CDS Central Counterparty Clearing Liquidation: Road to Recovery or Invitation to Predation?

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Motivation

- **Dodd-Frank legislation** - standardisation of CDS contracts and mandatory clearing

- **Large, opaque OTC market (11.8 Trillion)** - previously, most CDS bespoke and uncleared.

- **CCP (globally) systemically important institution**
  - Default fund cannot absorb default of more than 1 or 2 large members.
  - CCP pays *variation margin* for life of CDS contract.

- **Lehman Default on CDS contracts** - Clearing facilities left holding large positions (CCP)
  - CCP must sell/unwind positions quickly (5 days), common information.
  - Sold positions to Barclays at large loss.
If a large, global dealer bank failed today...

Would a CCP liquidation/unwinding of positions trigger a **fire-sale**, if member banks engaged in predation?

Could this cause a **CCP failure**?

Is there a **CCP Design** which would prevent predation, aid in CCP recovery, and be incentive compatible for both, banks and CCP?

- network problem (star)
- contagion (price-mediated) and amplification (predation)
- multi-bank, multi-asset, multi-period problem
Strands of Literature

I. Predation and Price Feedback Effects

- (Brunnermeier and Pedersen, 2005)
  Predation model for exchange-based trading (price-transparency).
  Predators sell in direction of distressed banks, buyback after liquidation (profit).
  - **Extension:** model opaque OTC market

II. Stability in Financial Networks

- (Cont and Wagalath, 2013)
  Model firesale and price-mediated contagion (indirect), increased covariance in hedge fund portfolios.
  - **Extension:** explicitly model the covariance between different assets *inside* portfolio.

- (Amini et al., 2015)
  Examine alternative CCP Design, incentive compatibility for banks and CCP.
  - **Extension:** model on-going variation margin exchange, dynamic reaction of banks to defaults, disciplinary mechanism.
Credit Default Swaps

- **Insurance** on reference entity, used for hedging/speculating
- Taken out on **notional** amount (i.e. value of bond position)
- Buyer pays **premium** to seller for life of contract (5-yr standard)
- Seller pays buyer if **reference entity** defaults (cash or physical delivery)
- **Standard CDS** premium is 100 or 500 bps (1 bps = 0.001%)
- Contract entered into a zero value - **up-front payment**.
- Market value expressed in **credit spread (bps)**, increased with default probability
- Buyer and seller exchange **Variation Margin** = Credit spread - Premium
- Feature: can sell/buy both sides cds contract multiple times - **Redundant Trades**
  - **Example 1**: Unwind 'sell' position by buying 'buy' position on asset k
  - **Example 2**: Sell 'sell' position on asset k to another party.
Dealer Banks & The Over-The-Counter CDS Market

- **Large market** (11.8 Trillion USD) with bespoke and standard CDS
- **OTC**/Non-exchange trading (Search market)
- **No price transparency**, through dealer banks (Bid-ask spread)
- Top 14 (core) dealers own 85% of global CDS market
- 75% trades are **dealer-to-dealer**

Top 14 dealers are members of all large **CCPs** (ICE and LHC-Clearnet)

Central Clearing Counterparty

- Facility **mediates** trades - Buyer to every seller, seller to every buyer
- Ensures adequate **collateral** and **compression** of trades (Min. counter-party risk)
- Holds little equity, charges **volume-based fee**

**Membership:** up-front initial margin contribution (Guarantee Fund), smaller Default Fund contribution
  - Initial Margin is proprietary bank property, Default Fund is communal (Risk-Sharing)
  - Default Fund is 10% size of Guarantee Fund, deemed insufficient.

**CCP Waterfall Procedure:** In default use...
  - Bank Contribution
  - CCP Equity Tranche
  - Default Fund
  - CCP Equity (remaining)
  - ... CCP Failure or Lender of Last Resort
Model Setup

- Star-shaped financial **network**, CCP connected to banks through CDS.
- **CCP** $i = 0$, **dealer banks** $i = \{1, \ldots, m\}$, CDS on **reference entities** $k = \{1, \ldots, K\}$
- **Side** of CDS contract position - buy or sell side,
  \[ X^B = +X \quad \text{and} \quad X^S = -X \]
- **Variation Margin** on nominal value for portfolio of bank $i$, for CDS on reference entity $k$,
  \[ V_i^k = \sum_{k=1}^{K} X_i^k \triangle S^k(t_\ell) \]
- Amount that bank $i$ **owes** to other banks $j$ in variation margin on CDS $k$,
  \[ L_i^k = \sum_{j=1}^{m} L_{ij}^k \]
- Bank $i$’s **net exposure** to counterparties ($j$),
  \[ \Lambda_i = \sum_{j=1}^{m} L_{ji}^k - \sum_{j=1}^{m} L_{ij}^k \]
Covariance and Price impact

