The Effect of Market Structure on Counterparty Risk

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Summary

I study two network structures of derivative contracts. These represent a bilaterally-cleared OTC market and a centrally-cleared market.

An initial bankruptcy induces counterparties to trade with price impact. The two market structures yield economically different:

- *price impact,*
- *distress-induced volatility, and*
- *follow-on bankruptcies (contagion).*

In a bilateral OTC market, counterparties may push markets farther than needed to recreate their positions.

Can price increased distress volatility in bilateral OTC markets versus centrally-cleared markets. This may suggest when and how to transition markets from bilateral OTC to central clearing.

The results also suggest that monitoring market size, exposure concentrations, and leverage ratios may allow us to infer a market's fragility. Finally, these results suggest that coordination by market authorities has value in times of distress.

Counterparty and Systemic Risk

Counterparty: other side of ongoing financial agreement.

Counterparty risk: Direct risk from counterparty default.

Systemic risk: Indirect risk via effects on overall market.

Central counterparty (CCP): counterparty to all contracts.

Why We Care

Distress increases volatility sharply and significantly.

- Spreads ↑ ⇒ transactions costs ↑; market liquidity ↓.
- Volatility ↑, forced onto survivors (externality).
- Vicious circle of market and funding liquidity.

Crisis bankruptcies also have real costs:

- Reduced funding liquidity affects non-financial firms.
- Less invested in risky assets: allocative inefficiency?
- Many people unemployed at once; complicates job searches.
- Also: Sudden and commensurate drop in tax revenues.

Recent History

Recent failures show range of possibilities:

- Near-bankruptcy: Bear Stearns (May 2008)
- Bankruptcy: Lehman Brothers (Sep 2008)
- Bankruptcy: Refco Inc? (Oct 2005, #1 CME broker)

Outstanding notional at CME before ceasing trading:

Bear	Lehman	Refco LLC
\$761 BB	\$1,150 BB	\$130 BB

Other bankruptcies: Askin Capital and Kidder Peabody (1994), LTCM (1998)

No CME defaults/trade halts for *any* of these events.

No CME defaults due to market distress — *ever*.

Effects of Invalidated Contracts

Suppose counterparty A net long.
⇒ other counterparties net short.

If counterparty A defaults:

- survivors re-create exposure from A.
- Thus survivors of market drop become net sellers.

Resulting trading differs among markets:

- CCP market: only CCP trades; net sell.
- OTC market: some counterparties sell, some buy.
  - Do they rehedge immediately? Push market further?

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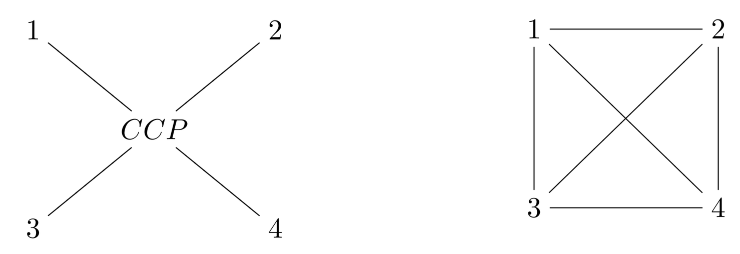
Model

Market Structures

Investigate two extremes of n-counterparty networks.



Star network: Market with CCP   Complete network: Bilateral "OTC" market

Nodes: counterparties (capital K, risk aversion λ).

Edges: swap/futures contracts on a risky asset linking counterparties i, j

Contract exposure: $q_{ij} = -q_{ji}$; $q_{i<j} \overset{iid}{\sim} N(0, \eta^2)$

- Same net exposures in both networks.

Event Timing

Events occur at discrete times:

$t = 0$: Bankruptcy of counterparty n occurs.
Contracts q_{in} invalidated; unwanted exposure forced on survivors.

$t = 1$: Living counterparties trade in response to bankruptcy.

$t = 2$: Living counterparties close out bankruptcy-induced exposure.

