16	0.24	2.44	0.02	0.17
PCA	0.32	3.11	0.00	0.24	0.16	1.51	0.13	0.12

t = October 2002-September 2005

$t+1$ = July 2007-December 2008

Max % Loss \equiv Max Loss / Mkt Cap at June 2007



Early Warning Signs

$$\text{rank}_{i,\text{loss},t+1} = \alpha + \beta \text{rank}_{i,\text{causality},t} + \text{rank}_{i,\text{leverage},t} + \text{rank}_{i,\text{PCA},t} + \epsilon_i$$

Panel A: PCA, Leverage, and systemic risk measures based on Granger causality are calculated over October 2002-September 2005

	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Intercept	16.33	2.08	7.59	1.00	8.83	1.13	16.19	2.17	6.86	0.94	10.40	1.38	7.59	1.00	8.97	1.18
Leverage	0.23	2.26	0.25	2.59	0.25	2.54	0.23	2.22	0.28	2.87	0.25	2.52	0.25	2.59	0.25	2.54
PCA	0.33	3.17	0.29	2.93	0.31	3.11	0.31	2.97	0.22	2.15	0.27	2.67	0.29	2.93	0.29	2.89
# of "In" Connections	0.06	0.57														
# of "Out" Connections			0.28	2.77												
# of "In+Out" Connections					0.23	2.26										
# of "In-from-Other" Connections							0.08	0.76								
# of "Out-to-Other" Connections									0.34	3.26						
# of "In+Out Other" Connections											0.23	2.21				
Closeness													0.28	2.77		
Eigenvector Centrality															0.25	2.44
R-square	0.16		0.23		0.21		0.16		0.26		0.21		0.23		0.22	

Systemically Important Institutions

Out-to-Other

WELLS FARGO & CO NEW
PROGRESSIVE CORP OH
BANK OF AMERICA CORP
STEWART W P & CO LTD
UNITEDHEALTH GROUP INC
INVESTMENT TECHNOLOGY GP INC NEW
CITIGROUP INC
U B S AG
FEDERAL NATIONAL MORTGAGE ASSN
AMERICAN EXPRESS CO
AMBAC FINANCIAL GROUP INC
Kingsgate Global Ltd USD Shares
T ROWE PRICE GROUP INC
JEFFERIES GROUP INC NEW
X L CAPITAL LTD
M B N A CORP
M B I A INC
Graham Global Investment K4D-10
AMERICAN INTERNATIONAL GROUP INC
ACE LTD

Aggregate Measure

DEUTSCHE BANK AG
U B S AG
FEDERAL NATIONAL MORTGAGE ASSN
Tomasetti Investment LP
LEHMAN BROTHERS HOLDINGS INC
C I G N A CORP
JEFFERIES GROUP INC NEW
CITIGROUP INC
INVESTMENT TECHNOLOGY GP INC NEW
LINCOLN NATIONAL CORP IN
AMERICAN INTERNATIONAL GROUP INC
BEAR STEARNS COMPANIES INC
ACE LTD
C I T GROUP INC NEW
WASHINGTON MUTUAL INC
RAYMOND JAMES FINANCIAL INC
BANK OF AMERICA CORP
STEWART W P & CO LTD
PROGRESSIVE CORP OH
HARTFORD FINANCIAL SVCS GROUP IN

Max Percentage Loss

Perry Partners LP
EDWARDS A G INC
Canyon Value Realization (Cayman) Ltd (A)
C I T GROUP INC NEW
Tomasetti Investment LP
BEAR STEARNS COMPANIES INC
ACE LTD
LEHMAN BROTHERS HOLDINGS INC
WASHINGTON MUTUAL INC
Kingsgate Global Ltd USD Shares
FEDERAL HOME LOAN MORTGAGE CORP
FEDERAL NATIONAL MORTGAGE ASSN
RADIAN GROUP INC
AMERICAN INTERNATIONAL GROUP INC
AMBAC FINANCIAL GROUP INC
STEWART W P & CO LTD
M G I C INVESTMENT CORP WIS
WACHOVIA CORP 2ND NEW
HARTFORD FINANCIAL SVCS GROUP IN
X L CAPITAL LTD

Conclusions

- The financial system has become more **complex** as distinctions between hedge funds, insurance companies, banks, and broker/dealers have blurred, thanks to financial innovation and deregulation; greater **interconnectedness**
- We propose measuring systemic risk indirectly via econometric techniques such as **principal components analysis** and **Granger-causality tests**
 - Principal components analysis provides a broad view of commonality among all four groups of financial institutions
 - Granger-causality networks capture the intricate web of dynamic and causal statistical relations among individual firms in the finance and insurance industries

Conclusions

- Using monthly returns for hedge-fund indexes and portfolios of publicly traded banks, insurers, brokers, we show that such indirect measures can:
 - identify periods of market dislocation and distress
 - Serve as **early warning signals**
- Moreover, over the recent sample period, our empirical results suggest that the **banking and insurance sectors** may be more important sources of systemic risk than other financial institutions, which is consistent with the anecdotal evidence from the current financial crisis.

Thank You!

