Systemic Risk and Central Clearing Counterparty Design

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April 2017

What this paper is about

- Examine effects of central clearing counterparty (CCP) on a financial network from ex post and ex ante (systemic risk measure) perspective
- Propose CCP design with "hybrid" guarantee fund that is netted against liabilities
- Simple enough for exact analysis of trade off between systemic risk reduction and banks' incentive to join CCP
- Sophisticated enough to capture real world orders of magnitude of capital, guarantee funds, and fees (stylised CDS OTC market data BIS 2010)

Main findings

- Ex post: CCP reduces banks' liquidation and shortfall losses, improves aggregate surplus
- Ex ante: find explicit threshold on CCP capital and guarantee fund for systemic risk reduction
- Design of "hybrid" guarantee fund netted against liabilities is superior to ("pure" guarantee) default fund plus margin fund
  - hybrid implies similar systemic risk
  - hybrid gives much larger banks' incentive compatibility

Outline

Outline

Setup

- Two periods $t = 0, 1, 2$
- Values at $t = 1, 2$ are random variables on $(\Omega, \mathcal{F})$
- m interlinked banks $i = 1 \dots m$

Instruments

Bank i holds

- Cash γ_i: zero return
- External asset (e.g. long-term investment maturing at $t = 2$):
  - fundamental value Q_i at $t = 1, 2$
  - liquidation value $P_i < Q_i$ at $t = 1$
- Interbank liabilities:
  - formation at $t = 0$
  - realization/expiration at $t = 1$: L_{ij}
- No external debt

Example of interbank liabilities: CDS (premiums paid before $t = 0$. At $t = 1$ change in credit spreads or defaults)

At $t = 1$

- Interbank liabilities realize: $L_{ij}(\omega)$
- We compute a network fixed point to obtain the **actual** payments (equilibrium)
- With these equilibrium payments, we derive: assets A_i, nominal cash balance, amount of liquidations Z_i, capital C_i , capital surplus C_i^+, capital shortfall C_i^-.

Aggregate surplus identity

Lemma: The aggregate surplus depends on interbank liabilities only through implied liquidation losses:

$$\sum_{i=1}^{m} C_i^+ = \sum_{i=1}^{m} \gamma_i + \sum_{i=1}^{m} Q_i - \sum_{i=1}^{m} Z_i(Q_i - P_i).$$

$\rightarrow$ Forced liquidation of external assets lowers aggregate surplus.

$\rightarrow$ Absent external asset, cash gets only redistributed in network. No dead weight losses.

Outline

Central Clearing Counterparty (CCP)

- We label the CCP as $i = 0$
- All liabilities are cleared through the CCP

$\rightarrow$ star shaped network

- Proportionality rule: CCP liabilities have equal seniority

$\rightarrow$ interbank clearing equilibrium can be directly computed (no fixed point problem)

Capital structure of CCP

- The CCP is endowed with
  - external equity capital γ_0
  - **guarantee fund**

$$\sum_{i=1}^{m} \mathbf{g_i}$$

  where $\mathbf{g_i} \leq \gamma_i$ is received from bank i at time $t = 0$
- Guarantee fund is hybrid of margin fund and default fund:
  - GF payment g_i netted against bank liability (margin fund)
  - GF absorbs shortfall losses of defaulting banks (default fund)
- Banks' shares in the guarantee fund have equal seniority

Liabilities

- Bank i's net exposure to CCP
  Λ_i
- Bank i's nominal liability to the CCP (**netting**)

$$\widehat{L}_{i0} = \left(\Lambda_i^- - \mathbf{g_i}\right)^+$$

$\rightarrow$ CCP charges a volume based fee f on bank i's receivables

$$f \times \Lambda_i^+$$

Nominal guarantee fund

- Bank i's nominal share in the guarantee fund: guarantee fund contribution after it has absorbed the loss from bank i

Aggregate surplus identity with CCP

Lemma: The aggregate surplus with CCP depends on clearing mechanism only through implied liquidation losses:

$$\sum_{i=0}^{m} \widehat{C}_i^{+} = \sum_{i=0}^{m} \gamma_i + \sum_{i=1}^{m} Q_i - \sum_{i=1}^{m} \widehat{Z}_i(Q_i - P_i).$$

