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
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 \( k \),
  \[
  V_i^k = \sum_{k=1}^{K} X_i^k \Delta S^k(t_\ell)
  \]
- 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**,

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

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

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

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

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

- The **market value** of the portfolio bank \( i \) is the altered by,

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

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

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

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

\[
X_{ij}^{k,p}(t_\ell) \triangle S^k(t_\ell) = X_{ij}^{k,p}(t_{\ell-1}) f(\triangle S^k(t_{\ell-1})) = \left[ X_{ij}^{k,p}(t_{\ell-1}) \triangle S^k(t_{\ell-1}) \right]^+
\]
Concept: Covariance Map

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 \textit{taylor-expansion} of the pricing function,

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

- Pricing: Covariance, Price-impact ($P$), Predation ($\mathcal{P}$), Liquidation ($\Gamma_j^k = a_j^k \tau$)

$$
X_i^k \Delta S^k(t_{\ell}) = P_0 + P_1 \Gamma_j^k + \mathcal{P} \Gamma_j^k + P_2 \Gamma_j^k + P_3 \Gamma_j^k
\geq 0
$$

$$
= [X_i^k \Delta S^k(t_{\ell-1})]^+ + P_1 a_j^k \tau + \mathcal{P} a_j^k \tau + P_2 a_j^k \tau + P_3 a_j^k \tau
$$
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, $\triangle S^k$.

$$V_i =$$

$$\sum_k X_i^k(\ell \tau) \triangle S^k(\ell \tau) = \sum_k \left( X_i^k((\ell - 1)\tau) + a_{ij}^k \right) \triangle S^k(\ell \tau)$$

$$= \sum_k \left( X_i^k((\ell - 1)\tau) \triangle S^k((\ell - 1)\tau) \right)^+$$

$$+ \left( \sum \frac{X_i^k}{X_j^k} X_j^k \right) + \epsilon \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 1)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$

primary price impact

$$+ \left( \frac{1}{2!} \right) \left( \frac{3}{2!} \right) \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 2)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$

CCP liquidation

$$+ \left( \frac{1}{3!} \right) \left( \frac{9}{3!} \right) \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 2)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$

secondary price impact

$$+ \left( \frac{1}{3!} \right) \left( \frac{9}{3!} \right) \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 2)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$

tertiary price impact

$$+ \left( \frac{1}{3!} \right) \left( \frac{9}{3!} \right) \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 2)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$

$$+ \left( \frac{1}{3!} \right) \left( \frac{9}{3!} \right) \sum \left( \frac{X_i^k}{X_j^k} X_j^k \right) \sum \left( \triangle S^k((\ell - 2)\tau) \right) \left( \frac{X_i^k}{D_k} + \frac{a_{ij}^k \tau}{X_j^k} \right)$$
Pure Fund vs. Hybrid Fund

- 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 ($G_i = \sum_{i=1}^{m} g_i$)
  - 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 ($\bar{G}_i$), but same surplus ($\bar{C}_0$)
  - 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 ($\hat{C}_i$)
Each period \( (t) \) has \( (\ell) \) trading time-steps \( (\tau = 1 \text{ day}) \) \( \Rightarrow \) \( t\ell\tau \ldots \)

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

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

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.

\[
X^k_{ij}(t(\ell-1)\tau) \triangle S(t(\ell-1)\tau) \geq [X^k_{ij}(t\ell\tau) \triangle S(t\ell\tau)] \quad \text{if} \quad \triangle S(t(\ell-1)\tau) \geq |\triangle S(t\ell\tau)|, \quad X^k_{ij}(t(\ell-1)\tau) = X^k_{ij}(t\ell\tau)
\]

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

\[
\hat{G}_i^{\text{gt}}(t_{\tau} = 3) = (g_i - \hat{G}_i^*)
\]

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.

\[
\mathbb{E} [\hat{C}_0(t_{\ell\tau} = 3)] \geq \mathbb{E} [\bar{C}_0(t_{\ell\tau} = 3)]
\]
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

[Graph showing Final CCP Loss for different numbers of predatory banks and banks with collusion vs. no collusion.]
Simulation Results IV: Predation Profits & Margin Refill

**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
Summary & Limitations

In Summary:

- CCP will always lower its profits if it engages in a liquidation to offload a defaulters 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)