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

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Motivation

- **Post-2008 Dodd-Frank legislation**:
  Standardised CDS contracts & Mandated central clearing.
- **Large, Opaque OTC market ($11.8 Trillion USD)**:
  CDS mostly bespoke & Largely uncleared.
- **CCP → Global Systemically Important Institution (GSII)**
  - 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 Derivative Contracts**:
  CCPs left holding large positions
  - CCP must unwind positions quickly (5 days) – common information.
  - Offloaded positions to Barclays at fraction of value.

Research Question

What if a large, global dealer bank failed today...

Could a CCP unwinding strategy trigger **default contagion**:

- If members (distressed) liquidate?
- If members (unconstrained) engage in predation?

Could this result in **CCP failure**?

Is there a **CCP/Regulatory** tool to prevent predation and aid CCP recovery?

Would it be **incentive compatible** for the CCP and Members?

- network problem (star)
- contagion (price-mediated) and amplification (predation)
- multi-agent, 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 agents, buyback after liquidation (profit).
    - **Extension:** Model the 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 compatible for banks.
    - **Extension:** Model on-going variation margin exchange, dynamic reaction of banks to defaults, disciplinary mechanism.

Strands of Literature II

III. Determinants of Changes In CDS-Spreads

Empirical Work: Determine that variables thought to explain credit-spread changes, have only fraction of explanatory power.

- **(Collin-Dufresne and Martin, 2001)**
  Observe most of credit-spread change is driven by common, systematic component (difficult to explain).
  - **Extension:** Theoretical CDS-spread model; permanent and time-dependant component.
- **(Tang and Yang, 2005)**
  Determine systematic component has time dimension. Explains the co-movements in credit default spreads.
  - Time component persists for max. 2 trading periods or becomes permanent.
  - **Extension:** Model CDS-covariance and incorporate in the CDS-spread model.
- **(Tang and Yan, 2017)**
  Identify the fundamental determinants of CDS-spread and the effects of excess demand and supply (asymmetric).
  - Excess demand driven by info with fundamental content.
  - Excess supply liquidity-driven with little such information.
  - **Extension:** CDS-spread model has transitory price impact from trading.

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)**, increases with default probability.
- Buyer and seller exchange **Variation Margin** = Credit Spread - Premium
- Feature: Buy/Sell both sides CDS contract multiple times → **Redundant Trades**
  - **Buy-side** (long CDS contract) & **Sell-side** (short CDS contract)
  - **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[1]) with bespoke and standard CDS.
- **Over-the-counter trading** (search market).
- **No price transparency**, through dealer banks (bid-ask spread).
- Top 14 (**Core**) dealers own 85% (notional) of global CDS market.
- 75% trades are **Dealer-to-Dealer**.
- Top 14 dealers are members of all large **CCPs** (ICE, CME, LHC-Clearnet[2])

  (**Dealer Banks:** *Bank of America, N.A. Barclays Capital, BNP Paribas Citigroup, Credit Suisse, Deutsche Bank AG, Dresdner Kleinwort, Goldman, Sachs & Co., HSBC Group, JPMorgan, Chase Morgan Stanley, The Royal Bank of Scotland, Group Societe Generale, UBS AG, Wachovia Bank N.A., A Wells Fargo Company*)

[1] The CDS market size dropped from $61 trillion (end 2007) to $9.4 trillion (2017) due to central clearing.

[2] ICE Clear Credit clears the largest share of the single-name CDS market with approx. 77.1%, followed by 18.8% for ICE Europe, 3.69% for CME, 0.369% for LCH CDS Clear and 0.0369% for JSCC.

Central Clearing Counterparty

- Facility **mediates** trades - Buyer to every seller, seller to every buyer.
- Ensures adequate **collateral** and **compression** of trades (Min. Counterparty Risk).
- Holds little equity, charges **volume-based fee**.
- **Membership:** Up-front initial margin contribution (Guarantee Fund), smaller Default Fund contribution.
  - Initial Margin is proprietary to dealer, Default Fund is risk-sharing fund.
  - Default Fund is $\approx$ 10% size of Guarantee Fund, deemed insufficient.
- **Existing CCP Default Waterfall Procedure:** In default use...
  1. Member Contribution
  2. CCP Equity Tranche
  3. Default Fund
  4. Remaining CCP Equity
  5. ... CCP Failure or Lender of Last Resort!

