Systemic Risk in a Network Context

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Outline

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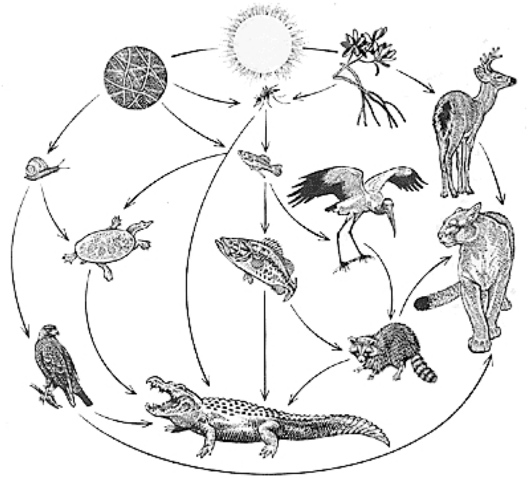
The LTCM Episode

Friends of LTCM

Source: Simon Levin

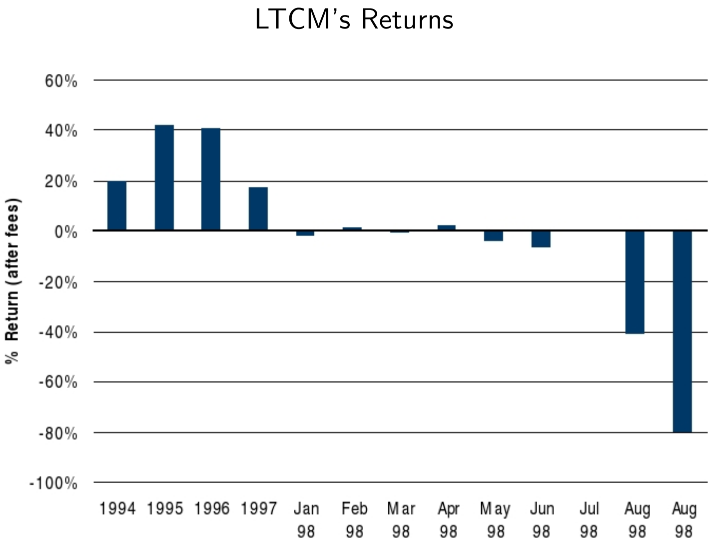
The LTCM Episode (cont'd)

The LTCM Ecosystem



Source: Simon Levin

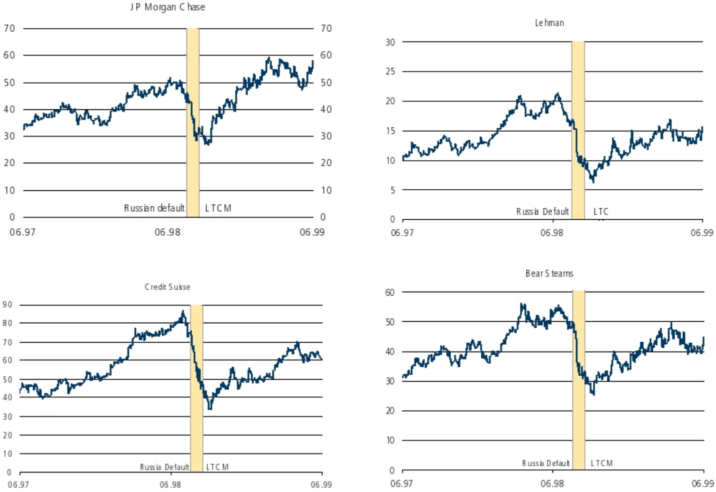
The LTCM Episode (cont'd)



Source: Philippe Jorion

The LTCM Episode (cont'd)

Counterparties' Share Prices



Source: Credit Suisse, Datastream

The LTCM Episode (cont'd)

- Prices moved outside of "normal" ranges and continued to slide
- Normal stabilizers were not working—no new risk capital entered the market (most trying to exit)
- Bank managers were under pressure to avoid risk of further loss
- Forced liquidation of leveraged positions
- Volume (liquidity) declined in many markets, in some cases dramatically
- Rumors of major financial institutions under pressure
- Increase in derivatives exposure and risk of contagion
- Crisis continued for a period, even after LTCM rescue

Background

High concentration of derivatives markets

The largest five dealers among U.S. insured commercial banks held 96.2% of all contracts held by this group (in terms of notional).

