THAT'S ONE THING ABOUT HIM, HE KNOWS WHEN TO STOP!
Central counterparty (CCP) resolution
The right move at the right time.

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BIS

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Disclaimer: The views expressed here are those of the authors and not necessarily of the Bank for International Settlements
Motivation

- CCPs are systemic nodes
  - Increasing proportion of central clearing

Data source: BIS

- CCP resilience, recovery and resolution are essential to financial stability
- Entering into CCP resolution is an irreversible decision under uncertainty
- Timing is important
Key trade-off and preliminary findings

This paper develops a real option model
  ▶ Optimal stopping problem to minimize expected losses
    ▶ Too early
      ▶ Lose the option value of waiting
    ▶ Too Late
      ▶ Losses could be extremely large and threaten financial stability

Preliminary findings
  ▶ Additional resources dedicated to CCP resolution
    ▶ The probability of CCP recovery is higher
    ▶ Conditional on resolution, expected losses are larger
Literature review

► CCP recovery and resolution
  ► [Elliott(2013)], [Duffie(2014)]
  ► [Raykov(2016)], [Singh and Turing(2018)]

► Central clearing
  ► [Duffie and Zhu(2011)], [Cont and Kokholm(2014)],
    [Kubitza, Pelizzon, and Getmansky(2018)]
  ► [Domanski, Gambacorta, and Picillo(2015)], [Cont(2017)]

► Real option
  ► [McDonald and Siegel(1986)], [Dixit(1989)]
  ► [Pindyck(1990)], [Dixit and Pindyck(1994)]
Institutional background

Resilience
- Use pre-funded resources for losses
  - Success: CCP returns to bus. as usual
  - Not successful

Recovery
- Allocate remaining losses via cash calls, VMGH etc
  - Success
  - Not successful
- Bridge to new entity (critical services) and orderly wind-down (non-critical services)
Model setup - Agents

- **Buyers**
  - expose to real economy risk
  - fully hedge with a (long-dated) derivatives contract

- **Sellers**
  - make market for the derivatives
  - could default due to large price movements

- **A CCP**
  - sits between the buyers and the sellers
  - has one recovery tool following its rule book

- **A resolution authority**
  - minimizes expected losses from CCP recovery
  - decides when to resolve the CCP
- LIBOR increases
- Buyers and sellers need to exchange VM
- Sellers default
- The CCP needs to cover the default losses

**Model setup - Default scenario**

<table>
<thead>
<tr>
<th>Asset</th>
<th>CCP</th>
<th>Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIBOR (Defaulting)</td>
<td>Fix (Defaulting)</td>
<td>VM payable</td>
</tr>
<tr>
<td>VM receivable</td>
<td>VM payable</td>
<td>Liquid assets</td>
</tr>
<tr>
<td>Fix</td>
<td>LIBOR</td>
<td>IM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equity</td>
</tr>
</tbody>
</table>
Model setup - Recovery starts

- The prefunded resources are exhausted
- The CCP needs to use recovery tools
- Recovery tools
  - Cash calls
  - VMGH
- Uncertainties
  - Market risk
  - Liquidity risk
Model setup - uncertainties

- Liquidity events

\[ dN_t = \begin{cases} 
0, & 1 - \lambda_t \, dt \\
1, & \lambda_t \, dt 
\end{cases} \]

- Marked-to-market losses

\[ dX_t = \sigma_t X_t \, dz_t \]

- Cash inflow \( \tilde{R}_t \, dt \)

\[ d\tilde{R}_t = -\varepsilon \tilde{R}_t \, dN_t \]
Model setup - interlinked uncertainties

- When $\frac{X_t}{R_t}$ is large, the CCP is less likely to recover
  - Derivatives market get more volatile $\implies \sigma_t$ is large
  - Participants are less willing to provide liquidity $\implies \lambda_t$ is large
Model setup - Successful recovery

- Cash calls are honored
- Cash outflows decrease
- CCP is recovered successfully
Model setup - CCP resolution

- Cash calls are not honored
- Cash outflows increase
- The resolution authority steps in
Optimal stopping problem

