
THAT'S ONE THING ABOUT HIM, HE KNOWS WHEN TO STOP!

BANK FOR INTERNATIONAL SETTLEMENTS

Central counterparty (CCP) resolution

The right move at the right time.

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BIS

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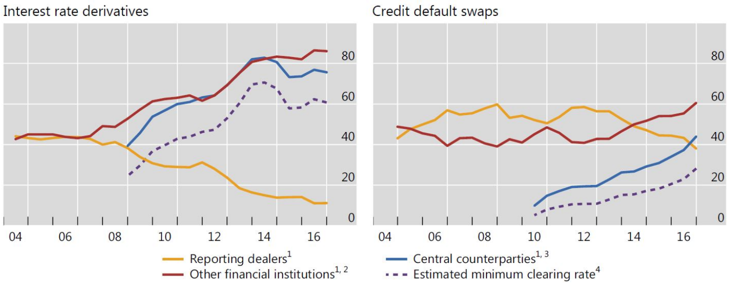
Disclaimer: The views expressed here are those of the authors and not necessarily of the Bank for International Settlements

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

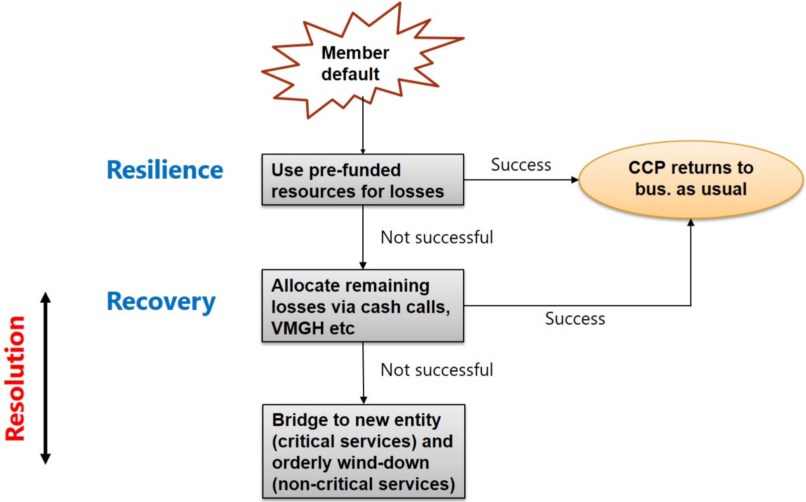
Preliminary findings

- 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)]
  - [Koeppl and Monnet(2013)], Biais, Heider and Hoerova (2012, 2016, 2018)
  - [Domanski, Gambacorta, and Picillo(2015)], [Cont(2017)]
- Real option
  - [McDonald and Siegel(1986)],[Dixit(1989)]
  - [Pindyck(1990)], [Dixit and Pindyck(1994)]

