Counterparty risk externality: Centralized versus over-the-counter markets

Viral Acharya Alberto Bisin

NYU-Stern, CEPR and NBER NYU and NBER

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Introduction

- OTC markets have often been at the center of systemic risk.
- E.g., Bear Stearns, Lehman Brothers and A.I.G.
- While ex post contagion was clearly an issue, the build up of ex ante positions seemed also troublesome, especially in case of A.I.G.
- Were OTC contracts sufficiently conditioned on counterparty risk?
- Was that even possible?
- This paper compares OTC markets to centralized ones, highlighting an important negative externality of OTC markets due to *opacity*.

Counterparty risk externality (Acharya and Engle, 2009)

- If A sells insurance to B, turns around and sells insurance to C, then unless the two risks being insured are uncorrelated, the second trade dilutes the value of B's insurance.
- Key question: Does the market structure enable/allow participants to internalize the externality?
- As otherwise, A may have incentives to keep selling insurance, collect upfront premia and default ex post.
- Answer: Depends on whether B can condition the insurance price from A on what else A sells. Typically, in OTC markets this is not possible. This is what we mean by *opacity of OTC markets.*

Summary of results

- We develop a GE setup with default (Geanakoplos, 1997, Geanakoplos-Zame, 1998, Dubey-Geanakoplos-Shubik, 2005) to formalize counterparty risk externality and OTC markets.

1. Centralized clearing with transparency is constrained efficient.
2. OTC market is in general not and is characterized by excessive “leverage” (short positions) and counterparty risk.
3. Collateral constraints can restrict default but may constrain risk-sharing too much; Subordination of OTC claims in bankruptcy limit externality to centralized positions but there is still counterparty risk externality in OTC.
4. Production economy; Centralized counterparty (exchange).

Framework for thinking through the results

- Arrow (1970): externalities, missing markets, over-production of "commodities" that feature externalities.
- Underlying causes of externalities:
  1. Lack of commitment (property rights): Primary rationale for observing default.
  2. Transaction costs: Operational costs (e.g., of providing transparency, setting up of clearing platforms, etc.)
  3. Monopolies or oligopolies: Small number of buyers and sellers.
  4. Information issues: Bargaining with private information.
- This paper: Relies on lack of commitment and assumes transaction costs (implicitly) while analyzing different market structures (OTC, centralized clearing, transparency, exchange).

Example I - The exchange economy

- $t = 0, 1$.
- Agents $i = 1, 2, 3$.
- State of the world at date 1 is $s = G, B$ with probability p and $(1-p)$, respectively.

- Mean-variance utility:

$$E[u(x_0, x(s)] = x_0 + E(x(s)) - \frac{\gamma}{2} var(x(s))$$

- 1 *and* 2 *have endowment in* G *but none in* B; *the opposite for* 3:

$$\begin{aligned} w^1(G) &> w^2(G) > w^3(G) = 0, \\ w^1(B) &= w^2(B) = 0 < w^3(B). \end{aligned}$$

Example - Financial markets

- Trading is over-the-counter (OTC).
- Only financial claim is an insurance contract with

  nominal payoff: $R(G) = 0$ and $R(B) = R > 0$,
  actual payoff in state B: $R^{+} \leq R$,
  price per unit of insurance: q (not a schedule).

- The only agent who can default is 3, from whom 1 and 2 purchase insurance.
- To limit the size of short positions, default is assumed to have a (possibly small) direct deadweight cost with a pecuniary equivalent ε that is proportional on the positions defaulted upon.
  - Recourse to non-pledgeable endowments and franchise values.

Example - Default condition

- Trading positions are $(z^1, z^2, z^3) > 0$.
- Payoffs:

$$(x_0^1, x_0^2, x_0^3) = (w_0^1 - z^1 q, w_0^2 - z^2 q, w_0^3 + z^3 q),$$

$$[x^1(G), x^2(G), x^3(G)] = [w^1(G), w^2(G), w^3(G)], \text{ and}$$

$$[x^1(B), x^2(B), x^3(B)] = [R^+ z^1, R^+ z^2, w^3(B) - R^+ z^3 - \epsilon z^3 1_D],$$

- 1_D is an indicator variable for default $(R^+ < R)$.
- Equivalently, $x^3(B) = \max(w^3(B) - Rz^3, -\epsilon z^3)$.