Outline

Scope

- Compare financial network with and without CCP
- **Convention:** For comparison we set

$$C_0 = \gamma_0$$

CCP ex post effects

Theorem:

The CCP reduces

- liquidation losses $\widehat{Z}_i \leq Z_i$
- bank shortfalls (bankruptcy cost) $\widehat{C}_i^- \leq C_i^-$

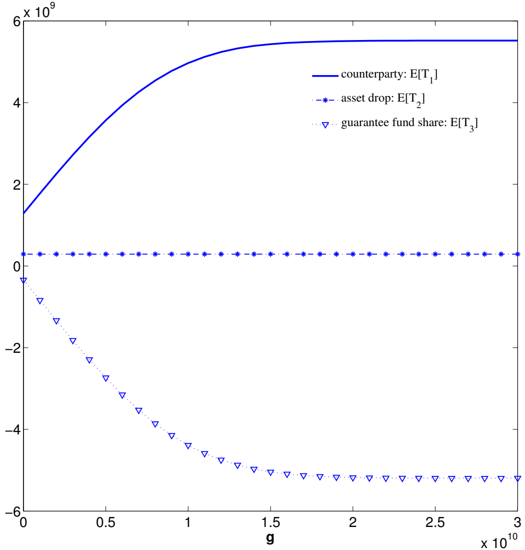
The CCP improves

- aggregate terminal bank net worth $\sum_{i=1}^m \widehat{C}_i \geq \sum_{i=1}^m C_i$
- aggregate surplus

$$\sum_{i=0}^m \widehat{C}_i^+ = \sum_{i=0}^m C_i^+ + \underbrace{(Q_i - P_i)\sum_{i=1}^m (Z_i - \widehat{Z}_i)}_{\geq 0}$$

The CCP imposes shortfall risk $\widehat{C}_0^- \geq 0$

CCP impact on banks' net worth decomposition



Outline

Systemic risk measure

- Write $\boldsymbol{C} = (C_0, \ldots, C_m)$ and $\widehat{\boldsymbol{C}} = (\widehat{C}_0, \ldots, \widehat{C}_m)$
- Generic coherent risk measure $\rho(X)$
- Aggregation function, $\alpha \in [1/2, 1]$,

$$A_\alpha(\boldsymbol{C}) = \underbrace{\alpha \sum_{i=0}^m C_i^-}_{\text{bankruptcy cost}} - \underbrace{(1-\alpha) \sum_{i=0}^m C_i^+}_{\text{tax benefits}}$$

- Systemic risk measure (Introduced independently in a working paper version of 2013)

$$\mathcal{R}(\boldsymbol{C}) = \rho\left(A_\alpha(\boldsymbol{C})\right)$$

Systemic risk reduction

Theorem: The CCP reduces systemic risk, $\mathcal{R}(\widehat{\boldsymbol{C}}) < \mathcal{R}(\boldsymbol{C})$, if[1]

$$\underbrace{\alpha\rho\left(\widehat{C}_0^-\right)}_{\text{shortfall risk of CCP}} < \underbrace{-\rho\left(-\Delta_\alpha\right)}_{\text{risk-adjusted value of } \Delta_\alpha}$$

where

$$\Delta_\alpha = \alpha \underbrace{\sum_{i=1}^m \left(C_i^- - \widehat{C}_i^-\right)}_{\text{cost of intermediation}} + (1-\alpha) \underbrace{\sum_{i=1}^m \left(Z_i - \widehat{Z}_i\right)\left(Q_i - P_i\right)}_{\text{mitigation on liquidation losses}} \geq 0$$

does not depend on $(f, \boldsymbol{g})$.