Results Overview

A Summary of Key Results:

- **Always lower CCP profits** with constrained unwinding (time/equity)
  → *Future research for unwinding strategies.*
- **Predation decreases profits** of all members & pushes all dealers toward default
  → *Institute hybrid fund to disincentivize predation.*
- **Risk-sharing guarantee fund** offers legal, enforceable disciplinary mechanism for predation
  → *Viable for CCP and regulatory intervention.*
- **Risk-sharing guarantee fund** increases protection for CCP equity for a large default
  → *CCP incentive-compatible and increases financial stability.*
- **Risk-sharing guarantee fund** increases effectiveness of bailout by Lender of Last Resort
  → *Margin refill reduces size of bail-out required.*
- **Lender of Last Resort** targeted liquidity injection at distressed dealers
  → *higher likelihood of success when very low/very high levels of distress only.*

Model Setup

- **Star-shaped Financial Network:** CCP connected to members through CDS.
- Network: **CCP** ($i = 0$), **Dealer Members** ($i = \{1, .., m\}$),
  CDS **Reference Entities** ($k = \{1, ..., K\}$)
- **Side (p)** of CDS contract: Buy (p=B) or **Sell** side (p=**S**),

$$X^B = +X \quad \text{and} \quad X^{\mathbf{S}} = -X \tag{1}$$

- **Variation Margin**(VM_i) on the nominal value (V_i) of dealer's i CDS portfolio,

$$VM_i \approx [\triangle V_i]^+ = \sum_{k=1}^{K} X_i^k \triangle S^k(t_\ell) \geq 0 \tag{2}$$

- **Liability:** Dealer i **owes** to other dealers j in variation margin (on CDS k),

$$L_i^k = \sum_{j=1}^{m} L_{ij}^k = VM_i^k \tag{3}$$

- **Multi-lateral Netting**: Dealer i's **net exposure** to counterparties j,

$$\Lambda_i = \sum_{k=1}^{K} \Big(\sum_{j=1}^{m} L_{ji}^k - \sum_{j=1}^{m} L_{ij}^k\Big) \tag{4}$$

Covariance and Price impact

- CDS exhibit spread **covariance** - Model can assume a volatility-like structure,

$$X_{ij}^{k,p}\,\Sigma_{ij}\,X_{ji}^{k,p} \tag{5}$$

- Specialise to a **linear price impact formulation**,

$$X_{ij}^{k,p}\,f(X_{ji}^{k,p}) \quad \text{with} \quad f(X_{ji}^{k,p}) = S^k(t_\ell)\left(\frac{X_{ji}^{k,\pm p}}{D_k}\right) \tag{6}$$

- D_k: Vector of **market depth** for CDS assets of type k.
- If S is CDS-spread then $\triangle S$ is **change** in CDS-spread,

$$\triangle S^k(t_\ell, t_{\ell-1}) = S^k(t_\ell) - S^k(t_{\ell-1}) \tag{7}$$

- **Price Impact**: Trade (liquidation effect) on spread,

$$S^k(t_\ell) = S^k(t_{\ell-1})\left(1 - \frac{1}{D_k}\sum_{j\in\mathcal{D}} X_j^k(t_{\ell-1}, t_{\ell-2})\right) \tag{8}$$

Variation Margin & CDS-spread

- The **change** in the market value of dealer member i's CDS holding is,

$$\triangle V_i^k = X_i^k \triangle S^k(t_\ell, t_{\ell-1}) = X_i^k \triangle S^k(t_{\ell-1}, t_{\ell-2}) \left(1 - \frac{1}{D_k} \sum_{j \in \mathcal{D}} X_{j,t_{\triangle \ell}}^k \right) \quad (9)$$

- Permanent Price Impact: CDS-spread on k moves due to changes in **fundamentals**[3],

$$\triangle S^k(t_{\ell-1}, t_{\ell-2}) \rightarrow \triangle F^k(t_{\ell-1}, t_{\ell-2}) \quad (10)$$