- CDS exhibit covariance - can assume a volatility-like structure,

\[ X_{ij}^{k,p} \Sigma_{ij} X_{ij}^{k,p} \]

- Specialise to a linear price impact formulation,

\[ X_{ij}^{k,p} F(X_{ij}^{k,p}) \quad \text{with} \quad F(X_{ij}^{k,p}) = |\Delta S^k(\ell_T)| \left( \frac{X_{ij}^{k,-p}}{D_k} \right) \]

- \( D_k \) - vector of market depth for CDS assets of type \( k \).
- \( S \) is CDS-spread \( \Rightarrow \) \( \Delta S \) change in CDS-spread is,

\[ \Delta S^k(t_\ell) = S^k(t_\ell) - S^k(t_{\ell-1}) \]

- Liquidation effect on price, due to CCP liquidation of bank \( j \),

\[ \Delta S^k(t_\ell) = \Delta S^k(t_{\ell-1}) \left( 1 - \frac{1}{D_k} \sum_{j \in D} X^k_j \right) \]
Variation Margin & CDS-spread

- The **market value** of the portfolio bank $i$ is the altered by,

$$V_i^k = X_i^k \Delta S^k(t_\ell) = X_i^k \Delta S^k(t_{\ell-1}) \left(1 - \frac{1}{D_k} \sum_{j \in D} X_j^k\right)$$

- CDS-spread on $k$ moves due to changes in **fundamentals** (Permanent Price Impact),

$$\Delta S^k(t_\ell) = f(\Delta S^k(t_{\ell-1}))$$

- Absent liquidation, only **fundamental** CDS-spread change alters value of portfolio,

$$X_{ij}^{k,p}(t_\ell) \Delta S^k(t_\ell) = X_{ij}^{k,p}(t_{\ell-1}) f(\Delta S^k(t_{\ell-1})) = [X_{ij}^{k,p}(t_{\ell-1}) \Delta S^k(t_{\ell-1})]^+$$
Figure: Covariance relationships of banks in terms asset holdings (colour) and of spatial distance to defaulted assets
The Mathematical Structure I: Reduced Form

- **CDS-Pricing Structure** \( \approx \) akin to **taylor-expansion** of the pricing function,

\[
V_i^k = X_i^k \triangle S^k(t_\ell) = X_i^k \frac{F(X_i^k)}{0!} + X_i^k \frac{F'(X_i^k)}{1!} + \frac{1}{1!} X_i^k \frac{F'(X_j^k)}{1!} + \frac{1}{2!} X_i^k \frac{F''(X_j^k)}{2!} + \frac{1}{3!} X_i^k \frac{F'''(X_j^k)}{3!}
\]

- Pricing: Covariance, Price-impact \((P)\), Predation \((P')\), **Liquidation** \((\Gamma_j^k = a_j^k \tau)\)

\[
X_i^k \triangle S^k(t_\ell) = P_0 + P_1 \Gamma_j^k + P \Gamma_j^k + P_2 \Gamma_j^k + P_3 \Gamma_j^k
\]

\[
= \left[ X_i^k \triangle S^k(t_{\ell-1}) \right]^+ + P_1 a_j^k \tau + P a_j^k \tau + P_2 a_j^k \tau + P_3 a_j^k \tau
\]
Main Proposition: The variation margin on a bank’s portfolio is determined by the size of its positions, $X_i^k$, and the degrees of covariance relationships with liquidated assets in the market, through the pricing functional, $\Delta S^k$.