[1] if and only if for $\rho(X) = \mathbb{E}[X]$

Acceptable equity, fee, and guarantee fund policies

- CCP and banks are risk neutral
- Utility function = expected surplus $\mathbb{E}\left[C_i^+\right]$
- Policy $(\gamma_0, f, \boldsymbol{g})$ is incentive compatible if

$$\mathbb{E}\left[\widehat{C}_i^{\,+}\right] \geq \mathbb{E}\left[C_i^+\right] \quad \forall i = 0 \ldots m.$$

- Policy $(\gamma_0, f, \boldsymbol{g})$ is acceptable if incentive compatible and

$$\mathcal{R}(\widehat{\boldsymbol{C}}) \leq \mathcal{R}(\boldsymbol{C})$$

Symmetric case

Assumption: $\gamma_i \equiv \gamma$, $g_i \equiv g$, and

$$(Q_i, P_i, \{L_{ij}\}_{j=1\dots m}, \{L_{ji}\}_{j=1\dots m}), \quad i = 1 \dots m$$

is exchangeable.

Theorem:

- Policy $(\gamma_0, f, \boldsymbol{g})$ incentive compatible if and only if

$$\gamma_0 \leq \mathbb{E}\left[\widehat{C_0}^{+}\right] \leq \gamma_0 + \sum_{i=1}^{m} \mathbb{E}\left[\left(Z_i - \widehat{Z}_i\right)(Q_i - P_i)\right]$$

- Existence theorem for acceptable policies
- Every acceptable policy is Pareto optimal

Outline

Parameters

- Symmetric CDS inter dealer network based on BIS 2010 data
- gross market value $W = \$1tn$
- $m = 14$ banks
- $\gamma_i = \gamma = \$30bn$
- $Q_i = Q = \$15bn$, $P_i = Q_i/3$
- CCP: $\gamma_0 = \$5bn$, fee $f = 2\%$ ($\approx 1bp$ of notional)
- Systemic risk measure $\mathcal{R}(\boldsymbol{C}) = \mathbb{E}\left[A_{0.9}(\boldsymbol{C})\right]$
- Model:

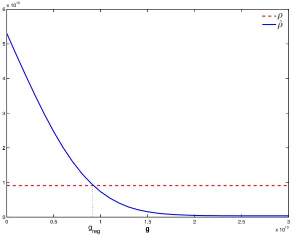
$$W = \sum_{i \neq j} \mathbb{E}\left[|X_{ij}|\right], \quad X_{ij} \text{ i.i.d. } N(0, \sigma)$$

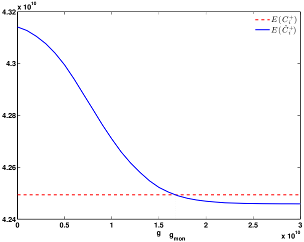
$$L_{ij} = \left(|X_{ij}| - |X_{ji}|\right)^+$$

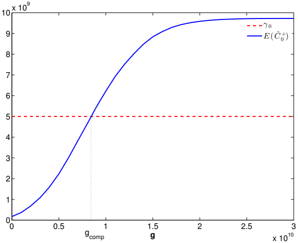
Systemic risk, banks' and CCP utility as functions of g

There exists acceptable and incentive compatible policies:

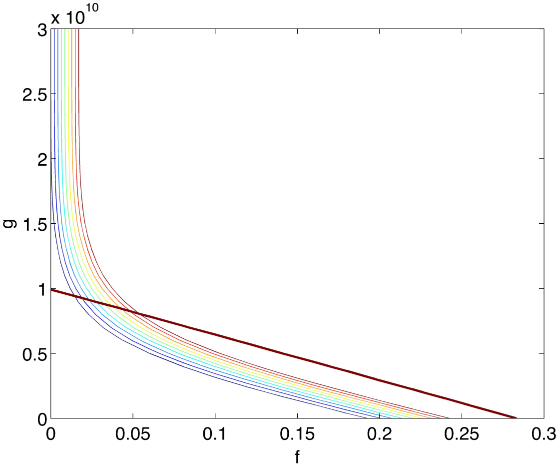
$g_{\text{reg}}, g_{\text{comp}} < g_{\text{mon}}$