- Temporary Price Impact: from trading/liquidation through $f(X_{j,t_{\triangle \ell}}^k)$
- Absent trading, only change in fundamental CDS-spread alters VM,

$$VM_i^{k,p}(t_\ell) = [\, X_{ij}^{k,p}(t_{\ell-1}) \, (\triangle F^k(t_{\ell-1,t_{\ell-2}}) \,]^+ \quad (11)$$

- With trading, primary and temporary impact on CDS-spread alters VM,

$$VM_{i,(t_\ell)}^{k,p} = \quad (12)$$

$$\left[X_{ij}^{k,p}(t_{\ell-1}) (\triangle F_{(t_{\ell-1,t_{\ell-2}})}^k - \triangle S_{(t_{\ell-1},t_{\ell-2})}^k \frac{1}{D_k} \sum_{j \in \mathcal{D}} X_{j,t_{\triangle \ell}}^k) \right]^+$$

[3]Where F is a strictly positive, continuous, non-linear function (e.g. polynomial, trigonometric function bounded from the bottom by zero.)

Concept: Covariance Map

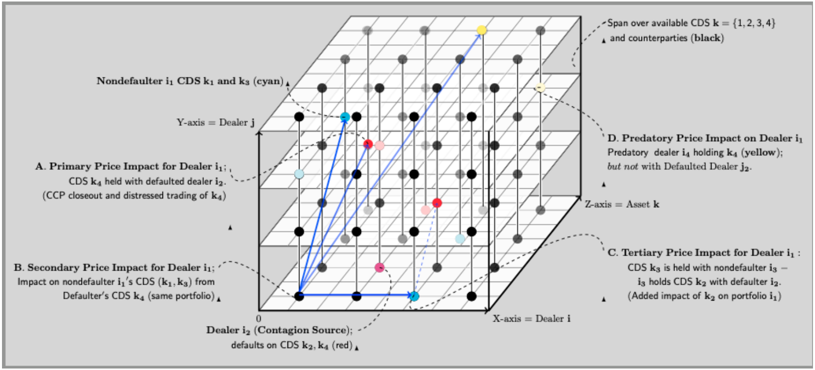

Figure: Covariance relationships Covariance relationships between CDS and counterparties in financial network - defined by the distance of dealers' CDS (colour) positions from a defaulter's CDS positions which are undergoing close-out by CCP.

The Mathematical Structure I: Symbolic Form

- If no trading before $S^k(t_\ell) = F^k(t_{\ell-2} - f(X^k_{j,t_{\triangle\ell}}{}^k)$ then $S^k(t_{\ell-1}) = F^k(t_{\ell-2})$
- The cumulative effect of the price impact can be seen by looking at the change in spread over the next time increment, in terms of the fundamentals (proof in appendix),

$$\triangle S^k(t_{\ell+1}, t_\ell) = \left[F^k(t_\ell) \; - \; \frac{S^k(t_\ell)}{D^k_{(t_\ell)}} \sum_{j \in \mathcal{D}} X^k_{j,(t_\ell)} \right] - \left[F^k(t_{\ell-1}) \; - \; \frac{\overbrace{F^k(t_{\ell-2})}^{S^k(t_{\ell-1})}}{D^k_{(t_{\ell-1})}} \sum_{j \in \mathcal{D}} X^k_{j,(t_{\ell-1})} \right] = \underbrace{F^k_{t_\ell} \; - \; F^k_{t_{\ell-1}}}_{\triangle F^k_{t_\ell, t_{\ell-1}}} - \underbrace{f_{t_\ell}(F^k_{t_{\ell-1}})}_{P_1} + \underbrace{f_{t_{\ell-1}}(F^k_{t_{\ell-2}})}_{P_2} + \underbrace{f_{t_{\ell-1}}(F^k_{t_{\ell-2}})}_{P_3} \tag{13}$$

- Where $X^k_{j,t_{\triangle\ell}}$ is the trading rate $A^k_{j,t_{\triangle\ell}}$ at $\tau = t_{\triangle\ell}$