Example - Equilibrium

Trading positions, price and payoff, (z^1, z^2, z^3, R^+, q), such that:

1. Each agent maximizes its expected utility by choosing its trade positions;
2. Market for insurance clears: $z^3 = z^1 + z^2$; and,
3. Bankruptcy: pro-rata sharing of agents 3's endowment between long positions:

$$R^+ = \begin{cases} \frac{w^3(B)}{z^1+z^2} & \text{if } 1_D = 1 \\ R & \text{else} \end{cases}$$

Example - Equilibrium (cont'd)

- Agent 1's maximization problem:

$$max_{z^1}\ w_0^1 - z^1 q + pw^1(G) + (1-p)R^+ z^1 - \frac{\gamma}{2} var(x^1(s)),$$

where

$$var(x^1(s)) = p(1-p)[w^1(G) - R^+ z^1]^2.$$

- The first-order condition for agent 1 implies that:

$$z^1(R^+, q) = \frac{1}{R^+}\left[w^1(G) - \frac{\Delta p}{\gamma p(1-p)}\right]. \qquad (1)$$

- Define "risk premium" $\Delta p \equiv [\frac{q}{R^+} - (1-p)]$.

Example - Equilibrium (cont'd)

- Agent 3's problem assuming No Default:

$$max_{z^3}\ w_0^3 + z^3 q + (1-p)[w^3(B) - Rz^3] - \frac{\gamma}{2} p(1-p)[w^3(B) - Rz^3]^2,$$

which yields

$$z_{ND}^3 = \frac{1}{R}\left[w^3(B) + \frac{\Delta p}{\gamma p(1-p)}\right]. \tag{2}$$

- If $\epsilon = 0$, there will be no default in equilibrium if and only if

$$w^3(B) \geq Rz_{ND}^3,$$

- This requires that $\Delta p \leq 0$ or $q \leq (1-p)R$: there is no "risk premium" in the insurance price.
- This will not hold in equilibrium if the insurance is against a risk that is aggregate in nature: $w^1(G) + w^2(G) > w^3(B)$.

Example - Equilibrium (cont'd)

- The problem of agent 3 when there is Default:

$$max_{z^3}\ w_0^3 + z^3 q - (1-p)\epsilon z^3 - \frac{\gamma}{2} p(1-p)(\epsilon z^3)^2.$$

- The insurer pledges the entire endowment in the bad state at $t = 1$ in order to collect as much insurance premium as possible at $t = 0$.
- From the first-order condition, we obtain that

$$z^3 = \frac{q - (1-p)\epsilon}{\gamma p(1-p)\epsilon^2}. \qquad (3)$$

- The lower the cost of default ϵ and greater the price of insurance q, the greater is the quantity of insurance supplied by the insurers.
- Clear markets to determine R^+ and Δp: both are increasing in ϵ.

Numerical example

$$
\begin{aligned}
w^1(G) &= 10,\ w^2(G) = 5,\ w^3(B) = 10, \\
p &= 0.9,\ \epsilon \text{ in the range } [0.1, 1.0]
\end{aligned}
$$

- Figures 1, 2 and 3 plot respectively z^3,R^+, and q, as a function of ϵ.
- Default takes place only for ϵ below ≈ 0.548.
- The smaller the ϵ, the larger is z^3 (insurance sold), default risk, and the smaller is q (default is rationally anticipated).
- Figure 4 plots the equilibrium utilities.
- Equilibrium risk-sharing is effectively independent of ϵ.
- The inefficiency stems from excessive leverage and excessive default.
- Planner: Can put a "position limit" (non-linear, exclusive pricing).
- In general, transparency and centralized counterparties can deal with counterparty risk externality.

