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.

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Research Question

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

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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.

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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)
  (**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*)

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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

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Model Setup

- Star-shaped financial **network**, CCP connected to banks through CDS.
- **CCP** $i = 0$, **dealer banks** $i = \{1, .., m\}$, CDS on **reference entities** $k = \{1, ..., K\}$
- **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),

$$\Lambda_i = \sum_{j=1}^{m} L_{ji}^k - \sum_{j=1}^{m} L_{ij}^k$$

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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**,

$$X_{ij}^{k,p}\,\mathbf{F}(X_{ij}^{k,p}) \quad \text{with} \quad \mathbf{F}(X_{ij}^{k,p}) = |\triangle S^k(\ell\tau)| \left(\frac{X_{ij}^{k,-p}}{D_k} \right)$$

- 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,

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

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Variation Margin & CDS-spread

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

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

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

$$\triangle S^k(t_\ell) \;=\; \mathbf{f}\Big(\triangle S^k(t_{\ell-1})\Big)$$

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

$$X_{ij}^{k,p}(t_\ell)\triangle S^k(t_\ell) \;=\; X_{ij}^{k,p}(t_{\ell-1})\; \mathbf{f}\,\Big(\triangle S^k(t_{\ell-1})\Big) \;=\; [\; X_{ij}^{k,p}(t_{\ell-1})\; \triangle S^k(t_{\ell-1})\;]^+$$

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Concept: Covariance Map

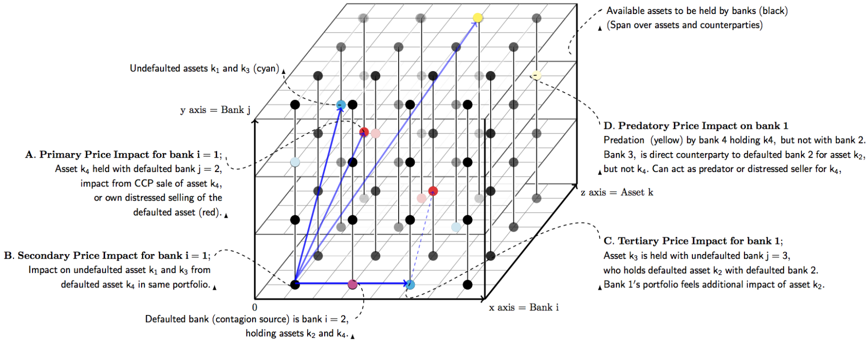

Figure: **Covariance relationships** of banks in terms asset holdings (colour) and of spatial distance to defaulted assets

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The Mathematical Structure I: Reduced Form

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

$$V_i^k = X_i^k \triangle S^k(t_\ell) = \underbrace{\frac{1}{0!} X_i^k \, \mathbf{F}(X_j^k)}_{\textit{fundamental}} + \underbrace{\frac{1}{1!} X_i^k \, \mathbf{F}'(X_j^k)}_{\textit{primary}} + \underbrace{\frac{1}{1!} X_i^k \, \mathcal{F}'(X_j^k)}_{\textit{predatory}} + \underbrace{\frac{1}{2!} X_i^k \, \mathbf{F}''(X_j^k)}_{\textit{secondary}} + \underbrace{\frac{1}{3!} X_i^k \, \mathbf{F}'''(X_j^k)}_{\textit{tertiary}}$$

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

$$X_i^k \triangle S^k(t_\ell) = P_0 + P_1 \, \mathbf{\Gamma_j^k} + \mathcal{P} \, \mathbf{\Gamma_j^k} + P_2 \, \mathbf{\Gamma_j^k} + P_3 \, \mathbf{\Gamma_j^k}$$

$$= \underbrace{[\, X_i^k \triangle S^k(t_{\ell-1}) \,]^+}_{\geq 0} + P_1 \underbrace{a_j^k \tau}_{+/-} + \mathcal{P} \, a_j^k \tau + P_2 \, a_j^k \tau + P_3 \, a_j^k \tau$$

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The Mathematical Structure II: Full Form

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, $\triangle S^k$.

$\mathbf{V_i} =$

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

$$= \sum_k \underbrace{\Big\{[\,X_{ij}^k((\ell-1)\tau)\triangle S^k((\ell-1)\tau)\,]^+}_{fundamental\ cds-spread}$$

$$\text{primary price impact}\begin{cases} + \underbrace{\left(\sum_{j\in\mathcal{D}}\left|\frac{X_{ij}^k}{X_{ij}^k}\right|X_{ij}^k + \varepsilon\sum_{j'\notin\mathcal{D}}\left|\frac{X_{ij'}^k}{X_{ij'}^k}\right|X_{ij'}^k\right)\sum_{i'=1}^{m}|\triangle S^k((\ell-1)\tau)|\left(\frac{X_{ji'}^k}{D_k}\right)\left(\frac{a_{ji'}^k\tau}{X_{ji'}^k}\right)}_{CCP\ liquidation} \\ + \Bigg(\underbrace{\sum_{j\in\mathcal{D}}\left|\frac{X_{ij}^k}{X_{ij}^k}\right|X_{ij}^k\sum_{j\in\mathcal{D}}}_{distressed\ selling} + \underbrace{\varepsilon\sum_{j'\in\mathcal{D}}\left|\frac{X_{ij'}^k}{X_{ij'}^k}\right|X_{ij'}^k\sum_{j\notin\mathcal{D}}}_{distress/predation}\Bigg)|\triangle S^k((\ell-1)\tau)|\left(\frac{X_{ij}^k}{D_k}\right)\left(\frac{a_{ij}^k\tau}{X_{ij}^k}\right)\end{cases}$$