The Mathematical Structure IIa: Full Formula

- If $X^k_{j,t_{\triangle\ell}}$ is the trading rate $A^k_{j,t_{\triangle\ell}} = \sum_j a^k_{ji,t_{\triangle\ell}}$ per $\tau = t_{\triangle\ell}$.
- And dealers trade due to other dealers' optimal trading, the cds-spread from motivated trading is,

$$\sum_k \triangle S^k(t_{\ell+2}, t_{\ell+1}) = \sum_k^K \Bigg[\; F^k(t_{\ell+1}) - F^k(t_\ell) - \underbrace{F^k(t_\ell)\frac{\sum_{j\in\mathcal{D}} A^k_{j,(t_{\ell+1})}}{D^k_{(t_{\ell+1})}}\tau}_{CCP\ leads\ primary\ trading}$$

$$+ \underbrace{F^k(t_{\ell-1})\frac{\sum_i A^k_{i,(t_{\ell+1})}}{D^k_{(t_{\ell+1})}}\tau\frac{\sum_i A^k_{i,(t_\ell)}}{D^k_{(t_\ell)}}\tau}_{Primary\ distressed\ quick\ reaction} + \underbrace{F^k(t_{\ell-1})\frac{\sum_j A^k_{j,(t_\ell)}}{D^k_{(t_\ell)}}\tau}_{Primary\ predatory\ delay}$$

$$- \underbrace{F^k(t_{\ell-2})\frac{\sum_j A^k_{j,(t_\ell)}}{D^k_{(t_\ell)}}\tau\frac{\sum_i A^k_{i,(t_{\ell-1})}}{D^k_{(t_{\ell-1})}}\tau}_{Secondary\ distressed\ delay} + \underbrace{F^k(t_{\ell-2})\frac{\sum_{j''} A^k_{j'',(t_{\ell+1})}}{D^k_{(t_{\ell+1})}}\tau\frac{\sum_j A^k_{j,(t_\ell)}}{D^k_{(t_\ell)}}\tau\frac{\sum_i A^k_{i,(t_{\ell-1})}}{D^k_{(t_{\ell-1})}}\tau}_{Tertiary\ downstream\ response} \Bigg]$$

The Mathematical Structure IIb: Full Form

- *OTC market price intransparency* permits only a partial view of market prices and trading rates - **dealers can only trade the visible market price not the fundamental price!**
- Each dealer chooses optimal trading rate by approximating average market trading rate (of other traders).
- This shifts the price and permits the exchange (proof appendix) to the tradeable price $S^k_{t_\ell *}$ such that,

$$F^k_{t_{\ell-1}} \frac{A^k_i}{D^k} \tau \rightarrow S^k_{t_\ell *} \frac{A^k_i}{D^k} \tau \tag{14}$$

- The change in spread then incorporates a shift from the fundamental value,

$$S^k_{t_{\ell+1}} - S^k_{t_\ell} = - S^k_{t_\ell *} \frac{A^k_j \, \tau(t_{\ell+1}, t_\ell)}{D^k_{(t_\ell)}} = \triangle S^k_{(t_{\ell+1}, t_\ell)} \tag{15}$$

- Dealers mis-estimation of trading rates and subsequent shift in spread from fundamentals *obscures the price impact of dealers' own trading...*

Thus, predators become prey to own predatory behavior!

The Mathematical Structure IIc: Full Form

Proposition 1: A dealer's variation margin, given by the changing value of its portfolio, is determined by the type and size of CDS positions ($X_i^k = \sum_j^m X_{ij}^k$), as well as, the changing CDS-spread ($\triangle S^k$). The spread captures the magnitude of price impact exerted on the value of a dealer's CDS portfolio from market trading of a defaulter's CDS portfolio – based on the degrees of counterparty covariance between the particular CDS comprising those portfolios.