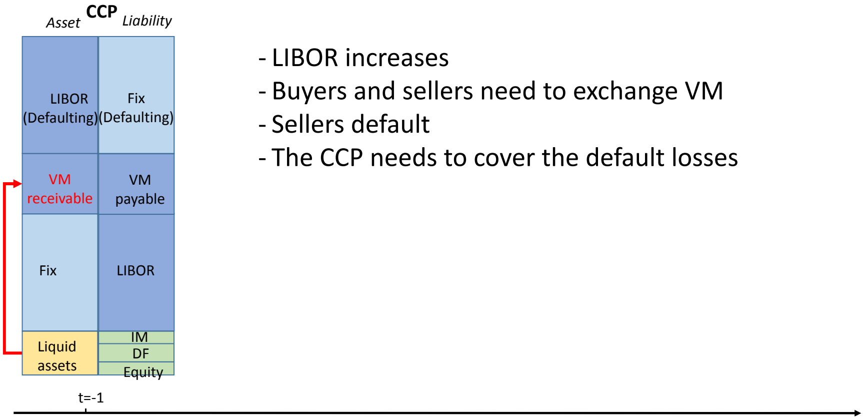
Institutional background



Model setup - Agents

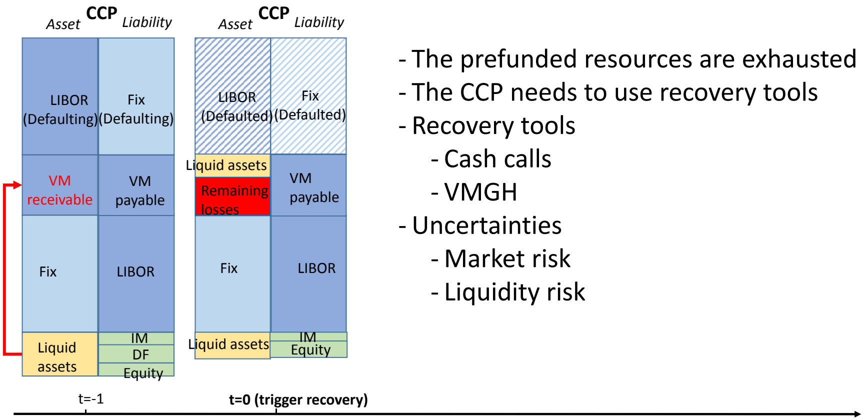
- Buyers
  - expose to real economy risk
  - fully hedge with a (long-dated) derivatives contract
- Sellers
  - make market for the derivatives
  - could default due to large price movements
- A CCP
  - sits between the buyers and the sellers
  - has one recovery tool following its rule book
- A resolution authority
  - minimizes expected losses from CCP recovery
  - decides when to resolve the CCP

Model setup - Default scenario



- LIBOR increases
- Buyers and sellers need to exchange VM
- Sellers default
- The CCP needs to cover the default losses

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

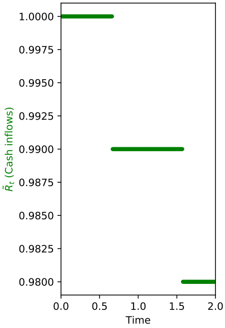
$$dN_t = \begin{cases} 0, & 1 - \lambda_t dt \\ 1, & \lambda_t dt \end{cases}$$

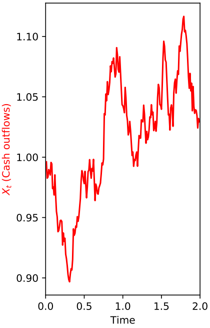
- Marked-to-market losses $X_t dt$

$$dX_t = \sigma_t X_t dz_t$$

- Cash inflow $\tilde{R}_t dt$

$$d\tilde{R}_t = -\varepsilon \tilde{R}_t dN_t$$

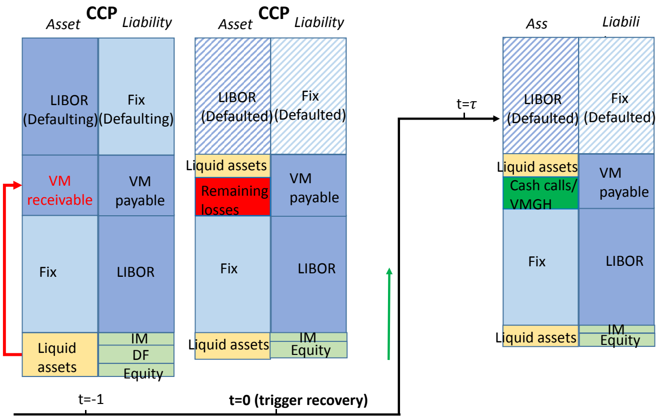




Model setup - interlinked uncertainties

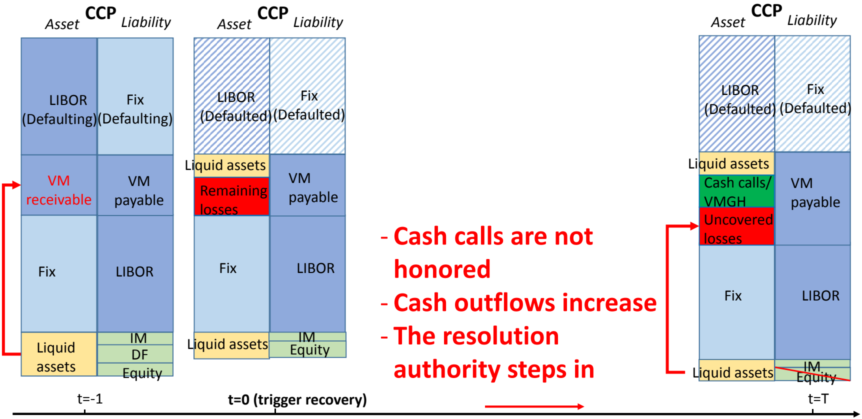
- When $\frac{X_t}{\tilde{R}_t}$ is large, the CCP is less likely to recover
  - Derivatives market get more volatile $\Longrightarrow \sigma_t$ is large
  - Participants are less willing to provide liquidity $\Longrightarrow \lambda_t$ is large

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

$$\max_{T} E\left[\underbrace{\int_0^T \left(\overbrace{\tilde{R}_t}^{\text{Inflow}} - \overbrace{X_t}^{\text{Outflow}}\right) dt}_{\text{recovery}} + \underbrace{\left(\overbrace{e}^{\text{Equity}} - \overbrace{I}^{\text{Inefficiency}} + \tilde{R}_T - X_T\right)}_{\text{resolution}}\right] := F(\tilde{R}, X) \quad (1)$$