Large dealers have high leverage ratios

At the end of 2005, gross credit exposure related to OTC derivatives was about USD 1,866 billion (given a market value of these contracts of USD 10,694 billion). Credit exposure related to derivatives was about 340% of risk-based capital on average at the largest dealers.

OTC derivatives markets have experienced several large credit events

Enron, LTCM, Metallgesellschaft, etc.

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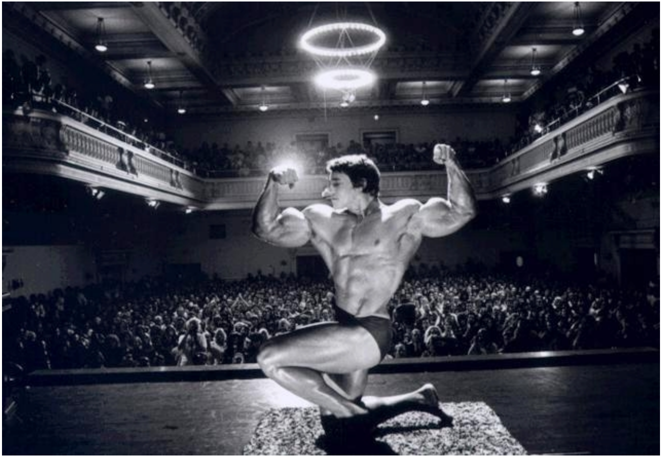
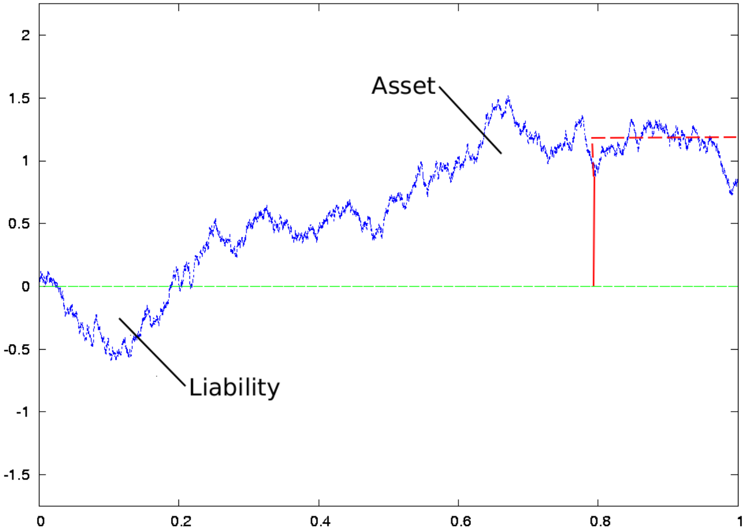
The Traditional View

The stability of the individual financial institutions leads to stability of the financial system.



Source: www.geektimes.com/michael

Credit Exposure and Margining



The Collateral "Trap"

A practitioner's perspective on collateral

The mechanisms by which collateral provides benefit is through improvement of the recovery rate. Collateral does not make it more or less likely that a counterparty will default and does not change the value of a defaulted transaction. (ISDA, 2005)

Collateral usage in OTC markets has grown significantly

At the end of 2005, the largest dealers had about USD 1,209 billion of collateral outstanding. Coverage ranges from about 15% in case of energy contracts to about 48% in case of interest rate contracts.

But: Ambiguous empirical observations

Several credit events in the OTC derivatives markets most likely were triggered by margin calls.

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Outline

Systemic Risk

Claim

Asset values in financial markets are dependent on the structure of the financial system. Therefore, asset values and risks should be analyzed in a systemic context.

Definition

Systemic risk is the risk that the default of one financial institution will trigger defaults of other financial institutions, directly or indirectly.