$$\sum_k^K X_i^k \triangle S^k_{t_{\ell+2},t_{\ell+1}} = \sum_k^K X_i^k \Bigg[\underbrace{\triangle F^k_{(t_{\ell+1},t_\ell)}}_{fundamental\ spread} - \underbrace{S^k_{t_{\ell^*+1}} \frac{\sum\limits_{j\in\mathcal{D}}^m a^k_{0j}\ \tau_{(t_{\ell+2},t_{\ell+1})}}{D^k_{t_{\ell+1}}}}_{CCP\ close-out\ liquidation}$$

$$\Bigg\{ - \underbrace{\triangle S^k_{(t_{\ell+1},t_\ell)} \frac{\sum\limits_{i,j\in\mathcal{D}}^m a^k_{ij}\ \tau_{(t_{\ell+2},t_{\ell+1})}}{D^k_{t_{\ell+1}}}}_{Distressed\ liquidation\ impact} + \underbrace{S^k_{t_{\ell^*}} \frac{\sum\limits_{i,j\notin\mathcal{D}}^m a^k_{ij}\ \tau_{(t_{\ell+1},t_\ell)}}{D^k_{t_\ell}}}_{Predatory\ liquidation\ impact}$$

$$+ \underbrace{\triangle S^k_{(t_\ell,t_{\ell-1})} \frac{\sum\limits_{i,j}^m a^k_{ij}\ \tau_{(t_{\ell+1},t_\ell)}}{D^k_{t_\ell}}}_{Secondary\ price\ impact} - \underbrace{[S^k_{t_{\ell^*-1}} + \triangle S^k_{(t_{\ell+1},t_\ell)}] \frac{\sum\limits_{i,j}^m a^k_{ij}\ \tau_{(t_{\ell+2},t_{\ell+1})}}{D^k_{t_{\ell+1}}}}_{Tertiary\ price\ impact} \Bigg]$$

Pure Fund vs. Hybrid Fund

Using CCP Design Framework of (Amini et al., 2015):

- Dealer: Has **Cash** (γ_i), **Initial Margin** (g_i), **External Asset**.(Q_i).
  Shortfall: Liquidate **fraction** Z_i of external asset Q_i, for **recovery value** R_i.
- **Guarantee Fund**: Sum of the members' initial margin contributions ($G_i = \sum_{i=1}^{m} g_i$)
  - **Pure Fund** (Current): Proprietary initial margin contribution.
  - **Hybrid Fund** (Proposed): Risk-sharing initial margin contribution (like Default Fund D_i)
- If **Net-Exposure** of dealer (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 (lower liquidation loss)
- **Incentive Compatibility**;
  - **Pure Fund** : CCP has larger guarantee fund ($\bar{G}_i$), with CCP surplus ($\bar{C}_0$)
  - **Hybrid Fund**: CCP has smaller guarantee fund ($\hat{G}_i$) to meet all shortfalls ($\hat{C}_i{}^-$), but larger aggregate member surplus ($\sum_{i=1}^{m} \hat{C}_i$),

Periods: Liquidation, Buyback, Recovery

Each period ($t = 1, 2, 3$) has (ℓ) trading time-steps ($\tau = 1\ day$) $\Rightarrow$ $t_{\ell\tau}\ldots$

1. **Period I - Closeout**
   - CCP 5-day unwinding window $\propto$ est. initial margin coverage
   - CCP trades at average market rate until $X^k_{ij\in D} = 0$ $\longrightarrow$ $a^k_0 = \frac{\sum^m_{i,j=1} a^k_{ij}}{m}$
   - Distressed dealers *choose to* liquidate with CCP $\longrightarrow$ $a^k_{i\in D} = a^k_0 \pm \epsilon^k_{i=d}$
   - Predators will liquidate as *fast* as possible without impact $\longrightarrow$ $a^k_i = a^k_j \pm \epsilon^k_{i=p}$
     - **Single/Colluding Predators**: liquidate until CCP is finished.
     - **Competing Predators**: finish liquidating before CCP.
2. **Period II - Buyback**
   - Predatory dealers buyback assets.
     - **Single/Colluding Predators**: obtain maximum profit.
     - **Competing Predators**: reap diminished profit due to early buyback.
3. **Period III - Resolution/Recovery**
   - CCP evaluation of remaining guarantee fund.
     - **Pure Fund**: Initial margin contribution returned (If positive).
     - **Hybrid Fund**: Predators *must* replenish initial margin depleted by dealer distress/default (Initial margin membership criteria!).