The resolution authority solves the following stopping problem

$$\max_T E \left[ \int_0^T \left( \begin{array}{cc}
\text{Inflow} & \text{Outflow} \\
\tilde{R}_t & -X_t \\
\text{recovery} & \text{resolution}
\end{array} \right) dt + \left( \begin{array}{cc}
\text{Equity} & \text{Inefficiency} \\
e & l + \tilde{R}_T - X_T \\
\text{recovery/continuation} & \text{resolution/stop}
\end{array} \right) \right] := F(\tilde{R}, X)$$

(1)

- Let $u_t$ denote the state variables: \{\tilde{R}_t, X_t\}
- $\pi(u_t) = \tilde{R}_t - X_t$ and $\Omega(u_t) = e - l + \tilde{R}_T - X_t$
- Hamilton-Jacobi-Bellman (HJB) equation

$$F(u_t) = \max \{ \pi(u_t) dt + F(u_t) + E[dF(u_t)], \Omega(u_t) \}$$
Optimal timing

- Optimal stopping regions are separated by threshold $u^*$
- Optimal timing of entry into resolution $T$
  - The first time when $u_t$ reaches $u^*$
- Successful recovery timing $\tau$ ($\geq 1$)
  - The first time when $\int_0^{\tau} (\tilde{R}_t - X_t) \, dt \geq 0$
- Resolve the CCP if $T < \tau$
State variables

- It is optimal to resolve the CCP when $\tilde{R}_t$ is small or $X_t$ is large.
- One can reduce the number of state variables to one: $G_t = \frac{X_t}{\tilde{R}_t}$.
Additional resources dedicated to resolution

**Proposition. Comparative statics**
With increasing additional resources dedicated to CCP resolution,
(i) the expected time to resolution increases,
(ii) the likelihood of successful recovery increases,
(iii) the losses conditional on resolution increases.
Additional resources dedicated to resolution

We establish a set of parameters for the base case

- \( \ln(X_t) \) has a variance of 1% per period (\( \sigma = 0.1 \))
- Liquidity event comes once per period (\( \lambda = 1 \))
- 10% of the surviving members suffer losses (\( \varepsilon = 0.1 \))
- Resolving the CCP leads to 1 unit of asset (\( e - l = 1 \))
- Initial loss is 10 unit (\( \tilde{R}_0 = X_0 = 10 \))
- Additional resources of 1 unit (\( \Delta e = 1 \))
Limitations/Extensions

- The current model assumes auctions fail
  - With successful auctions, the uncertainty on the cash outflow is resolved $\sigma_t = 0$
  - The option value of waiting will be smaller
  - The same logic should carry through

- The model assumes away the buyers and sellers’ incentives
  - Resolution by the authority may weaken the buyers and sellers’ incentives to cooperate in the default management
  - Taking into account the dynamic incentives of the buyers and sellers, the current thresholds might be too lenient.

- The base case calibration is rudimentary
  - Liquidity/credit stress testing results from CFTC and ESMA
  - Any other suggestions?
Appendix
Unlike cash calls, VMGH allows the CCP to directly reduce its liability

$$ R_t dt = X_t dt $$

$$ \frac{X_t}{R_t} = 1, \text{ i.e., the optimal stopping problem is not affected by the interlinkage of the uncertainties} $$

CCP’s cash inflow $R_t$ follows a geometric Brownian motion:

$$ dr_t = \sigma R_t dz_t. $$
The resolution authority solves the following stopping problem

\[
\max_T E \left[ \int_0^T (-C_t) \, dt + (e - l - C_T) \right] := V(C) \tag{2}
\]

- Hamilton-Jacobi-Bellman (HJB) equation

\[
V(C_t) = \max \left[ (-C_t \, dt + E[V(C_t) + dV(C_t)]) \right. \left. + \left( e - l - C_T \right) \right]
\]

\text{(Recovery \hspace{1cm} Resolution)}
State variables - VMGH

\[ C_t \text{ (Losses of the CMs)} \]

- \( C^* \)
- Successful recovery
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References III


References IV