Regime Switching Models

- Sudden regime-shifts in expected returns and volatilities:

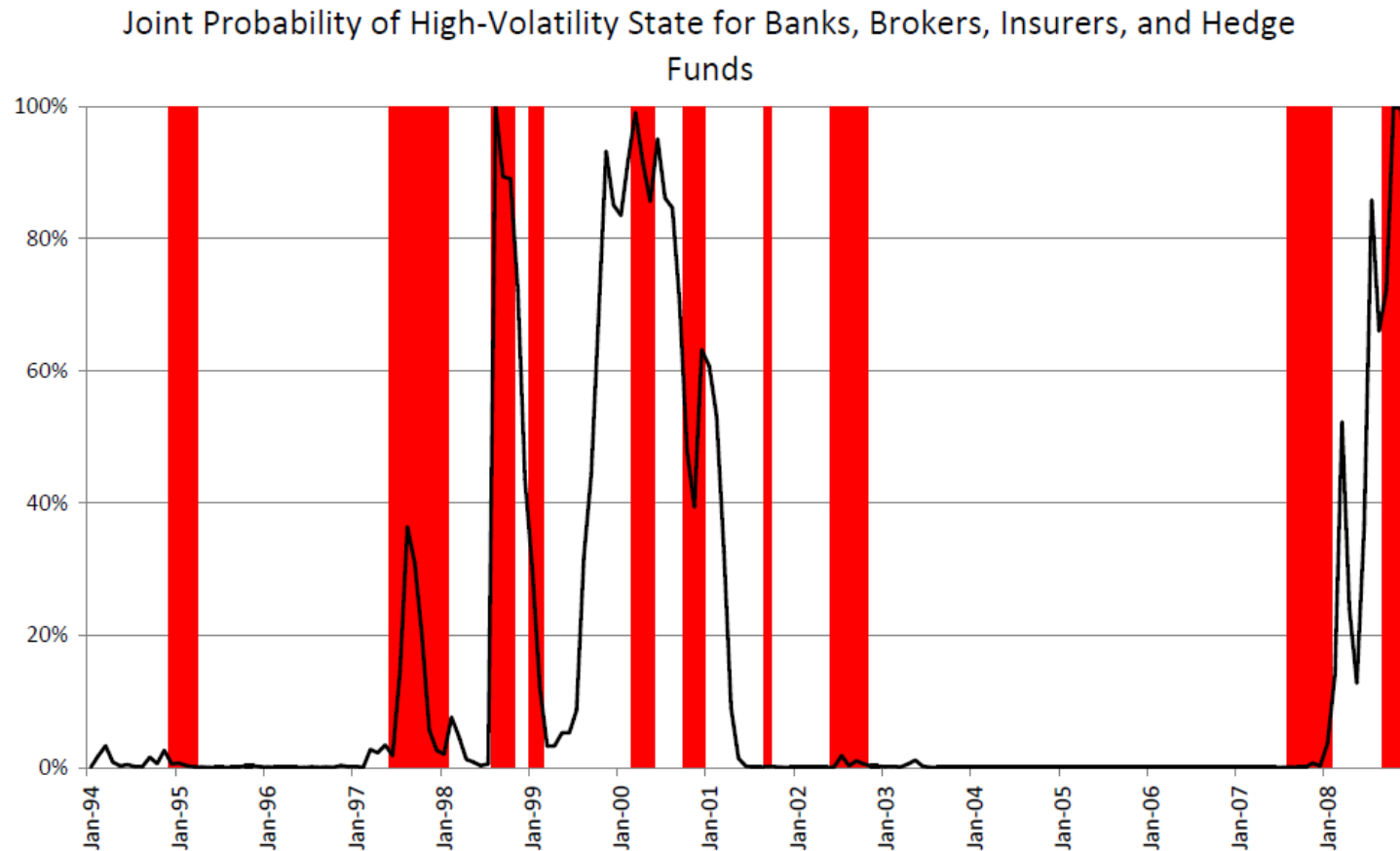
$$R_t^i = \mu_i(Z_{i,t}) + \sigma_i(Z_{i,t})u_t^i$$

- The possibility of switching from a normal to a distressed regime can serve as another measure of systemic risk.
- The joint probability of a high-volatility regime for each index captures stress periods characterized by high volatility for all four types of financial institutions.
- Commonality systemic risk measure may be:

$$J_{p,t} = \prod_{i=1}^m \text{Prob}(Z_{i,t} = 1 | \mathcal{R}_{i,t})$$

- Large $J_{p,t}$ accounts for contagion effects or the fact that the four sectors are all exposed to the same common factor.

Regime Switching Models



Non Linear Granger Causality Tests

- Based on the Granger causality of Markov chains driving financial institutions' means and variances switches.
- Let $Y_t = (S_t, Z_t)$ a Markov chain with transition probabilities

$$\begin{aligned} P(Y_t|Y_{t-1}, \dots, Y_0) &= P(Y_t|Y_{t-1}) = P(S_t, Z_t|S_{t-1}, Z_{t-1}) \\ &= P(S_t|Z_t, S_{t-1}, Z_{t-1}) \times P(Z_t|S_{t-1}, Z_{t-1}) \end{aligned}$$

Non Linear Granger Causality Tests

- We can thus define the strong Granger non-causality for a Markov chain

Z_{t-1} does not strongly cause S_t given S_{t-1}

$$P(S_t | S_{t-1}, Z_{t-1}) = P(S_t | S_{t-1}) \quad \forall t.$$

Similarly, S_{t-1} does not strongly cause Z_t given Z_{t-1}

$$P(Z_t | Z_{t-1}, S_{t-1}) = P(Z_t | Z_{t-1}) \quad \forall t.$$

- And test it via a likelihood ratio test.

Non Linear Granger Causality Tests

- Causal relationships are even stronger if we take into account both the level of the mean and the level of risk of these financial institutions

	Hedge Funds	Brokers	Banks	Insurers
	1994 to 2008			
Hedge Funds		0.0	0.0	0.0
Brokers	0.0		23.7	74.9
Banks	1.7	0.0		78.1
Insurers	6.7	82.0	93.1	

	Hedge Funds	Brokers	Banks	Insurers
	2001 to 2008			
Hedge Funds		0.3	1.3	8.8
Brokers	0.0		0.0	94.2
Banks	21.4	0.7		0.0
Insurers	36.6	0.2	0.0	