Contagion channels:

- Direct: bilateral claims (interbank loans, credit lines, derivatives)
- Indirect: asset prices

Structures of Financial Networks

Interbank Payments in the Fedwire Funds Service

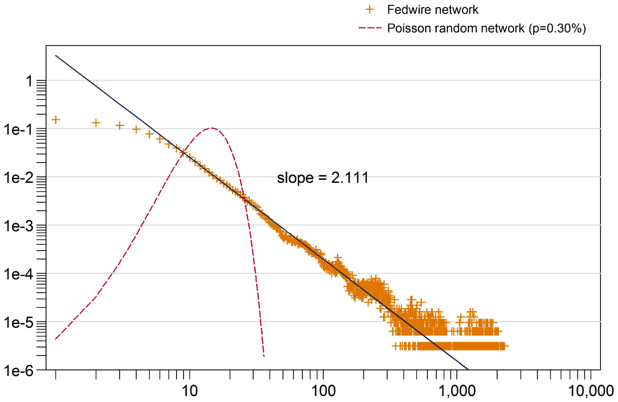
	Mean	Median	Min.	Max.	SD
Payments					
Volume (,000)	436	411	371	644	60.3
Value ($tr)	1.30	1.27	1.13	1.64	0.11
Average ($mn)	3.01	3.06	2.48	3.35	0.20
Components					
GWCC	6,460	6,484	6,355	6,729	83
DC	2	2	0	8	2
GSCC (n)	5,086	5,066	4,914	5,395	123
GIN	527	528	404	645	49
GOUT	774	782	595	916	67
Tendrils	103	103	88	116	7
Connectivity and Reciprocity					
m	76,614	75,397	69,077	94,819	6,151
p (%)	0.3	0.29	0.28	0.33	0.01
r (%)	21.5	21.5	21	23	0.03

	Mean	Median	Min	Max	SD
Distance Measures					
$\langle \ell \rangle$	2.62	2.63	2.56	2.66	0.02
$\langle \varepsilon \rangle$	4.67	4.63	4.18	5.74	0.33
D	6.6	7	6	7	0.5
$M(2)$ (%)	41.6	41.3	38.9	47.3	2.0
$M(3)$ (%)	95.9	95.8	95.1	97.1	0.5
$M(4)$ (%)	99.9	99.9	99.8	100	0.0
Clustering					
$\langle C \rangle$	0.53	0.53	0.51	0.55	0.01
Degree Distribution					
$\langle k \rangle$	15.2	14.8	13.9	17.6	0.8
Max k^{out}	1,922	1,913	1,772	2,269	121
Max k^{in}	2,097	2,070	1,939	2,394	115
$\hat{\gamma}^{out}_{MLE}$	2.11	2.11	2.09	2.14	0.01
$\hat{\gamma}^{in}_{MLE}$	2.15	2.15	2.15	2.18	0.01

Source: Arnold, Bech, Beyeler, Glass, Soramäki (2006)

Structures of Financial Networks (cont'd)

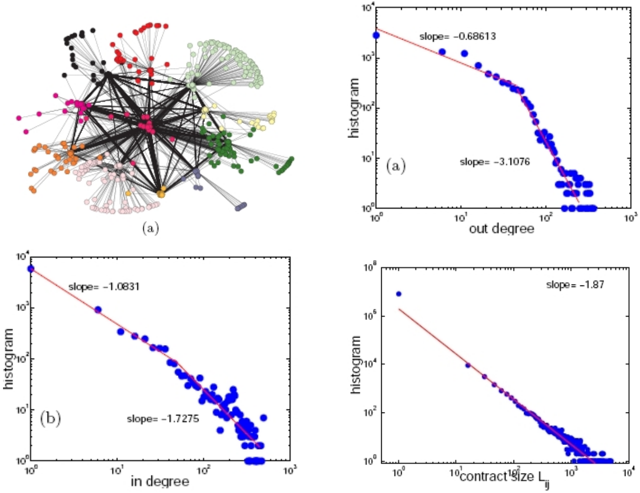
Interbank Payments in the Fedwire Funds Service



Source: Arnold, Bech, Beyeler, Glass, Soramäki (2006)

Structures of Financial Networks (cont'd)