Figure 1: The quantity of insurance sold (z^3) as a function of the deadweight cost of default (ε)

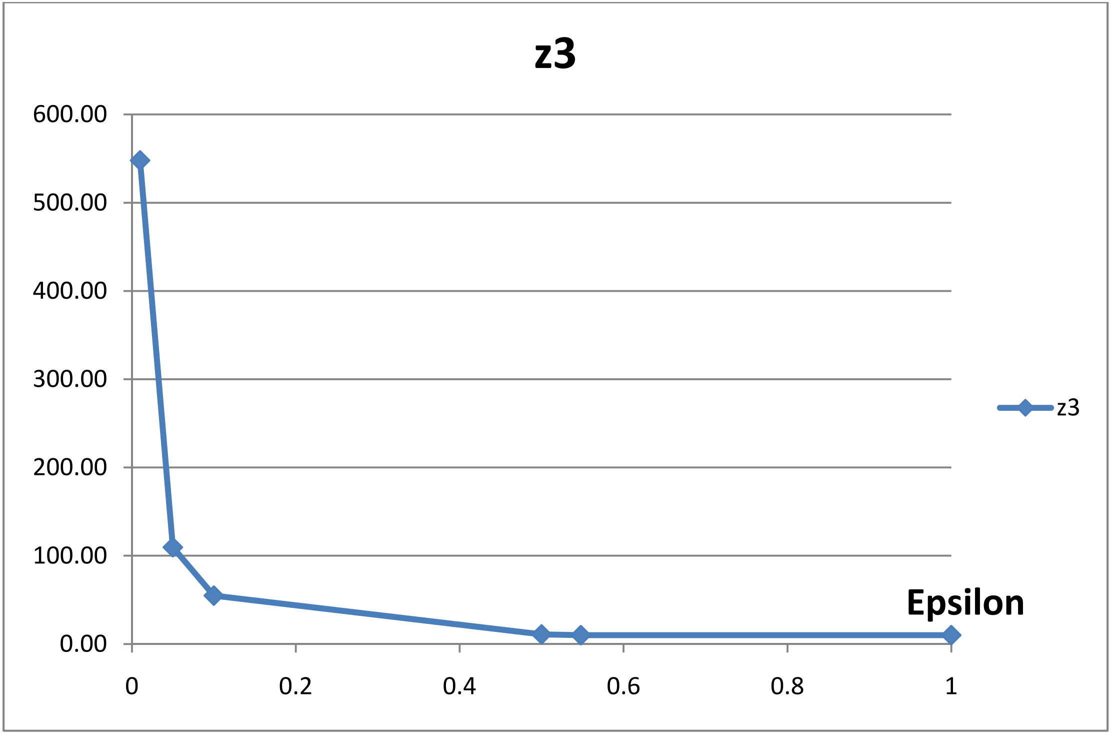


Figure 2: The realized payoff on the insurance (R^+) as a function of the deadweight cost of default (ε)

