Motivation

- A key post-crisis reform is the mandatory clearing of standardized OTC derivatives (CDS+IRS).
  - CCPs act as the buyer to every seller and the seller to every buyer
  - CCPs guarantee terms of trades by pooling the counterparty risks
  - Risk management of CCPs is crucial for financial stability
Bilateral Trading Markets

Diagram showing bilateral clearing with various nodes A, B, C, D, E, F, G, H, I, K, L, M, N representing different entities in the market. The diagram includes End-user, Small financial institution, and Large financial institution categories.
Collateral and CCP’s Default Waterfall

Members post two types of collateral: initial margin and default fund.

1. Defaulting member’s Initial Margin
2. Default funds
   - Prefunded Collateral Resources
3. Defaulting member’s Default Fund
4. CCP’s equity capital (tiny)
5. Surviving members’ Default Funds (loss mutualization)
6. Not prefunded Collateral Resources
   - Could be costly
7. End-of-Waterfall Resources (Assessments, IM Haircutting, VMGH)
Entering 2020, most CCPs had bigger default funds than a year ago

Abdool Fawzee Bhollah
Louie Woodall
03 Apr 2020

The default fund covering Paris-based LCH SA's €GCPlus tri-party repo service increased the most over 2019, by 57% to €225 million
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Size of default funds expressed as percentage of total IM as of Q4 2019, by clearing service
Motivation

- A key post-crisis reform is the mandatory clearing of standardized OTC derivatives (CDS+IRS).
  - CCPs act as buyer to every seller and seller to every buyer
  - CCPs guarantee terms of trades by pooling counterparty risks
  - risk management of CCPs is crucial for financial stability

- CCPs collect prepaid collateral: initial margin and default fund
  - initial margins are only used to absorb losses of the posting member
  - default funds are shared across members for loss mutualization

- Little is known about the design of collateral requirements for CCPs
  - how to allocate collateral in initial margin and default funds?
  - what are the economic tradeoffs between the two types of collateral?
A framework to jointly solve for initial margin and default funds
- both raise members’ pledgeable income, but are imperfect substitutes
- initial margin is more cost-effective to align members’ incentives
- default fund is less cost-effective for incentive provision ex-ante, but more valuable for CCP’s resilience ex-post

The optimal design of collateral trades off between minimizing
- members’ collateral opportunity cost ⇒ call for more initial margin
- CCP recapitalization cost ⇒ call for more default fund

Policy implications for CCP resilience and value of clearing
Literature

- **The Role of Collateral in Derivatives Markets**
  - Oehmke 2014; Bolton, Oehmke 2015; Biais, Heider, Hoerova 2016, 2019
  - We model the composition of collateral in central clearing

- **Loss-mutualization and Insurance**
  - Arrow, 1974; Raviv, 1979; Parlour, Plantin, 2008
  - We highlight the distinguishing features of central clearing

- **Central Clearing and CCP Regulation**
  - Acharya, Bisin 2014; Koeppl, Monnet, Temzelides 2012; Duffie, Zhu 2011; Biais, Heider, Hoerova 2012; Vuillemey 2019; Huang 2019
  - Boissel et al. 2017; Menkveld 2017; Cruz Lopez et al. 2017
  - We provide a normative analysis on the design of collateral requirements
Model
Model Setup: agents and assets

- A continuum of risk-averse (parameter $\gamma > 0$) protection buyers
  - an aggregate credit shock (prob = $p_c$) of $(-D)$ to endowed payoff
  - seek insurance against credit risk from dealers at price $A$ (endogenous)
- $N$ risk-neutral dealers, each selling a CDS and enjoying limited liability
  - fully invests $A$ in a risky asset
    - bad state (prob = $q_a$): payoff of 0, default
    - good state (prob = $1 - q_a$): payoff of $A \times R_a - p_c D$, survive
  - makes risk-management choice $a = \{s \text{ (to hedge)}, r \text{ (not to hedge)}\}$
    - $0 < q_s < q_r$, $R_s < R_r$
    - choice $a$ is unobservable
- Assume risk management is efficient: $\mu_s > \mu_r$, where $\mu_a = (1 - q_a)R_a$
Bilateral Trading Market

- $t = 0$: a buyer and a dealer trade CDS; buyer pays a unit price $A_{BT}$

- $t = 1$: the dealer receives i.i.d. payoff, delivers promise $D$ in the aggregate credit event $(p_c)$, and defaults with prob $p_cq_a$
Centrally Cleared Market

- CCP guarantees insurance payment $D$ to buyers.

- $t = 0$: CCP collects collateral from members: initial margin $I \in [0, D]$, default fund $F \in [0, D - I]$. Members incur opportunity cost $\beta(I + F)$.