$$+ \underbrace{\varepsilon\sum_{j=1}^{m}\left|\frac{X_{ij}^k}{X_{ij}^k}\right|X_{ij}^k\sum_{j'\notin\mathcal{D}}\sum_{i'=1}^{m}|\triangle S^k((\ell-1)\tau)|\left(\frac{X_{j'i'}^k}{D_k}\right)\left(\frac{a_{j'i'}^k\tau}{X_{j'i'}^k}\right)}_{predation}$$

$$+ \underbrace{\left(\frac{1}{2!}\right)\left(\left(\frac{3}{2!}\right)\sum_{j\in\mathcal{D}}\left|\frac{X_{ij}^k}{X_{ij}^k}\right|X_{ij}^k + \sum_{j'\notin\mathcal{D}}\left|\frac{X_{ij'}^k}{X_{ij'}^k}\right|X_{ij'}^k\right)\sum_{k'}\sum_{j=1}^{m}\left|\frac{X_{ij}^{k'}}{X_{ij}^{k'}}\right|\sum_{i'=1}^{m}|\triangle S^{k'}((\ell-2)\tau)|\left(\frac{X_{ji'}^{k'}}{D_{k'}}\right)\left(\frac{a_{ji'}^{k'}\tau}{X_{ji'}^{k'}}\right)}_{secondary\ price\ impact}$$

$$+ \underbrace{\left(\frac{1}{3!}\right)\left(\left(\frac{9}{3!}\right)\sum_{j\in\mathcal{D}}X_{ij}^k\sum_{k''=1}\left|1-\frac{X_{ij}^{k''}}{X_{ij}^{k''}}\right| + \sum_{j\notin\mathcal{D}}X_{ij}^k\sum_{k''=1}\left|1-\frac{X_{ij}^{k''}}{X_{ij}^{k''}}\right|\right)\sum_{i'=1}^{m}|\triangle S^{k''}((\ell-2)\tau)|\left(\frac{X_{ji'}^{k''}}{D_{k''}}\right)\left(\frac{a_{ji'}^{k''}\tau}{X_{ji'}^{k''}}\right)\Big\}}_{tertiary\ price\ impact}$$

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Pure Fund vs. Hybrid Fund

- Each bank has **cash**, γ_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 ($\hat{C}_i$)

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Periods: Liquidation, Buyback, Recovery

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

1. **Period I - Liquidation Stage (t=1)**
    - CCP has *5 days* to liquidate ∝ initial margin estimate ⇒ $(\mathbf{T} = \mathbf{5}\tau)$
    - CCP liquidates at avg. market rate ⇒ $(\mathbf{a_0^k} = \sum_{\mathbf{i=1}}^{\mathbf{m}} \sum_{\mathbf{j=1}}^{\mathbf{m}} \mathbf{a_{ij}^k}/\mathbf{m})$
    - Distressed banks *choose to* liquidate with CCP ⇒ $(\mathbf{a_{ij\in D}^k} = \mathbf{a_0^k}$ until $\mathbf{X_{ij\in D}^k} = \mathbf{0})$
    - Predators will liquidate as *fast* possible, without impact ⇒ $(\mathbf{a_{ij}^k} = \mathbf{a_0^k})$
        - **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!**

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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

$$\mathbf{P}_1\left(3\tau, \mathbf{X}_i^{k,S}(3\tau, a_{ji}^{k,\pm}(2\ell)), \triangle\mathbf{S}^{k,S}(3\tau,\ X_i^{k,S}(2\tau),\ \triangle S^{k,S}(2\tau),\ P_1(2\tau),\ \mathcal{P}(2\tau),\ P_2(1\tau),\ P_3(1\tau),\ a_{ji}^{k,\pm}(2\ell))\right)$$

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.

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

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

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

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

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

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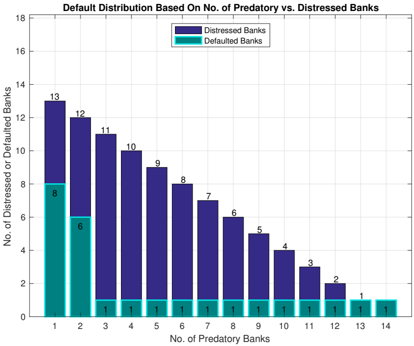
Simulation Results I: Default Distribution based on Market Depth