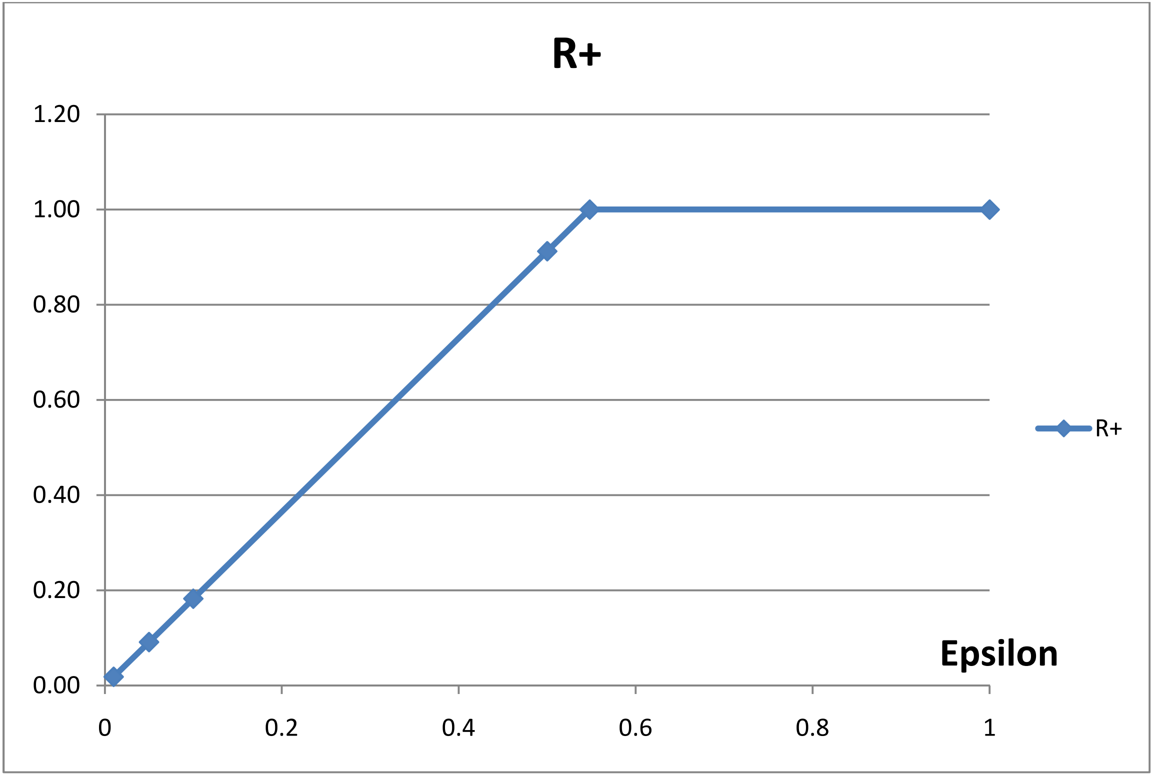


Figure 3: The equilibrium price of insurance (q) as a function of the deadweight cost of default (ε)