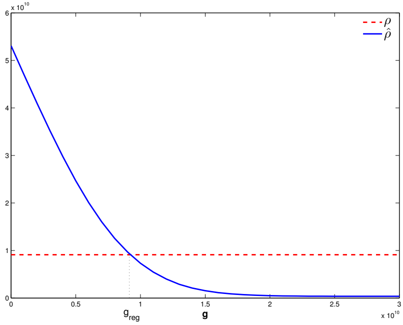


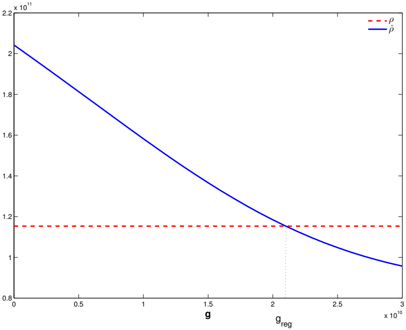


Incentive compatible utility indifference curves and systemic risk zero line in (f, g)



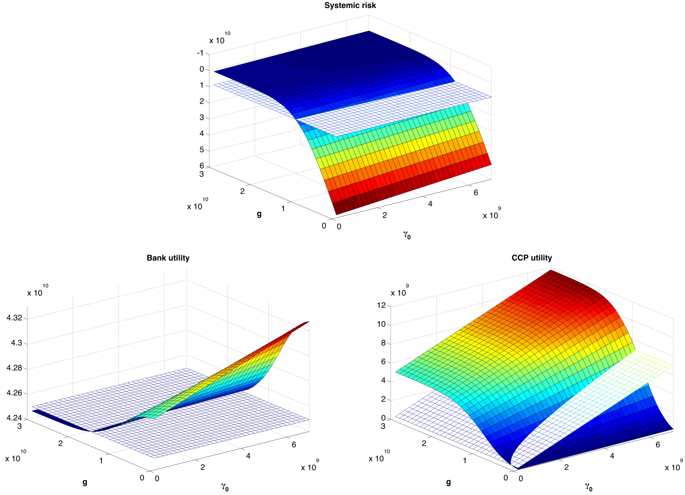
Systemic risk as functions of g for $m = 14$ vs. 10 banks





g_{reg} doubles: concentration risk matters!

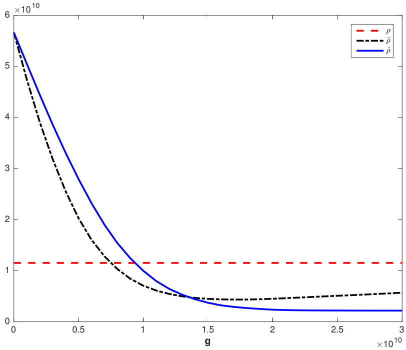
Systemic risk, banks' and CCP utility as functions of g, γ_0

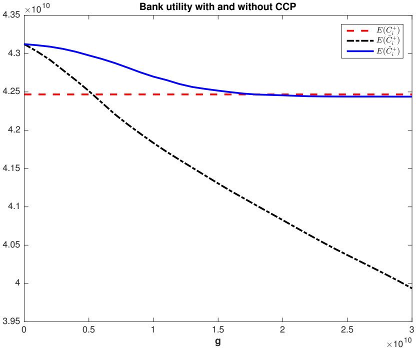


Hybrid vs. pure (default) guarantee fund

Pure guarantee fund: not netted agains liabilities, $\overline{L}_{i0} = \Lambda_i^-$.

Assets remaining with bank i, $\gamma_i - g_i + P_i$, form margin fund.





Systemic risk improvement is limited, while banks have no incentive compatibility: $g_{\mathrm{mon}} < g_{\mathrm{reg}}$.

Conclusion

- General financial network setup with and without CCP
- CCP improves aggregate surplus due to lower liquidation losses
- CCP reduces banks' bankruptcy cost
- CCP introduces tail risk, and may increase systemic risk
- Find exact condition for systemic risk reduction
- Simulation study illustrates range of acceptable CCP equity, fee, and guarantee fund policies
- Hybrid guarantee fund design greatly improves banks incentives to join CCP