- $t = 1$: $N_d$ members default; if all collateral is exhausted, CCP invokes end-of-waterfall resources at a cost $(1 + \beta)(N_d(D - I) - NF)^+$. 

Stylized model of the default waterfall end-of-waterfall resources are sufficient to prevent CCP’s default we do not model “CCP’s skin-in-the-game” (tiny in the waterfall) CCP acts as a social planner to maximize value of all market participants.
Centrally Cleared Market: default waterfall

1. Defaulting member’s Initial Margin
   \[ I \in [0, D] \]

2. Default funds

3. Defaulting member’s Default Fund
   \[ F \in [0, D - I] \]

4. Surviving members’ Default Funds
   (loss mutualization)
   \[(N - \mathcal{N}_d)F\]

5. End-of-Waterfall Resources
   \[(\mathcal{N}_d(D - I) - NF)^+\]
Centrally Cleared Market

- CCP guarantees insurance payment $D$ to buyers with certainty.
- $t = 0$: CCP collects collateral from members: initial margin $I \in [0, D]$, default fund $F \in [0, D - I]$. Members have opportunity cost $\beta(I + F)$.
- $t = 1$: $N_d$ members default; if all collateral is exhausted, CCP invokes end-of-waterfall resources at a cost $(1 + \beta)(N_d(D - I) - NF)^+$. 

⚠️ Stylized model of the default waterfall

- end-of-waterfall resources are sufficient to prevent CCP’s default
- we do not model “CCP’s skin-in-the-game” (tiny in the waterfall)
- CCP acts as a social planner and maximizes value of all market participants
Pricing of Bilateral and Centrally Cleared CDS

- Assumption 1: buyers have zero bargaining power and are sufficiently risk-averse, $\gamma > \gamma$
  - allows dealers to collect a high premium for a centrally cleared CDS
  - dealers’ participation constraint is satisfied

- A bilaterally traded CDS reduces buyer’s credit risk from $p_c$ to $p_c q_a$

  $$A_{BT} = p_c D (1 - q_r) (1 + \gamma D (1 - p_c - p_c q_r))$$

- A centrally cleared CDS reduces buyer’s credit risk from $p_c$ to 0

  $$A_{CCP} = p_c D (1 + \gamma D (1 - p_c)) > A_{BT}$$

- Assumption 2 (technical restrictions):
  - $D > \frac{A_{CCP} (\mu_s - \mu_r)}{(q_r - q_s) p_c} \Rightarrow$ dealers do not hedge without posting collateral
  - $A_{BT} R_s > D \Rightarrow$ a dealer is able to pay $D$ in the good state
A bilateral dealer chooses not to hedge ⇒ risk-shifting

\[ V_{BT} = \max_{a \in \{s,r\}} (1 - q_a) (A_{BT}R_a - p_c D) \Rightarrow a = r \]

A clearing member’s risk-management decision depends on collateral

\[ V(a_i, a_{-i}; I; F) = -(1 + \beta)(I + F) + (1 - p_c)(I + F) + \]

\[ (1 - q_{a_i}) \left( A_{CCP}R_{a_i} - p_c D + p_c I + p_c \mathbb{E}^a \left[ \left( F - \frac{N_d(D - I - F)}{N - N_d} \right)^+ \right] \right) \]

expected refund of collateral ⇒ increase in pledgeable income
The First-Best Benchmark: no collateral is needed

In the first-best, the CCP chooses \((a; I; F)\) to maximize value of all market participants

\[
\max_{(a; I; F)} \left\{ \sum_i V(a_i, a_{-i}; I; F) - (1 + \beta) p_c \mathbb{E}^a \left[ (N_d(D - I) - NF)^+ \right] \right\}
\]

Proposition 1: In the first-best, all dealers hedge and post zero collateral.

Costly collateral is collected only as an incentive device.
In the second-best, given \( a(I; F) \), the CCP chooses optimal collateral \( (I^{SB}, F^{SB}) \) to maximize value of all market participants

\[
\max_{(I,F)} \left\{ \sum_{i} V_i(a; I; F) - (1 + \beta) p_c \mathbb{E}^a \left[ (N_d(D - I) - NF)^+ \right] \right\}
\]

subject to

- **incentive compatibility**: \( V(a = s; I; F) \geq V(a = r; I; F) \)

- **individual rationality**: \( V(s; I; F) \geq V_{BT} \)
Proposition 2: Members’ risk-management choices depend on collateral $I$ and $F$.