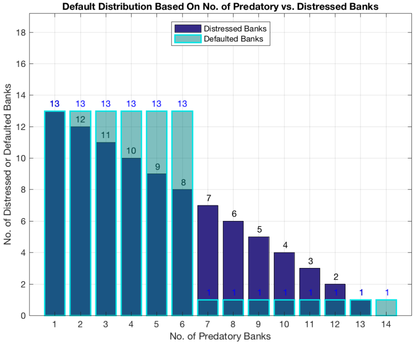


Figure: Under Normal Market Liquidity & Decreasing Market Liquidity

Simulation Results II: Final CCP Loss based on Market Depth (1)

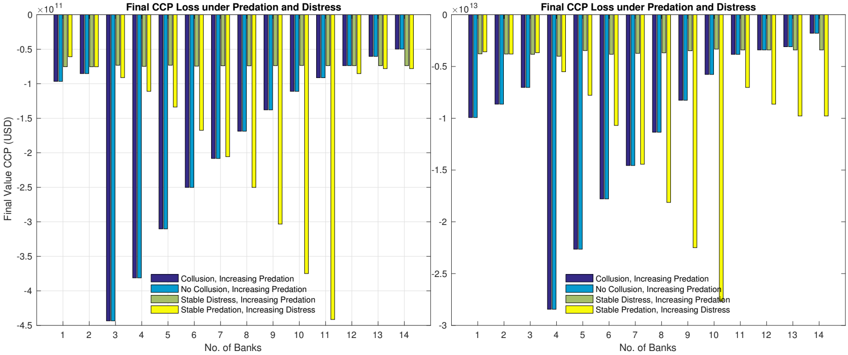


Figure: Under Normal Market Liquidity & Financial Crisis Market Liquidity

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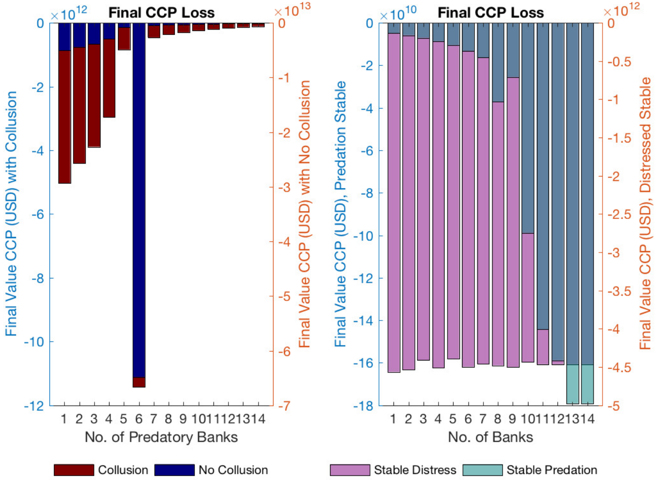
Simulation Results III: Final CCP Loss based for Decreasing Market Depth



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Simulation Results IV: Predation Profits & Margin Refill

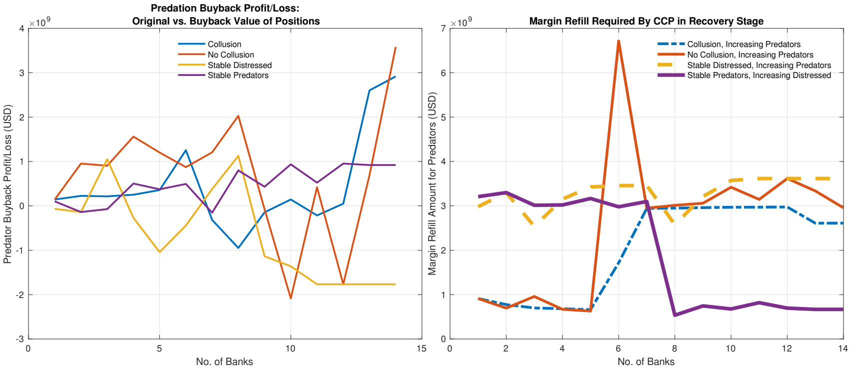

Figure: Under Decreasing Market Liquidity

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

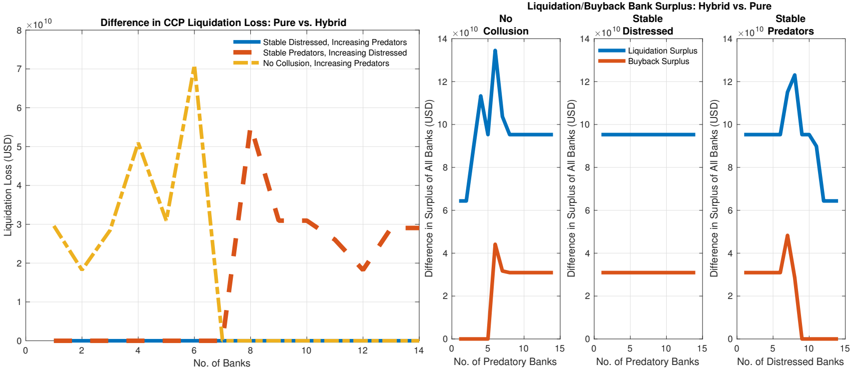

Figure: CCP Liquidation Loss & Aggregate Bank Liquidation/Buyback Surplus

Summary & Limitations

In Summary:

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

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