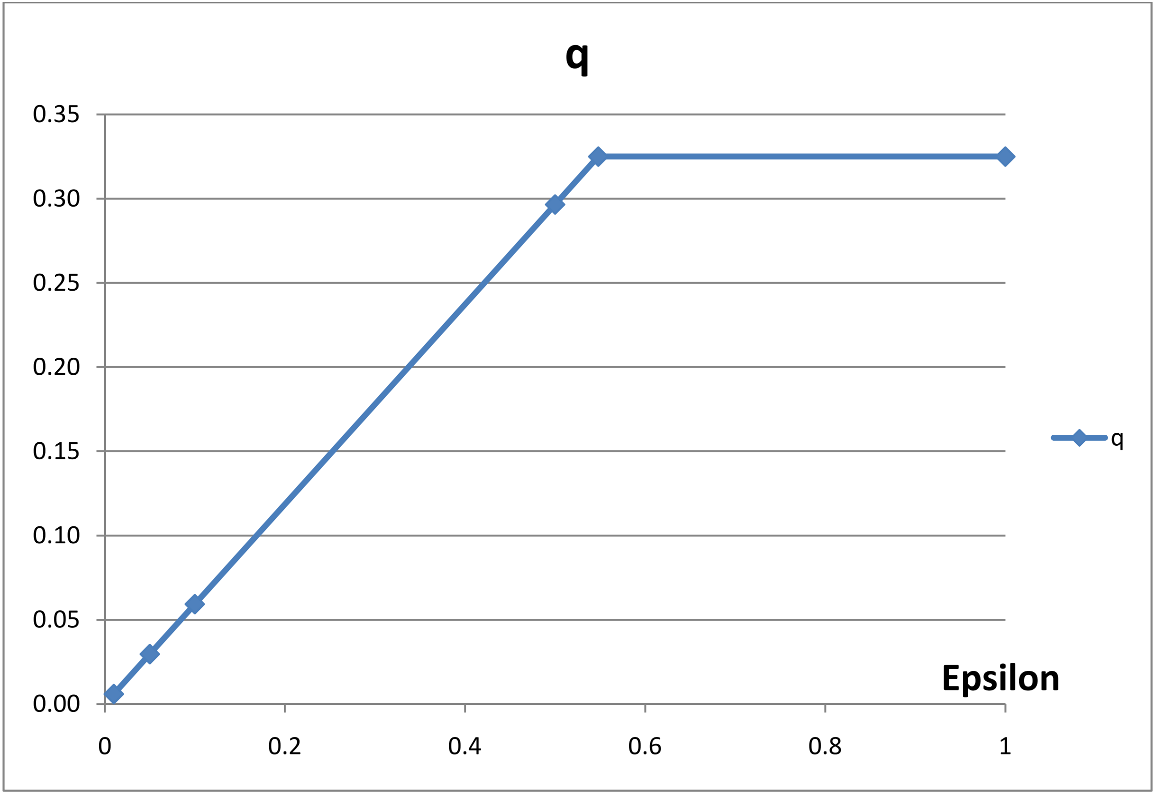
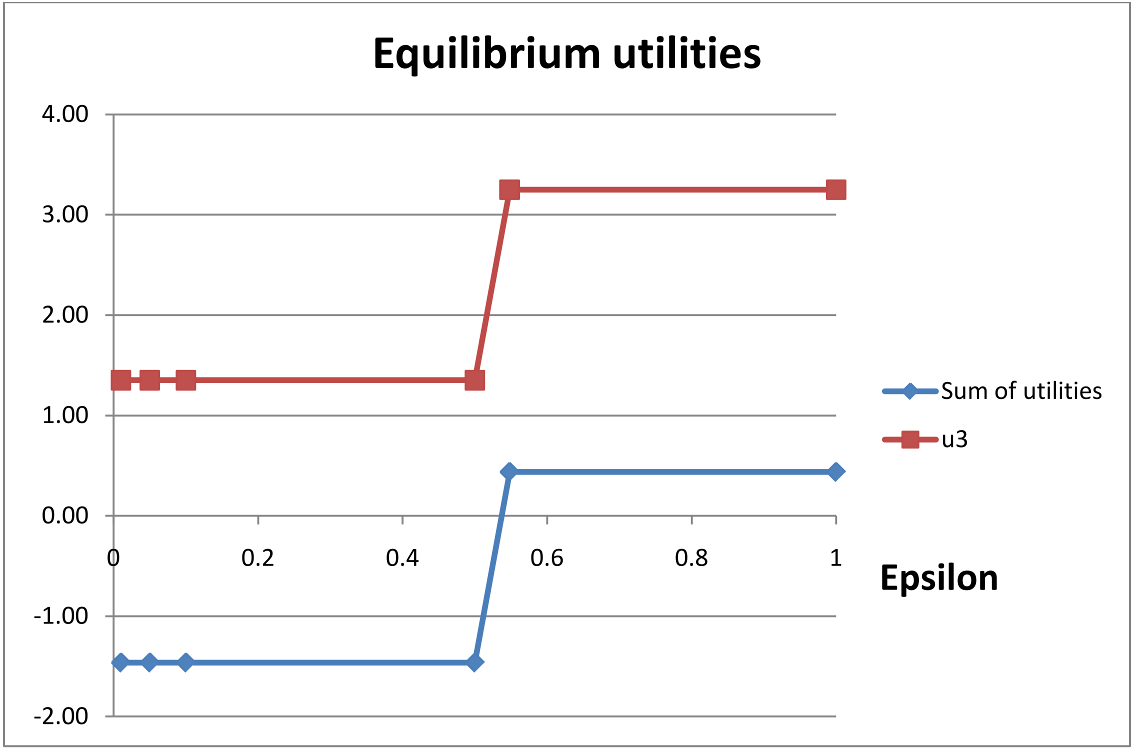


Figure 4: The equilibrium utilities as a function of the deadweight cost of default (ε)



Example II - The production economy

- Suppose there is no aggregate risk in endowments: $w^1(G) + w^2(G) = w^3(B)$.
- Instead endow agents 1 with production.
- Incur a cost $c(k)$ and produce return $f(G) > f(B)$.
- There is a "hedging risk premium" instead of "aggregate risk premium".
- Hedging is beneficial as it facilitates investment, but hedgers do not internalize the deadweight costs of insurer's default.
- In equilibrium, counterparty risk externality gives rise to excessive production relative to costs of hedging.

Model

- Agents, states and endowments:
  - $i = 1, ..., I$ types of agents
  - $s = 1, ..., S$ denote the states of uncertainty in the economy, which are realized at time 1. State s occurs with probability p_s, $\sum_s p_s = 1$.
  - w_0^i be the endowment of agent i at time 0; and $w_1^i(s)$ her endowment at time 1 in state s.
  - x_0^i be consumption of agent i at time 0; $x_1^i(s)$ be agent i's consumption at time 1 in state s.
  - The utility of agent i is denoted as $u^i(x_0^i, x_1^i(s))$.