$$V_i =$$

$$\sum_k X_i^k(\ell) \Delta S^k(\ell) = \sum_k \left\{ \left[ X_i^k((\ell-1)r) \Delta S^k((\ell-1)r) \right]^+ \right\}$$

$$+ \left( \sum_{j \in D} X_j^0 X_j^0 + \varepsilon \sum_{j' \in D} X_j^0 X_j^0 \right) \left[ \sum_{r=1}^m |\Delta S^k((\ell-1)r)| \left( X_i^k D_k \right) \left( \frac{a_{j',r}^k X_i^k}{X_j^0} \right) \right]$$

$$+ \left( \sum_{j \in D} X_j^0 X_j^0 + \varepsilon \sum_{j' \in D} X_j^0 X_j^0 \right) \left[ \sum_{r=1}^m |\Delta S^k((\ell-1)r)| \left( \frac{X_i^k}{D_k} \right) \left( \frac{a_{j',r}^k X_i^k}{X_j^0} \right) \right]$$

$$+ \left( \frac{1}{2!} \right) \left( \frac{\varepsilon}{2!} \right) \prod_{j \in D} X_j^0 X_j^0 \left[ \sum_{j' \in D} X_j^0 X_j^0 \right] \left[ \sum_{r=1}^m |\Delta S^k((\ell-2)r)| \left( \frac{X_i^k}{D_k} \right) \left( \frac{a_{j',r}^k X_i^k}{X_j^0} \right) \right]$$

$$+ \left( \frac{1}{3!} \right) \left( \frac{\varepsilon}{3!} \right) \prod_{j \in D} X_j^0 X_j^0 \left[ \sum_{j' \in D} X_j^0 X_j^0 \right] \left[ \sum_{r=1}^m |\Delta S^k((\ell-2)r)| \left( \frac{X_i^k}{D_k} \right) \left( \frac{a_{j',r}^k X_i^k}{X_j^0} \right) \right]$$

$$+ \left( \frac{1}{3!} \right) \left( \frac{\varepsilon}{3!} \right) \prod_{j \in D} X_j^0 X_j^0 \left[ \sum_{j' \in D} X_j^0 X_j^0 \right] \left[ \sum_{r=1}^m |\Delta S^k((\ell-2)r)| \left( \frac{X_i^k}{D_k} \right) \left( \frac{a_{j',r}^k X_i^k}{X_j^0} \right) \right]$$

primary price impact

CCP liquidation

distressed selling

distressed/predation

secondary price impact

liquidated assets in the market, through the pricing functional, $\Delta S^k$. $V_i =$
Each bank has cash, $\gamma_i$, an initial margin contribution $g_i$, and external asset $Q_i$. In liquidating fraction $Z_i$ of external asset $Q_i$, recovery value is $R_i$.

Guarantee Fund is sum of the initial margin contributions of banks ($G_i = \sum_{m=1}^{m} g_i$)
- Pure Fund (current): Initial margin contribution is proprietary to each bank
- Hybrid Fund (proposed): Initial margin contribution is shared among all banks (risk-sharing like Default Fund $D_i$)

If Net-Exposure/Liability of bank $i$ to CCP is negative ($\Lambda_i^- = \sum_{j=1}^{m} L_{ij} \leq 0$)
- Pure Fund: Initial margin used only after cash and external asset depleted
- Hybrid Fund: Initial margin used before cash or external asset (less risk of early liquidation loss)

In terms of Incentive Compatibility:
- Pure Fund: CCP has larger guarantee fund ($\hat{G}_i$), but same surplus ($\hat{C}_0$)
- Hybrid Fund: Banks have larger aggregate surplus ($\sum_{i=1}^{m} \hat{C}_i$), CCP has smaller guarantee fund ($\hat{G}_i$), but can be used to meet all defaults ($\hat{C}_i$)
Periods: Liquidation, Buyback, Recovery

Each period \( (t) \) has \((\ell)\) trading time-steps \((\tau = 1\) day\) ⇒ \(t\ell\tau\)...

1. **Period I - Liquidation Stage \((t=1)\)**
   - CCP has 5 days to liquidate \(\propto\) initial margin estimate ⇒ \((T = 5\tau)\)
   - CCP liquidates at avg. market rate ⇒ \((a_0 = \sum_{i=1}^{m} \sum_{j=1}^{m} a_{ij}/m)\)
   - Distressed banks *choose to* liquidate with CCP ⇒ \((a_{ij}^{k} \in D = a_{0}^{k} \text{ until } X_{ij}^{k} \in D = 0)\)
   - Predators will liquidate as *fast* possible, without impact ⇒ \((a_{ij}^{k} = a_{0}^{k})\)
     - Single predators/Colluding predators → liquidate until CCP is finished
     - Multiple (competing) predators → finish liquidating before CCP