The Austrian Banking System



Source: Thurner, Hanel, Pichler (2003)

Structures of Financial Networks (cont'd)

Bilateral Credit Exposures in the Swiss Banking System

	Interbank liabilities (in bn CHF)					
	Big banks	Cantonal banks	Regional and Raiffeisen banks	Other banks	Foreign banks	Total
Big banks	2.9	5.0	0.5	20.3	45.1	73.7
Cantonal banks	3.4	3.9	0.7	5.0	8.9	22.0
Regional and Raiffeisen banks	1.4	1.4	2.8	3.3	1.4	10.2
Other banks	30.9	7.9	7.1	45.9	23.3	115.0
Foreign banks	137.6	13.2	2.0	6.6	na	159.3
Total	176.3	31.3	13.0	81.1	78.7	380.3

Source: Müller (2005)

Measuring and Valuing Default Risk

Intensity-Based Approach

The value of a defaultable claim X is given by

$$S_t = E_{\mathbb{Q}^*}\left(\int_t^T B_u^{-1} Z_u \tilde{\lambda}_u du + B_T^{-1} X \mathbb{1}_{\{T<\tau\}} \middle| \mathcal{G}_t\right),$$

where B is the price of a risk-free bond, Z is the recovery process, $\tilde{\lambda}_t := \lambda \mathbb{1}_{\{\tau \geq t\}}$, and λ is the default intensity.

Measuring and Valuing Default Risk (cont'd)

Structural Approach

Let B denote the price of a T-maturity zero-coupon bond and

$$B(t, T) = \exp\left(-\int_t^T r(u)du\right), \quad \forall t \in [0, T].$$

Let X denote the face value of debt issued by a firm and A denote its value such that $A_t = E(A_t) + D(A_t, L)$. We assume that A has dynamics

$$dA_t = \left(rdt + \sigma_A dW_t^*\right),$$

where σ_A is the volatility coefficient of the value process. The probability of default of the firm, $\mathbb{P}\{A_t < X\}$, is given by $N(d_t)$ with

$$d_t = \frac{\ln(A_t/X) + (\mu - \frac{1}{2}\sigma_A^2)(T-t)}{\sigma_V\sqrt{T-t}},$$

the firm's *distance-to-default*.

Value in a Systemic Context

Model

Economy:

n investors in financial system

Risky endowments $\{\tilde{w}_i\}$ realized at date T with means $\{w_i\}$

Single fundamental asset with price v

Zero-coupon debt of i with face value $\bar{x}_i$ payable at T

Risk-free interest rate of zero

Balance sheets:

x_i: market value of i's debt

a_i: market value of i's assets

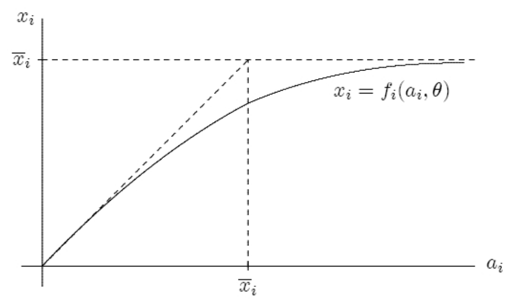
e_i: market value of i's equity, $e_i = a_i + x_i$

If i holds proportion π_{ik} of investor k's debt, then

$$a_i = w_i + y_i v + \sum_k \pi_{ki} x_k .$$

Value in a Systemic Context (cont'd)

Model



Source: Shin (2005)

The value of debt in the financial system, x, can be expressed as a fixed point $x = F(x, \theta)$.

Value in a Systemic Context (cont'd)

Systemic risk

Investor i defaults if

$$a_i = w_i + vy_i + \sum_k \pi_{ki} x_k < x_i = \sum_k \pi_{ik} x_i.$$

For a given structure of liabilities, π, i defaults if

$$w_i(\omega) < \sum_k (\pi_{ik} x_i - \pi_{ki} x_k) - vy_i.$$

Question: For a given π, how does a low realization of $\tilde{w}_i$ affect x and a?
$\Leftrightarrow$ For a given realization of w, how does π affect a?