Financial asset, trading and default risk

- For simplicity, only one financial asset is traded whose payoff is R, an exogenous non-negative vector in S (for example, a CDS contract).
- z_+^{ij} are the long positions of agent i sold by agents j.
- z_-^i are the short positions of agent i.
- In the event of default, counterparties holding long positions on the asset with the defaulting party (say i) have recourse only to a fraction $\alpha \in [0, 1]$ of the debtor's endowment $w_1^i(s)$.
- To limit the size of short positions, default is assumed to have a small direct deadweight cost εz_-^i that is proportional on the position defaulted upon.

Financial asset, trading and default risk (cont'd)

- Bankruptcy resolution: Pool recovery on all defaulting short positions and distributes pro-rata to all long positions.

- Default condition for short position (without netting):

$$w_1^i(s) + \sum_j R^j(s) z_+^{ij} - R(s) z_-^i < (1-\alpha)\, w_1^i(s) - \varepsilon z_-^i \ . \qquad (4)$$

- Agent i's short position payoffs are now written as

$$R^i(\mathbf{z}_+^i, z_-^i; s) = \begin{cases} \frac{\alpha w_1^i(s)}{z_-^i} \ \textit{if} \ I^d(\mathbf{z}_+^i, z_-^i; i, s) = 1 \\ R(s) \text{ otherwise} \end{cases} \qquad (5)$$

- No-netting externality: Default decision of agent i depends upon payoff on its long positions with agent j, that is, on the default decision of agent j.

Eliminating no-netting externality

- Bilateral netting:

$$z_+^{ij} z_-^i = 0, \text{ for any } j. \tag{6}$$

- Default condition for short position with netting:

$$w_1^i(s) - R(s) z_-^i < (1-\alpha)\, w_1^i(s) - \varepsilon z_-^i \ . \tag{7}$$

- Agent i's short position payoffs are now written as

$$R^i(z_-^i; s) = \begin{cases} \frac{\alpha w_1^i(s)}{z_-^i} \text{ if } I^d(z_-^i; i, s) = 1 \\ R(s) \text{ otherwise} \end{cases} \tag{8}$$

Competitive equilibrium of OTC markets

- There is no centralized clearing and disclosure, nor any centralized counterparty that sees all trades.
  - Trades of each agent i, $(\mathbf{z}^i_+, z^i_-)$, are *not* observed by other agents.

- Hence, price of short position sold by agent j is simply q^j.

- Budget constraints:

$$x^i_0 + \sum_j q^j z^{ij}_+ - q^i z^i_- = w^i_0,$$
$$x^i_1(s) = \max\left\{ w^i_1(s) + \sum_j R^j(s) z^{ij}_+ - R(s) z^i_-, (1-\alpha)\, w^i_1(s) - \varepsilon z^i_- \right\} \tag{9}$$

- Markets clear:

$$\sum_i z^{ij}_+ - z^j_- = 0, \text{ for any } j. \tag{10}$$

- Prices are rational:

$$q^j = \max_i E\left(m^i R^j\right), \text{ for any } j. \tag{11}$$

Centralized clearing with transparency

- Aggregates all the information about trades and disseminates it (in our simple set up, contemporaneously) to market participants.
- Same bankruptcy resolution and bilateral netting as with OTC.
- Trades of each agent i, $(\mathbf{z}_+^i, z_-^i)$, are observed by other agents.
- Hence, agent of type j with short position z_-^j will face an ask price map $q^j(z_-^j)$, that depends on public information about agent j (endowment, credit rating, etc.) and net short positions.
- Budget constraints... Markets clear...
- Prices:

$$q^j(z_-^j) = \max_i E\left(m^i R^j(z_-^j)\right). \tag{12}$$

Constrained efficiency of centralized clearing

- **Proposition 1.** *Any competitive equilibrium of the centralized clearing economy with transparency is constrained Pareto optimal.*
- Intuition: Each agent i that is short on the asset faces a price $q^i(z^i_-)$ that is conditioned on her positions.
- This gets the agent i to internalize the effect of her default on the payoff of long positions on the asset $R_+(s)$.
- A centralized counterparty such as an exchange (no market-wide transparency) achieves the same outcome.
- This is however not the case with OTC markets.