2. **Period II - Buyback Stage \((t=2)\)**
   - CCP and distressed banks finished liquidating
   - Predatory banks buyback assets,
     - Single predators/Colluding predators → max. profit
     - Multiple (competing) predators → diminished profit due to early buyback

3. **Period III - Resolution/Recovery Stage \((t=3)\)**
   - CCP evaluates state of guarantee fund, initial contributions
     - **Pure Fund**: Initial margin contribution returned (if positive)
     - **Hybrid Fund**: Predators *must* replenish initial margin contribution depleted by distressed/defaulted banks. *Initial margin membership criteria!*
Theoretical Results

1. **Liquidation and predation price impacts are cumulative (through the pricing functional):**
   - **For Banks:** Amplifies unfavourable CDS-spread movements, dampens positive CDS-spread movements
   - **For CCP:** Increases liability realisation (variation margin) and decreases liquidation profits

   \[ P_1 (3\tau, X^{k,S}(3\tau,a^k_i,\pm(2\ell)), \Delta S^{k,S}(3\tau, X^{k,S}(2\tau), \Delta S^{k,S}(2\tau), P_1(2\tau), P(2\tau), P_2(1\tau), P_3(1\tau), a^k_i,\pm(2\ell))) \]

2. **If one predator predates, then all predators are better off predating:**
   - Better off holding smaller position in same side of CDS if decreasing in value.

   \[ X^{k}(t_{\ell-1}) \Delta S(t_{\ell-1}) \geq [X^{k}(t_{\ell}) \Delta S(t_{\ell}) \text{ if } |\Delta S(t_{\ell-1})| \geq |\Delta S(t_{\ell})|, X^{k}(t_{\ell-1})=X^{k}(t_{\ell})] \]

3. **In hybrid guarantee fund structure, natural predation disincentive tool:**
   - CCP makes margin call on each profitable banks to replenish own initial margin contribution

   \[ \hat{G}_{i}^{9\ell} (t_{\ell} = 3) = (g_i - \hat{G}_{i}^{*}) \]

4. **Hybrid fund more incentive compatible for CCP if shortfall ≥ Guarantee Fund + CCP tranche:**
   - CCP expects to be better off using the hybrid approach and protecting its own equity.

   \[ \mathbb{E} [\hat{C}_0(t_{\ell} = 3)] \geq \mathbb{E} [\hat{C}_0(t_{\ell} = 3)] \]
Simulation Results I: Default Distribution based on Market Depth

Figure: Under Normal Market Liquidity & Decreasing Market Liquidity
Simulation Results II: Final CCP Loss based on Market Depth (1)

Figure: Under Normal Market Liquidity & Financial Crisis Market Liquidity
Simulation Results III: Final CCP Loss based for Decreasing Market Depth

- **Final CCP Loss**
  - No Collusion
  - Collusion

- **Final Value CCP (USD)**
  - Predation Stable
  - Distressed Stable

No. of Predatory Banks: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

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Simulation Results IV: Predation Profits & Margin Refill

**Predation Buyback Profit/Loss:**
Original vs. Buyback Value of Positions

- Collusion
- No Collusion
- Stable Distressed
- Stable Predators

**Margin Refill Required By CCP in Recovery Stage**

- Collusion, Increasing Predators
- No Collusion, Increasing Predators
- Stable Distressed, Increasing Predators
- Stable Predators, Increasing Distressed

**Figure:** Under Decreasing Market Liquidity
Simulation Results V: Pure vs. Hybrid Wealth for Decreasing Market Depth

**Figure:** CCP Liquidation Loss & Aggregate Bank Liquidation/Buyback Surplus
In Summary:

- CCP will always lower its profits if it engages in a liquidation to offload a defaulter's positions → find another way to unwind
- Predation decreases profits of all member banks pushes to default → educate member banks on own interest
- CCP has internal disciplinary mechanism for predation in Hybrid CCP structure → no extra regulatory intervention
- Hybrid guarantee fund increased protection for CCP equity (private profit) for a large default → increased financial stability

Limitations:

- Model doesn’t allow for creation of new relationships during trading periods (old ones change due to default/liquidation)
- Don’t have very extensive and fine-grained data for CDS or for internal CCP procedures (proprietary)
- Don’t use covariance/correlation data explicitly (tractability)