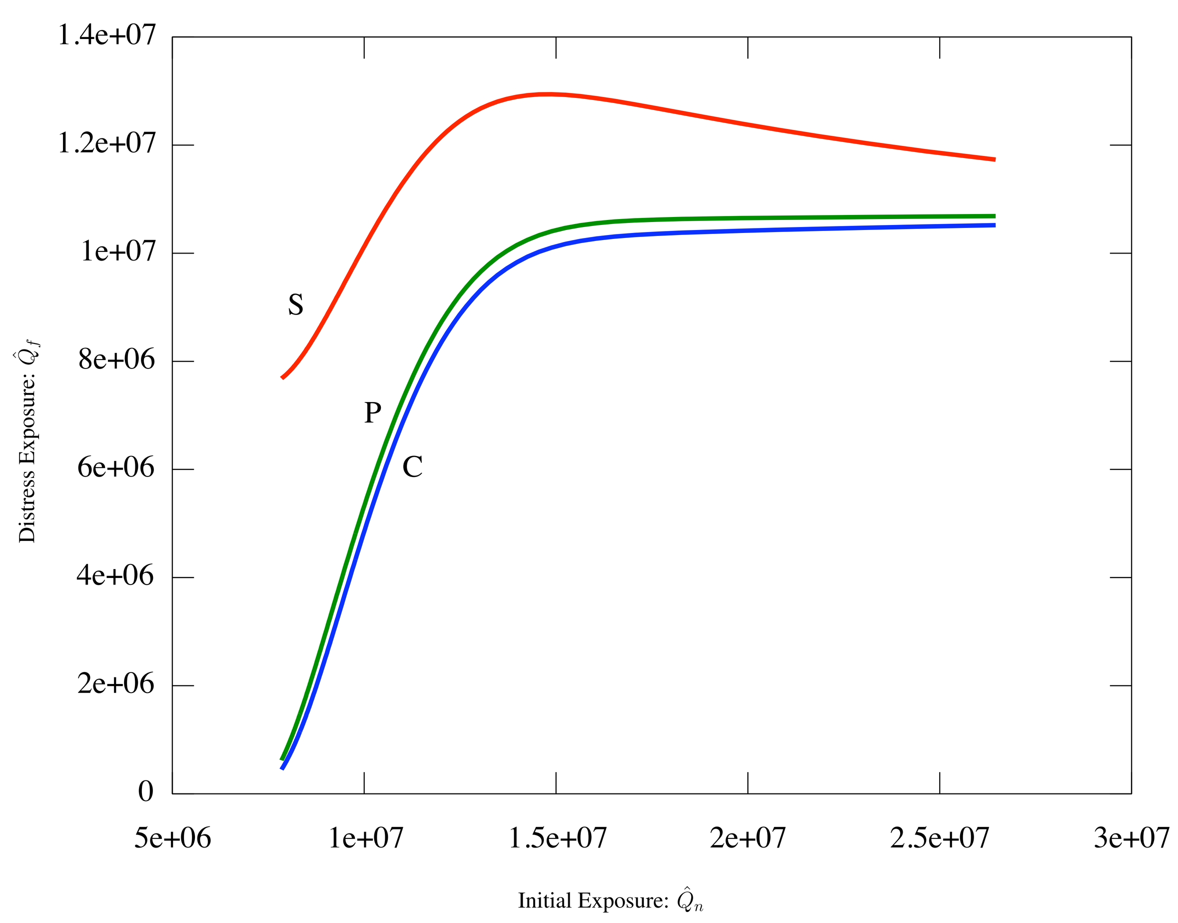
Example: Large Financial Bankruptcy

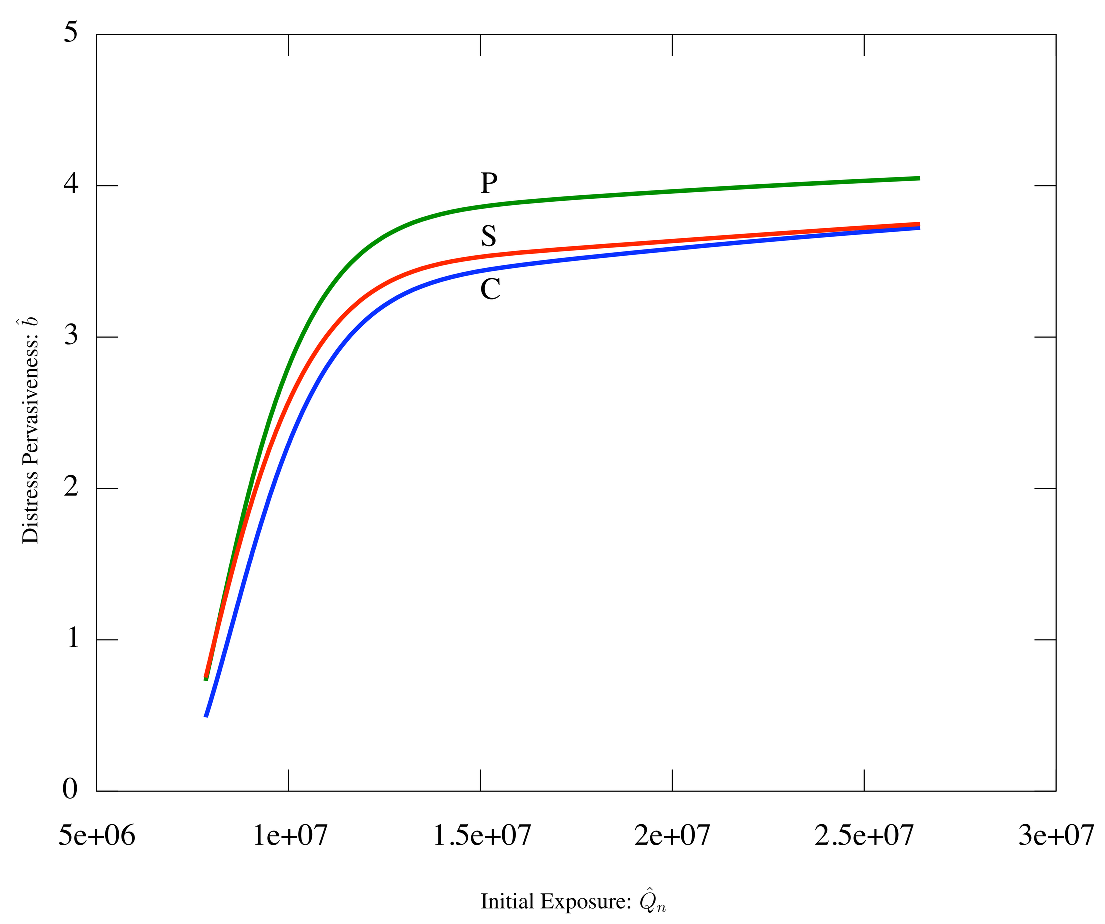
Consider large bankruptcy for market of $n = 10$ counterparties.