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

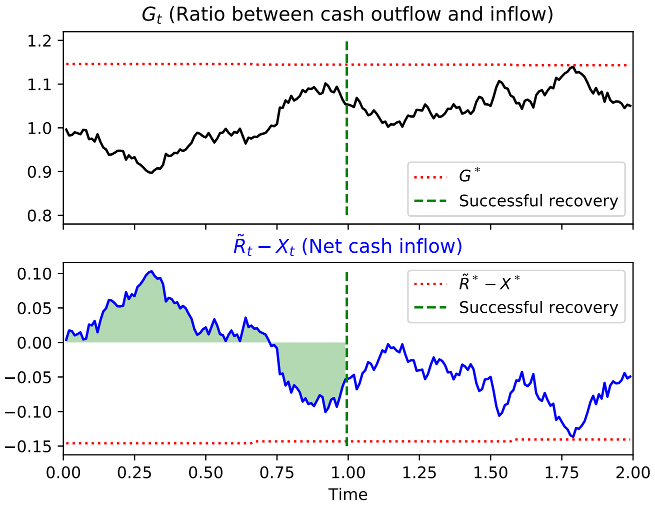
$$F(u_t) = \max\{\underbrace{\pi(u_t)dt + F(u_t) + E[dF(u_t)]}_{\text{recovery/continuation}}, \underbrace{\Omega(u_t)}_{\text{resolution/stop}}\}$$

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 τ (≥ 1)
  - The first time when $\int_0^\tau \left(\tilde{R}_t - X_t\right) dt \geq 0$
- 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,

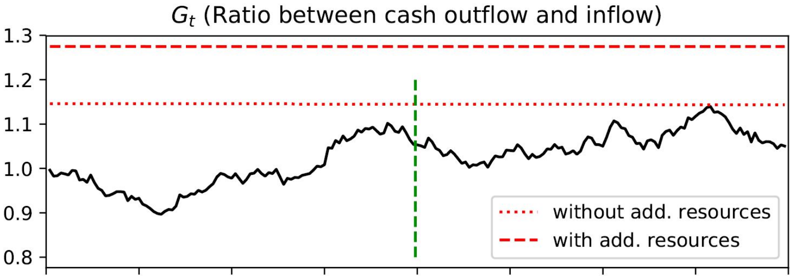
(ii) the likelihood of successful recovery increases,

(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

Uncertainties - VMGH

- Unlike cash calls, VMGH allows the CCP to directly reduce its liability

$$R_t dt = X_t dt$$

- $\frac{X_t}{R_t} = 1$, 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:

$$dR_t = \sigma R_t dz_t.$$

Optimal stopping problem - VMGH

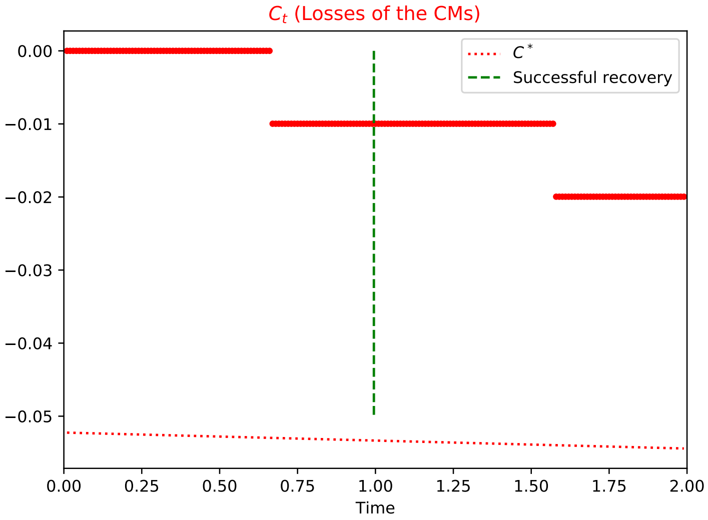
The resolution authority solves the following stopping problem

$$\max_{T} E\left[\int_0^T (-C_t)\,dt + (e - I - C_T)\right] := V(C) \qquad (2)$$

- Hamilton-Jacobi-Bellman (HJB) equation

$$V(C_t) = \max\left[\underbrace{(-C_t dt + E[V(C_t) + dV(C_t)])}_{\text{Recovery}}, \underbrace{(e - I - C_T)}_{\text{Resolution}}\right]$$

State variables - VMGH



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