Inefficiency of OTC markets

- **Proposition 2.** *Competitive equilibria of the centralized clearing economy with transparency cannot be robustly supported with OTC markets. Any competitive equilibrium of the centralized clearing economy with transparency in which default occurs with positive probability cannot be supported with OTC markets.*

- **Proposition 3.** *For deadweight costs ε small enough, any competitive equilibrium of the OTC markets economy is characterized by weakly greater (and robustly by strictly greater) leverage*

$$L^i = \frac{E(m^i R z^i_-)}{E(m^i w^i_1)}$$

and default with respect to centralized clearing economies with transparency.

Collateral requirements

- Post k bonds against each contact to counterparty.
- A "coarse" way of dealing with counterparty risk externality...
- Consider example I again.
- Agents of type 3 do not default provided
$$w^3(B) + kz^3 - Rz^3 \geq -\varepsilon z^3 \ . \tag{13}$$
- Date-0 feasibility of posting collateral requires
$$w_0^3 + qz^3 \geq kz^3 \ . \tag{14}$$
- Efficiency can be achieved in the example only if
$$(R - \varepsilon)z_{ND}^3 - w^3(B) \leq w_0^3 + q_{ND}z_{ND}^3 \ . \tag{15}$$

Collateral requirements (continued)

- Collateral increases insurer's liability, like ε.
- But creating such liability is bounded by date-0 endowments.
- When ε is small, default can be averted with collateral only if risk-sharing is constrained to inefficiently low levels.
- More generally, this can lead to over-investment in potentially low-yielding collateral assets.
- The real issue is that given opacity, bilateral collateral constraint is not conditioned on *what else is being done*.
- With transparency, collateral constraint can take the form $k^i(z^i_-)$, but of course prices and position limits can then also deal efficiently with counterparty risk externality.

Subordination of OTC claims

- It is important to consider co-existence of centralized markets with transparency and OTC markets.
- If they are pari-passu, OTC markets extend counterparty risk externality fully to centralized contracts.
- Suppose OTC claims are junior in bankruptcy to centralized ones.
- Example I: Since there is full transfer of insurer's endowment in state B, no agent will go to OTC market (no collateral for junior claims).
- In general, OTC contracts alter insurer's decision to default:

$$w_1^j(s) - R(s)\left(z_-^j + z_-^{j,OTC}\right) < (1-\alpha)\, w_1^j(s) - \varepsilon \left(z_-^j + z_-^{j,OTC}\right).$$

- Strategic default incentives strengthen with OTC: at the margin, payoffs declines from R to $(R - \varepsilon)$.

Implications

- Acharya, Engle, Figlewski, Lynch and Subrahmanyam (2009):
  1. Centralized registry with no disclosure to market participants;
  2. Centralized counterparty with no disclosure (except aggregates) to market participants; and,
  3. Exchange with public disclosure of prices and volumes.

- Registry is sufficient only if regulators will impose efficient leverage constraints.

- But transparency or centralized counterparty suffice.

- Some contracts may remain OTC: subordination in bankruptcy implies these contracts would have no counterparty risk externality on centrally cleared or exchange-traded ones.

Related literature

- Bilateral OTC markets: Duffie, Garleanu and Pedersen (2005, 2007)
- Credit derivatives in ongoing crisis: Restoring Financial Stability (2009), Stulz (2009), ...
- Moral hazard of insurer: Allen and Carletti (2006), Thompson (2009), Zawadowski (2009).
- Exclusive contracts: Bisin and Gottardi (1999), Leitner (2009), ...
- Fragmentation in netting with product-wise centralized clearing: Duffie and Zhu (2009).
- Asymmetric information: Akerlof (1970), Rothschild and Stiglitz (1976), Santos and Scheinkman (2001).

Conclusions

- A GE model of counterparty risk with welfare comparisons between centralized and OTC markets.
- Formalizing a "counterparty risk externality" that can lead to excessive leverage, default risk and production in opaque markets.
- Future work:
  - Too-big-to-fail problem
  - Asymmetric information
  - Large player(s)
  - Market incentives for transparency