Systemic Risk and Central Clearing Counterparty Design

Andreea Minca
(joint with Hamed Amini and Damir Filipović)

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
1. Financial network
2. Central counterparty clearing
3. Ex post effects of central counterparty clearing
4. Systemic risk and incentive compatibility
5. Simulation study
Outline

1. Financial network
2. Central counterparty clearing
3. Ex post effects of central counterparty clearing
4. Systemic risk and incentive compatibility
5. Simulation study
Two periods $t = 0, 1, 2$
Values at $t = 1, 2$ are random variables on $(\Omega, \mathcal{F})$
$m$ interlinked banks $i = 1 \ldots m$
Bank $i$ holds

- Cash $\gamma_i$: 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 $C_i^−$. 
Aggressive surplus identity

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

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

→ Forced liquidation of external assets lowers aggregate surplus.
→ Absent external asset, cash gets only redistributed in network. No dead weight losses.
Outline

1. Financial network

2. Central counterparty clearing

3. Ex post effects of central counterparty clearing

4. Systemic risk and incentive compatibility

5. Simulation study
Central Clearing Counterparty (CCP)

- We label the CCP as $i = 0$
- All liabilities are cleared through the CCP
  - star shaped network
- Proportionality rule: CCP liabilities have equal seniority
  - interbank clearing equilibrium can be directly computed (no fixed point problem)
Central counterparty clearing

Capital structure of CCP

- The CCP is endowed with
  - external equity capital $\gamma_0$
  - guarantee fund

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

where $g_i \leq \gamma_i$ 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 $\Lambda_i$
- Bank $i$’s nominal liability to the CCP (netting)

$$\hat{L}_{i0} = (\Lambda_i^+ - g_i)^+$$

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

$$f \times \Lambda_i^+$$
Central counterparty clearing

Nominal guarantee fund

- Bank $i$’s nominal share in the guarantee fund: guarantee fund contribution after it has absorbed the loss from bank $i$
Lemma: The aggregate surplus with CCP depends on clearing mechanism only through implied liquidation losses:

\[ \sum_{i=0}^{m} \hat{C}_i^+ = \sum_{i=0}^{m} \gamma_i + \sum_{i=1}^{m} Q_i - \sum_{i=1}^{m} \hat{Z}_i(Q_i - P_i). \]
Outline

1. Financial network

2. Central counterparty clearing

3. Ex post effects of central counterparty clearing

4. Systemic risk and incentive compatibility

5. Simulation study
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 $\hat{Z}_i \leq Z_i$
- bank shortfalls (bankruptcy cost) $\hat{C}_i^- \leq C_i^-$

The CCP improves

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

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

The CCP imposes shortfall risk $\hat{C}_0^- \geq 0$
Ex post effects of central counterparty clearing

CCP impact on banks’ net worth decomposition

Figure: Expected differences in stand-alone risk components with and without CCP as functions of guarantee fund contribution. Number of banks is $m = 14$. CCP equity is $\gamma = 5 \times 10^9$. Fee is $f = 2\%$. 

Andreea Minca (Cornell) Systemic Risk and CCP Design April 2017 19 / 32
Outline

1. Financial network
2. Central counterparty clearing
3. Ex post effects of central counterparty clearing
4. Systemic risk and incentive compatibility
5. Simulation study
Systemic risk measure

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

$$A_{\alpha}(\mathbf{C}) = \alpha \sum_{i=0}^{m} C_i^- - (1 - \alpha) \sum_{i=0}^{m} C_i^+$$

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

$$\mathcal{R}(\mathbf{C}) = \rho(A_{\alpha}(\mathbf{C}))$$
Theorem: The CCP reduces systemic risk, $\mathcal{R}(\hat{C}) < \mathcal{R}(C)$, if

$$
\alpha \rho \left( \hat{C}_0^- \right) < -\rho \left( -\Delta_\alpha \right)
$$

shortfall risk of CCP

risk-adjusted value of $\Delta_\alpha$

where

$$
\Delta_\alpha = \alpha \sum_{i=1}^{m} \left( C_i^- - \hat{C}_i^- \right) + (1 - \alpha) \sum_{i=1}^{m} \left( Z_i - \hat{Z}_i \right) \left( Q_i - P_i \right) \geq 0
$$

cost of intermediation

mitigation on liquidation losses

does not depend on $(f, g)$.

---

$^1$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 $\equiv$ expected surplus $\mathbb{E} [C_i^+]$
- Policy $(\gamma_0, f, g)$ is incentive compatible if
  $$\mathbb{E} \left[ \hat{C}_i^+ \right] \geq \mathbb{E} \left[ C_i^+ \right] \quad \forall i = 0 \ldots m.$$
- Policy $(\gamma_0, f, g)$ is acceptable if incentive compatible and
  $$\mathcal{R}(\hat{C}) \leq \mathcal{R}(C)$$
Symmetric case

Assumption: \( \gamma_i \equiv \gamma, \ g_i \equiv g \), and

\[
(Q_i, P_i, \{L_{ij}\}_{j=1}^{m}, \{L_{ji}\}_{j=1}^{m}), \quad i = 1 \ldots m
\]
is exchangeable.

Theorem:

- Policy \((\gamma_0, f, g)\) incentive compatible if and only if

\[
\gamma_0 \leq \mathbb{E} \left[ \hat{C}_0^+ \right] \leq \gamma_0 + \sum_{i=1}^{m} \mathbb{E} \left[ (Z_i - \hat{Z}_i) (Q_i - P_i) \right]
\]

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

1. Financial network
2. Central counterparty clearing
3. Ex post effects of central counterparty clearing
4. Systemic risk and incentive compatibility
5. Simulation study
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 $\mathcal{R}(C) = \mathbb{E}[A_{0.9}(C)]$
- Model:

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

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

$g_{\text{reg}}$ doubles: concentration risk matters!
Simulation study

Systemic risk, banks’ and CCP utility as functions of $g$, $\gamma_0$
Hybrid vs. pure (default) guarantee fund

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

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: $g_{\text{mon}} < g_{\text{reg}}$. 
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