Market Structure, Counterparty Risk, and Systemic Risk

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Counterparty Risk

- *Counterparty*: other side of ongoing financial agreement.
  - A bank enters into a swap with you on the S&P 500.
- Counterparty Risk
  - Risk resulting from default/bankruptcy of a counterparty.
  - Strictly: Risk to you from one of your counterparties.
  - Broadly: Includes effects on overall market (our concern).
- This broad definition we refere to as *systemic risk*.

Counterparty Risk to Systemic Risk

- Counterparty risk affects market when large failure looms:
  - Near-bankruptcy of Bear Stearns (May 2008)
  - Bankruptcy of Lehman Brothers (Sep 2008)
  - Bankruptcy of Refco Inc? (Oct 2005, owned #1 CME broker)
- Outstanding notional at CME before ceasing trading:

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

  - N.B. No defaults or trade halts at CME for these events.
- Other bankruptcies: Askin (1994), LTCM (1998, why I care).
- Is counterparty risk an "accelerant" in financial crises?
  - (Yes.) So why couldn't CRWG define counterparty risk?

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Systemic Risk

- Distress increases volatility sharply and significantly.
  - Widens spreads: transactions costs ↑; market liquidity ↓.
  - Volatility is pushed onto the survivors (externality).
- Crisis bankruptcies have real costs:
  - Virtuous, vicious circles of market and funding liquidity[2].
  - Reduced funding liquidity affects non-financial firms also.
  - Less invested in risky assets; allocative inefficiency?
  - Higher unemployment: harder job searches, lower tax revenue.
  - Bernanke (1983): affects credit markets; possible depression.

[2] Brunnemeier and Pedersen (2009).

Results Preview

- Market structure affects contagion and exposure to defaults.
- Specifically: complete networks magnify systemic risk.
  - Disagrees with Allen and Gale (2000), Nier et al (2007).
  - Differing creation of complete networks.
  - Unnetted rehedging lets buyers, sellers create chaos.
- However, cannot eliminate counterparty or systemic risk.
- Tool to estimate market fragility. (not about network genesis)
  - Fragility estimable with a few metrics of market core.
  - Can price distress volatility of differing structures.

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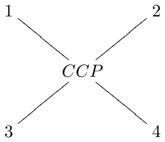
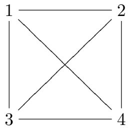
Model: Market Structures

- Investigate two extremes of *n*-counterparty networks.



Star network
(Market with CCP[3])



Complete network
(Bilateral "OTC" market)

- Each node is a counterparty (capital K, risk aversion λ).
- Each edge is a contract[4] linking counterparties i and j
- Contract exposure: $q_{ij} = -q_{ji}$; $q_{i<j} \overset{iid}{\sim} N(0, \eta^2)$
- Counterparty i's net exposure[5]: $Q_i = \sum_{j \neq i} q_{ij}$.
- Same net exposures (Q_i's) in both networks.

[3]Central counterparty.

[4]A swap or forward on a risky asset.

[5]This is where Diamond & Gale went wrong.

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Model: Event Timing

To study counterparty risk, events occur at discrete times.

$t = 0$: Bankruptcy of counterparty n occurs.

- All contracts with counterparty n are invalidated.
- Pushes unwanted exposure onto other $n - 1$ counterparties.

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

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

Order of trading in a period is random, not strategic.

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Model: Price Impact of Trading

- Each counterparty i trades shares at times $t = 1, 2$.
- Huberman and Stanzl (2004) arbitrage-free price impact.
  - Impact has linear permanent component[6].
  - Permanent component impacts prices for later traders.
- Trade ordering, price impact create low and high prices.
- Time periods are very short; two simplifying assumptions:
  1. Prices have no drift other than price impact due to trading.
  2. Price diffusion is Gaussian (not log-normal).
- Impact would be worse if it reflected counterparty risk fears.

[6] Price impact could arise from inventory risk cost, non-crisis adverse selection.

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Effects of Invalidated Contracts

- Suppose counterparty A is net long the market.
- $\Rightarrow$ Other counterparties are net short the market.
- These are their preferred equilibrium positions.
- Thus when counterparty A defaults:
  - Survivors must re-create exposure from counterparty A.
  - Survivors become net sellers.
- CCP market: only CCP trades; net sell.
- OTC market: some counterparties will sell, some will buy.
- However, counterparties trade in own interest.
  - Do they rehedge immediately? Push market further?

Large Bankruptcy

- Consider bankruptcy of a large financial firm.
- Assume large market move r_0 at $t = 0$ induces bankruptcy.
- Net exposure Q_n probably large; may estimate via EVT[7].
  - Trading at $t = 1, 2$ will move market a lot.
- Move will be further in direction that caused bankruptcy.
- This raises two distressing possibilities:
  - Contagion: move may cause other counterparties to fail; or,
  - Checkmate: hedging may bankrupt the hedger.
- Bilateral OTC: Counterparties anticipate this, trade selfishly.
  - All hedge anticipated follow-on bankruptcy exposure $\hat{Q}_f$.
  - Longs, shorts may largely self-segregate rehedge timing.
- Thus network structure matters.

[7] Equivalent: endow counterparties with perfect information, examine most likely $Q_n | r_0$.