Theoretical Results I

★ **Prop 2: Price impact on CDS-spread removes decreases info about fundamental value.**

- Trading dynamics (demand/supply) invisible in opaque OTC market.

$$\triangle s^k(t_{\ell\tau}) = \underbrace{v}_{P_0} - \underbrace{\frac{1}{D_k}(\mathcal{S}^k(t_{(\ell-1)\tau}) - \sum_i^I X_i^k(t_{(\ell-1)\tau}))}_{P_1,\ \mathcal{P},\ P_2,\ P_3} \quad (16)$$

★ **Prop 3: 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.

$$X_{ij}^k(t_{(\ell-1)\tau})\triangle S(t_{(\ell-1)\tau}) \geq [X_{ij}^k(t_{\ell\tau})\triangle S(t_{\ell\tau}) \quad \text{if} \quad |\triangle s_{t_{(\ell-1)\tau}}| \geq |\triangle s_{t_{(\ell\tau}}|,\ X_{ij}^k(t_{(\ell-1)\tau}) = X_{ij}^k(t_{(\ell)\tau})$$

★ **Prop 4: The price impact of liquidation and predation is cumulative:**

- **For Members:** Amplifies unfavourable CDS-spread movements, dampens positive movements
- **For CCP:** given by lemma 1

$$\mathrm{P}_1\ (3\tau, \mathrm{X}_i^{k,S}(3\tau, a_{ji}^{k,\pm}(2\ell)), \triangle \mathrm{S}^{k,S}(3\tau,\ x_i^{k,S}(2\tau),\ \triangle s^{k,S}(2\tau),\ P_1(2\tau),\ \mathcal{P}(2\tau),\ P_2(1\tau),\ P_3(1\tau),\ a_{ji}^{k,\pm}(2\ell)))$$

Theoretical Results II

★ **Lem 1: Unwinding, CCP feels price/predation impact on income (↓), variation margin (↑):**

- Defaulters' shortfalls carried through periods and met by proceeds from closeouts.

$$L_0(t+s) \quad = \quad L_0(t) \quad + \quad \underbrace{L_0^{\mathcal{D},-}(t+s)}_{L_{ij}^{\mathcal{D},-}(t+s)=X_{t+s}\left(\Delta S_t+\sum_{s=1}^{T}\Delta S_{t+s}\right)} \quad \text{where } X_{t+s} \leq X_t$$

★ **Prop 5: In hybrid guarantee fund structure, natural predation disincentive tool:**

- CCP makes margin call on each profitable banks to replenish own initial margin contribution.

$$\hat{G}_i^{\mathfrak{R}}(t_{T_\tau}=3) = (g_i - \hat{G}_i^\star)$$

★ **Prop 6: Hybrid fund incentive compatible for CCP if shortfall $\geq$ Guarantee Fund + Tranche:**

- CCP expects to be better off using the hybrid approach and protecting its own equity.

$$D_{tot}^\star + (1-\epsilon)\Big(\gamma_0 + f\sum_{i=1}^{m}\Lambda_i^+\Big) < \epsilon\Big(\gamma_0 + f\sum_{i=1}^{m}\Lambda_i^+\Big) + G_{tot}^\star \leq \mathbb{E}\left[C_0^-(t_{\ell_\tau}=3)\right]$$

$$\mathbb{E}\left[\hat{C}_0(t_{\ell_\tau}=3)\right] \geq \mathbb{E}\left[\bar{C}_0(t_{\ell_\tau}=3)\right]$$

Simulation: Description

- **Network (nodes)** & agent-based model (14 dealers + CCP) of discrete event (exogenous default).
- **Dealer behaviour** given by regulation/trading rules (exchange of variation margin)
- Previous **empirical work** provides OTC data [Oehmke and Zawadowski 2017, Darrell Duffie and Vuillemey 2015, Amini et al. 2015b] for market size, CCP size, dealer holdings, turnover per trading day.
- Notional position size in each CDS, fundamental CDS-spread changes determined with **distribution** created from data parameters.
- **Exogenous default perturbs network producing knock-on effects:**
  - Exogenous default,
  - CCP unwinding, member trading → change in CDS-spread (price impact),
  - Realise variation margin payments, net-exposure, pay CCP/CCP pays, determine defaults,
  - Defaulters' positions moved to CCP account
  - CCP starts unwinding ...

Goal: Visualise CCP-specific default dynamics, pin-point underlying drivers.