- posting collateral increases pledgeable income, alleviates risk-shifting
- total refundable collateral needs to be $D - \frac{A_{CCP}(\mu_s - \mu_r)}{(q_r - q_s)p_c}$
- IC curve satisfies $\frac{\partial \hat{F}(I)}{\partial I} < -1$
  $\Rightarrow$ when initial margin decreases by 1, default fund increases by $1+$.  
  $\Rightarrow$ initial margin is more cost-effective in aligning members’ incentives.
Proposition 3: The incentive-constrained optimal collateral is $I^{SB} > 0$ and $F^{SB} = 0$ when marginal collateral cost equals CCP recapitalization cost.

- CCP recapitalization is financed ex-post, thus is cheaper ($\beta > p_c \beta$)
- minimizing members’ collateral posting is the primary goal

$\Rightarrow$ initial margin is preferred
Optimal Collateral Requirements: extreme market events

- Prefunded Collateral with cost $\beta$
- Not prefunded, with cost $\alpha$

**Defaulting member’s Initial Margin**
$I \in [0, D]$

**Defaulting member’s Default Fund**
$F \in [0, D - I]$

**Surviving members’ Default Funds (loss mutualization)**
$(N - \mathcal{N}_d)F$

**End-of-Waterfall Resources**
$(\mathcal{N}_d(D - I) - NF)^+$
Proposition 4: The incentive-constrained optimal collateral is $I^{SB} = 0$ and $F^{SB} > 0$ if CCP recapitalization cost is higher than collateral cost, i.e., $\beta < p_c \alpha$.

- reducing recapitalization cost via mutualization is the primary goal
  ⇒ default fund is preferred
  ⇒ a reason to increase default funds amid Covid-19 Crisis (Risk.net)
Optimal Cover Rule for Default Funds: “Cover x\%”

Proposition 5: Default fund follows a “Cover x\%” rule, as $N \to \infty$.

- cover number increases with $N$; Cover x\% has little variation with $N$
- implications: cover a fixed fraction rather than a fixed number
- the rule is robust to entry and exit of members
Robustness 1: convex CCP recapitalization cost

In systemic events, i.e., when multiple members default, CCP might face increasing marginal costs to raise end-of-waterfall resources:

\[ \alpha \left( \left( N_d(D - I) - NF \right)^+ \right)^2. \]

- the trade-off between initial margin and default fund is robust

\[ \Rightarrow \text{ nonlinearity allows to pin down interior levels of collateral} \]
Robustness 2: heterogeneity in size

CCPs’ exposures tend to concentrate in a few large clearing members. Suppose \( i \) is \( K \) times \( (K > 1) \) the size of others: \( KD, KA_{\text{CCP}}R_a \)

![Diagram illustrating economic forces and required collateral]

- economic forces from the baseline model persist
- required collateral is disproportionately lower for the big member
  \( ⇒ \) it is easier for the big member (as a coordinated group of \( K \) small members) to internalize the externalities
Policy Implications: collateral design and CCP resilience

- Our results inform the optimal design of collateral requirements
  - CCPs are required to quarterly disclose their default waterfalls
  \[ \Rightarrow \text{it is feasible to closely monitor CCP collateral requirements} \]

- CCP having to recapitalize is a warning sign against its resilience
  - high recapitalization cost $\alpha$ as a strong regulatory weight on reducing systemic distress
  \[ \Rightarrow \text{expected loss at the CCP under the optimal collateral requirements} \]
  \[ (I_{SB}, F_{SB}) \text{ converges to 0} \]

- Our results show the value of central clearing under optimal collateral
  - members prefer to join CCP than trade bilaterally
Policy Implications: the value of central clearing

What if trades in bilateral markets are fully collateralized?
⇒ Dealers choose to hedge, and impose zero counterparty risk to buyers
⇒ But full collateralization is too costly ⇒ members prefer CCP
Policy Implications: the value of central clearing

What about using incentive-compatible margin in bilateral markets?
⇒ Dealers choose to hedge, and impose counterparty risk $p_c q_s$ to buyers.
⇒ But collateral is higher than in central clearing ⇒ members prefer CCP
Empirical Implications

1. CCP collects more collateral when the CDS reference entity has higher credit risk; Members with more effective risk management post less collateral.

2. Fraction of default fund decreases with collateral opportunity cost, increases with measures of systemic distress.

3. Total default funds increase with number of members. Larger members post more collateral, but disproportionately lower default fund.
Conclusions

- We develop a new framework of collateral requirements for CCPs.
- We study the trade-off between initial margin and default fund
  - initial margin is more cost-effective to align incentives
  - default fund allows for members’ loss-sharing ex-post, but is less valuable for incentive provision ex-ante
- We solve for the incentive-constrained optimal collateral
  - use initial margin during normal times, default fund in extreme market events when CCP recapitalization is costly
  - offer a rationale for collecting default funds and a “Cover x%” rule
  - insights generalize to settings with heterogeneous members