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Large Bankruptcy: Equilibrium Trade

- CCP anticipates follow-on bankruptcies $\Rightarrow$ equilibrium trade.
- OTC traders anticipate one another, follow-on bankruptcies.
  - However: buyers, sellers may separate when they trade.
  - Those same side as net rehedge (most at-risk) rehedge first.
  - Those on other side wait to allow maximum distress.
  - Random trade sequence $\Rightarrow$ uncertain low price.
  - Use all these to solve for equilibrium OTC net trade.
- In both cases, can estimate two key quantities:
  - Follow-on bankruptcy exposure $\hat{Q}_f$ (distress exposure):
  - # follow-on bankruptcies $\hat{b}$ (distress pervasiveness):

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Strategic Trading: All Together Now?

Proposition (Pooling)

In bilateral OTC markets, buyers and seller may split their trades between periods 1 and 2 according to cost minimization. This pooling of buying and selling is a Bayesian Nash equilibrium.

Proposition (Separating)

In bilateral OTC markets, buyers and sellers may separate with buyers in one period and sellers in the other period. This separating of trade timing is a Bayesian Nash equilibrium.

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Bad Behavior? Checkmate and Hunting

Proposition (Checkmate)

A large enough initial bankruptcy may yield a follow-on bankruptcy in expectation — despite any finite effort by the troubled counterparty.

Proposition (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.

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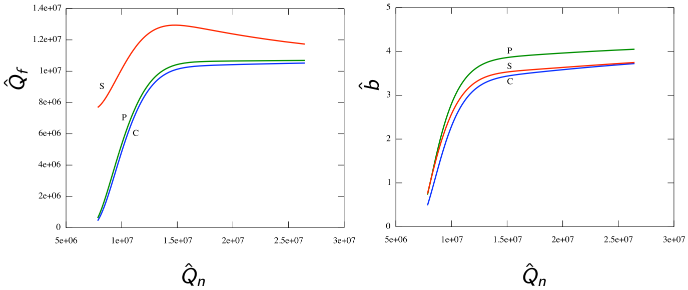
Large Bankruptcies: Indicative Distress

- Consider large bankruptcy for $n = 10$ counterparties[8].
- Std deviation of bilateral contract exposure $\eta = 1,000,000$.
- Distress exposure $\hat{Q}_f$ and pervasiveness $\hat{b}$ vs. $\hat{Q}_n$.



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

$C - P \vee S$: *Distress envelopes: exposure, pervasiveness*

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[8] Price impact parameters are as in Almgren and Chriss (2001).

Large Bankruptcies: From Market Impact to Real Effects

- Suppose $\hat{Q}_n = \$10$ MM; GARCH variance decay $= 0.9$.
- For CCP market, E(market impact) $= -\$30$.
  - Effective annual volatility goes from 30% to 38%.
- Pooled OTC buyers, E(market impact) $= -\$31$.
  - Annual volatility $\uparrow$ to 328% (instant.), 146% (effective).
- OTC buyers, sellers separate: E(market impact) $= -\$41$.
  - Annual volatility $\uparrow$ to 596% (instant.), 268% (effective).
- \$40 MM mkt size[9], 8% eq premium, avg risk aversion $\hat{\lambda} = 3$.
  - 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$\times$ market size.

[9] Approximately $2(\hat{Q}_n + \hat{Q}_f)$.

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Large Bankruptcies: Not So Random

- Complete networks admit two destabilizing events:
  - Checkmate: weak counterparty may have no beneficial trade.
  - Hunting: counterparties force others into bankruptcy.
- Worse, hunting is a full equilibrium behavior.
  - Market may be pushed far beyond one follow-on bankruptcy.
- Are counterparties selfishly amoral/evil? Maybe not.
  - Trade amount may pre-hedge expected follow-on bankruptcies.
  - This reduces surprise need for trading in period 2.
- CCP markets have fewer such destabilizing events.
  - Suggests central clearing reduces OTC market volatility.
- If traders fear CCP may fail, result here is best case:
  - Result probably lies somewhere inside distress envelope.

Conclusion

- Even small bankruptcies temporarily increase volatility.
- For a large bankruptcy in a bilateral OTC market:
  - Counterparties may be unable to save themselves (checkmate).
  - Counterparties may hunt their weakest peers for profit.
  - Volatility externality (and thus cost) higher than CCP market.
- Self-segregating buyers, sellers in OTC markets can be nasty:
  - Externality distress cost $\gg$ market size. (market failure!)
- Suggests benefits to centralized clearing in OTC markets[10].
- Volatility externality cost $\Rightarrow$ when to move markets to CCP.
- Three metrics may tell us when markets are more/less brittle.
  - $n = \#$ counterparties in market core (complete network);
  - $\bar{K}$ = mean capital for core counterparties; and,
  - $\eta =$ std deviation of core counterparties risk exposure.

[10] Biais, Heider, Hoerova (2011) suggests CCP is capital efficient.

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P.S. Difference from Allen and Gale (2000)

- Allen and Gale (2000): complete networks are more robust.
- I disagree: complete networks are more fragile.
- Why? Differing methods of network construction.
- Allen and Gale approach: top-down.
  - Net exposure: $Q_i \overset{iid}{\sim} N(0, (n-1)\eta^2)$
  - Contract exposure: $q_{ij} = Q_i/(n-1)$. (all same sign)
- My approach: bottom-up.
  - Contract exposure: $q_{i<j} \overset{iid}{\sim} N(0, \eta^2)$; $q_{ij} = -q_{ji}$;
  - Net exposure: $Q_i = \sum_{j \neq i} q_{ij}$; $Q_i \overset{iid}{\sim} N(0, (n-1)\eta^2)$.
- Same net exposures Q_i's, different contract exposures q_{ij}'s.
- Strategic separation of buyers, sellers unlikely in A&G.

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