Simulation Results Ia: Default Distribution based on Market Depth

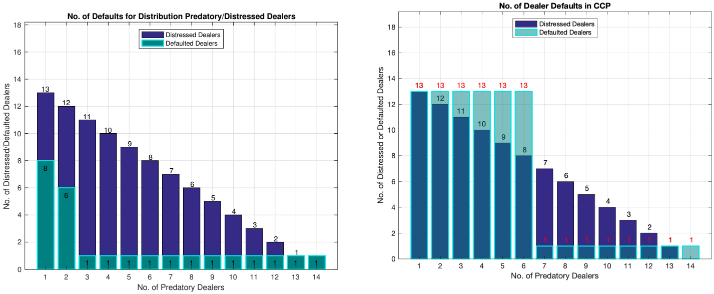

Figure: Under Normal Market Liquidity (left) & Decreasing Market Liquidity (right):
Shows decreasing dealer distress and increasing predatory banks.
Defaults increase rapidly with decreasing liquidity.

Simulation Results Ib: Default Distribution based on Market Depth

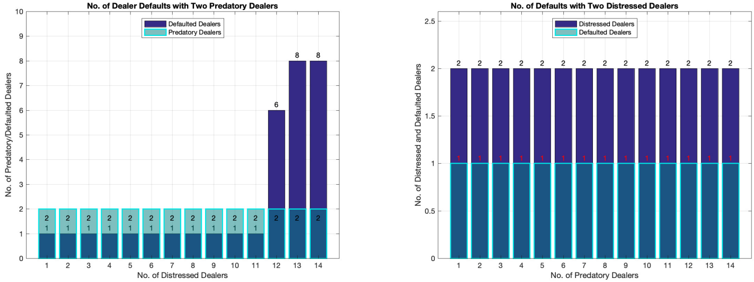

Figure: Under Normal Market Liquidity (left) & Decreasing Market Liquidity (right):
Low levels of predatory banks does not decrease defaults.
Defaults highly driven by level of distressed dealers.

Simulation Results II: Final CCP Loss based on Market Depth

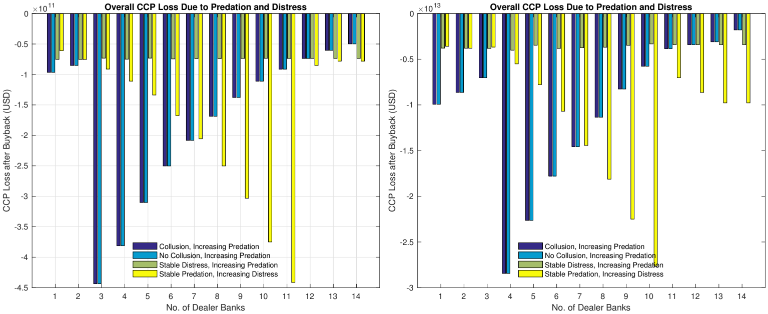

Figure: Under Normal Market Liquidity (left) & Financial Crisis Market Liquidity (right):
Low distressed/predatory dealer levels (yellow/green bars) and level of predator competition (blue and aqua bars). Dealer distress (shortfall) creates larger than predatory profits (refill margin).

Simulation Results III: Final CCP Loss based for Decreasing Market Depth

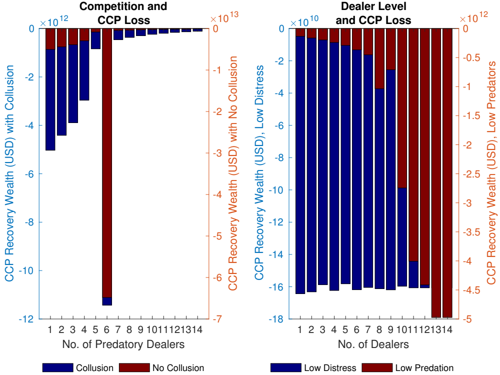

Figure: Decreasing Market Liquidity - Left: Predatory competition (x-axis, red bars) decreases profits and increases CCP losses (y-axis). **Right:** Effect of Low, stable level of predation (red) or distress effect (blue) on CCP losses. The x-axis provides the number of increasing predatory/distressed dealers. Low levels of distressed banks (blue) lowers CCP losses.