Standard deviation of bilateral contract exposure $\eta = 1,000,000$.

Risky asset: currently at \$50; 30% annual volatility.

For All Initial Exposures





Lines: (**C**)CP; (**P**)ooled OTC; (**S**)eparated OTC

$P - S$: Envelopes of distress exposure, pervasiveness

For a Specific Initial Exposure

Suppose $\hat{Q}_n$ = 10,000,000; GARCH variance decay of 0.9.

	(C)CP	(P)ooled OTC	(S)eparate OTC
E(price impact)	−\$30	−\$31	−\$41
Instantaneous volatility	38%	328%	596%
Effective volatility	30%	146%	268%

Notation

n = the number of counterparties;
q_{ij} = exposure of counterparty i to j via contract;
Q_n = net exposure of initially-bankrupted counterparty;
r_0 = market move in period of initial bankruptcy;
$\hat{Q}_n$ = extreme-value theory estimate of $Q_n | r_0$;
$\hat{Q}_f$ = *distress exposure*: E(follow-on bankruptcy exposure);
$\hat{b}$ = *distress pervasiveness*: E(# follow-on bankruptcies).

Price Evolution Dynamics

1. Trading in a period is ordered randomly, not strategic.
2. Trading incurs linear (arbitrage-free) permanent impact.
3. Trade ordering, price impact create low and high prices.
4. Short time periods: 0 price drift, Gaussian diffusion.

Large Financial Bankruptcy

Assume large market move r_0 at $t = 0$ induces bankruptcy.

Maximum-likelihood exposure $\hat{Q}_n$ to rehedge given r_0.

- Survivors have perfect information of $\hat{Q}_n$ (via EVT).
- Anticipate follow-on bankruptcy exposure $\hat{Q}_f$.

For bilateral OTC market, all counterparties may trade.

- Trouble: overtrading (at $t = 1$) to be expected.
- Longs, shorts may self-segregate rehedge timing.

Bad Behavior

Proposition 1 (Checkmate) *A large enough initial bankruptcy may yield a follow-on bankruptcy in expectation — despite any finite effort by the troubled counterparty.*

Proposition 2 (Hunting) *For a complete network of 3 or more counterparties and a large enough initial bankruptcy, two or more other counterparties may profit by driving a survivor into (follow-on) bankruptcy.*

A Separating Equilibrium?

An extreme possibility exists in bilateral OTC markets: Buyers and sellers may separate when they trade.

1. Those on same side as net rehedge rush to hedge first.
2. Those on other side wait to allow maximum distress.

If net rehedge makes sellers panic, net sale in period 1 is:

$$-E\Big(\sum_{i=1}^{n-1}[x_i]^-\Big|\sum_{i=1}^{n-1} x_i = -\hat{Q}_n - \hat{Q}_f\Big) \tag{1}$$

$$\approx -(n-1)^{3/2}\eta\phi(\mu^*) - (\hat{Q}_n + \hat{Q}_f)(1 - \Phi(\mu^*)) \tag{2}$$

where $\mu^* = \frac{\hat{Q}_n + \hat{Q}_f}{(n-1)^{3/2}\eta}$ (net rehedge in std devs/survivor) and ϕ, Φ are standard normal pdf, cdf.

Real Effects

Suppose $\hat{Q}_n$ = 10 MM, market size of \$40 MM[1].

If 8% equity premium and mean risk aversion of $\hat{\lambda} = 3$:

- Equilibrium allocation to risky asset: 29% (71% cash).
- Post-crisis: 19% (CCP), 1.2% (OTC pool), 0.4% (OTC sep).

Cost of distress externality:

- \$3.2MM (CCP), \$123 MM (OTC pool), \$425 MM (OTC sep).
- Cost of OTC market distress is 3–11× market size.

Given 2–3 bankruptcies; mean employees, compensation:

- 260,000–400,000 unemployed; \$33–\$49 billion pay loss.
- At 40% total taxes: revenue loss of \$13–\$20 billion.

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