Simulation Results IVa: Predation Profits & Margin Refill

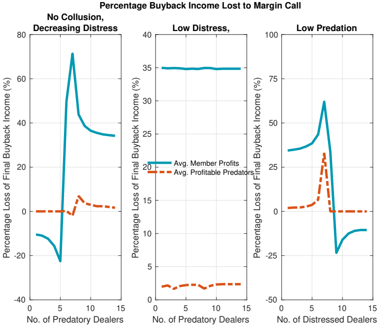

Figure: Under Decreasing Market Liquidity - Realised avg profit loss to margin refill for all members (aqua) vs. profitable predators (red) (after call). Profit loss to margin refill as % of buyback income (y-axis). **Left:** Predation profits outweigh margin refill payment for avg. distress levels (conflict of high profits, but high margin refill from distress vs. loss of predator competition). **Middle:** Low margin refill with low distress (prey). **Right:** Low losses from predatory competition vs. Strong profit decrease from margin refill (high distress).

Simulation Results IVb: Predation Profits & Margin Refill

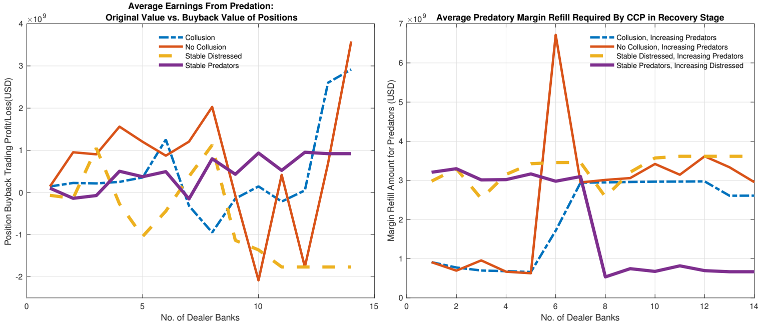

Figure: Under Decreasing Market Liquidity - **Left:** Avg predation earnings/loss (y-axis) in various trading scenarios (colours). Effect of distress level (high prey) and competition
(early buyback) on predators' profit/loss in buyback of original positions.
Right: Avg margin refill (y-axis) by predators alone. Effect of increasing margin demand with decreasing distressed dealers to prey upon (red/blue).

Simulation Results V: Pure vs. Hybrid Wealth for Decreasing Market Depth

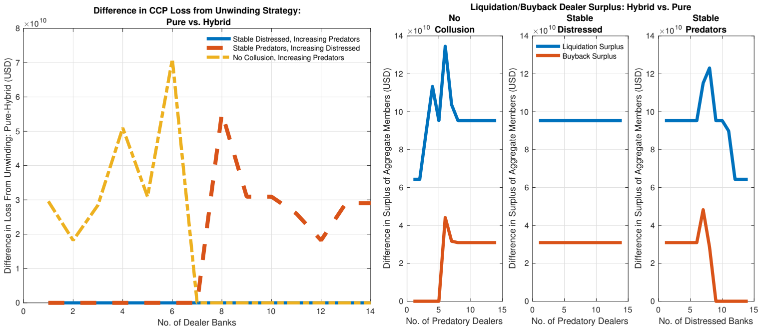

Figure: CCP & Aggregate Member Hybrid Fund Incentive Compatibility -
Left: Equal/larger loss from CCP unwinding (y-axis) with pure vs. hybrid fund.
Right: Higher member surplus (y-axis) for liquidation (blue)/buyback (red) hybrid vs. pure fund. [R1: Increasing predatory competition (x-axis)/decreasing distress.
R2: Low level (two) distressed dealers with increasing predation (x-axis).
R3: Increasing distress (x-axis) and low level (two) of predators.]

Limitations & Thanks

Simulation Limitations and Possible Extensions:

- Allow formation of new trading contracts (existing change from default/liquidation)
- Obtain (if possible) further data for CDS or for internal CCP procedures (proprietary)
- Introduce covariance/correlation data explicitly (tractability)
- Introduce an empirically estimated size for each price impact effect.

Thank You For Your Time & Your Attention!