
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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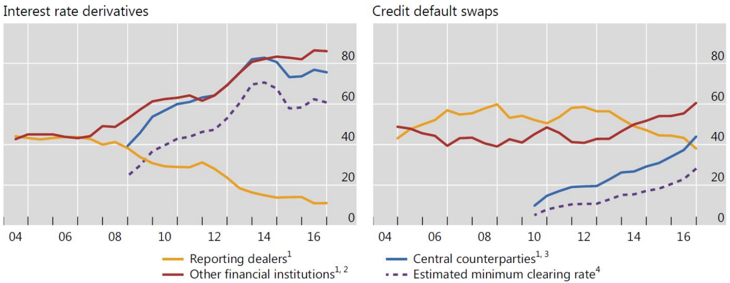
BIS

15 November, 2018

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

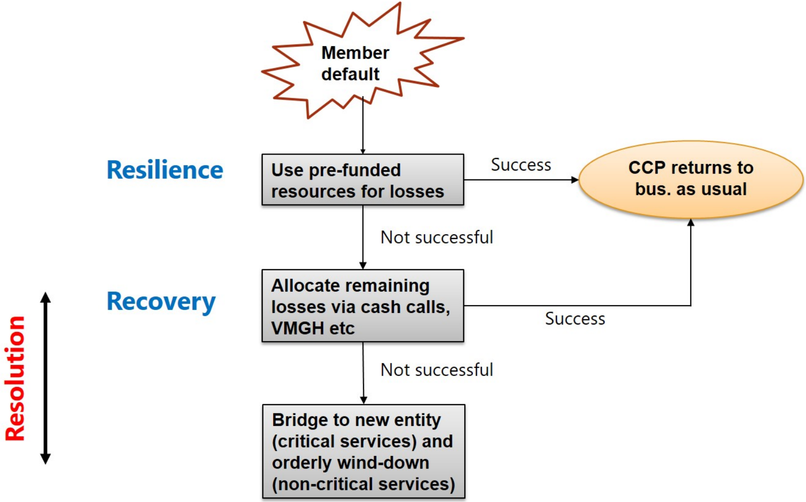
Preliminary findings

- 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)]

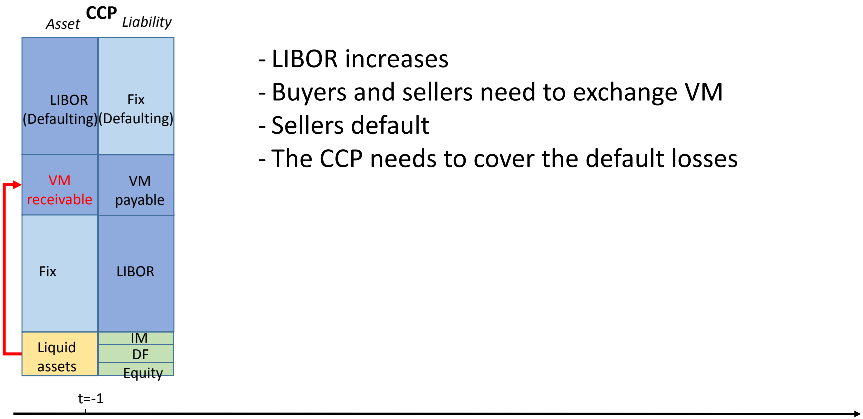
Institutional background



Model setup - Agents

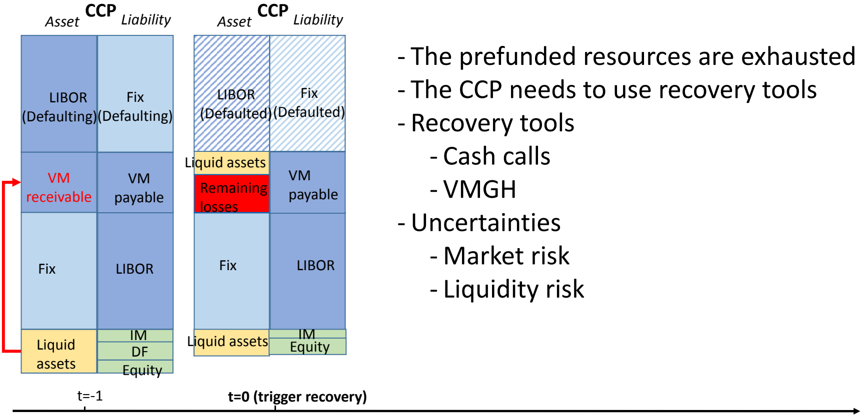
- Buyers
  - expose to real economy risk
  - fully hedge with a (long-dated) derivatives contract
- Sellers
  - make market for the derivatives
  - could default due to large price movements
- A CCP
  - sits between the buyers and the sellers
  - has one recovery tool following its rule book
- A resolution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

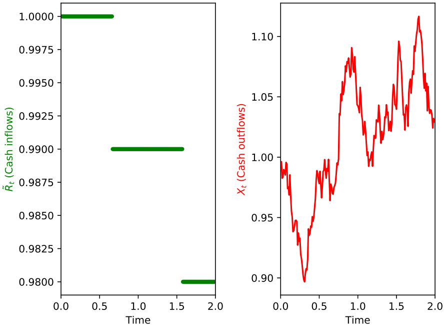
$$dN_t = \begin{cases} 0, & 1 - \lambda_t dt \\ 1, & \lambda_t dt \end{cases}$$

- Marked-to-market losses $X_t dt$

$$dX_t = \sigma_t X_t dz_t$$

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

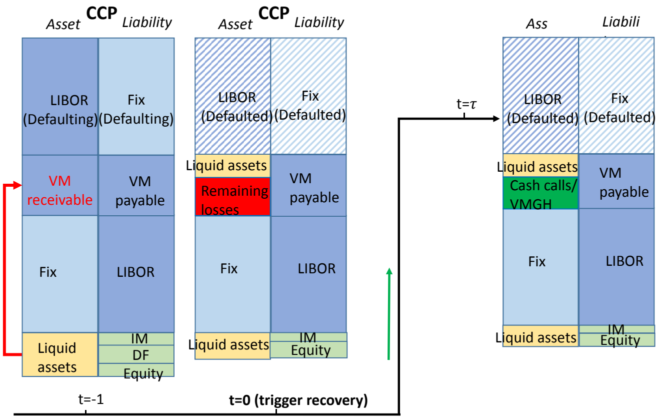
$$d\tilde{R}_t = -\varepsilon \tilde{R}_t dN_t$$



Model setup - interlinked uncertainties

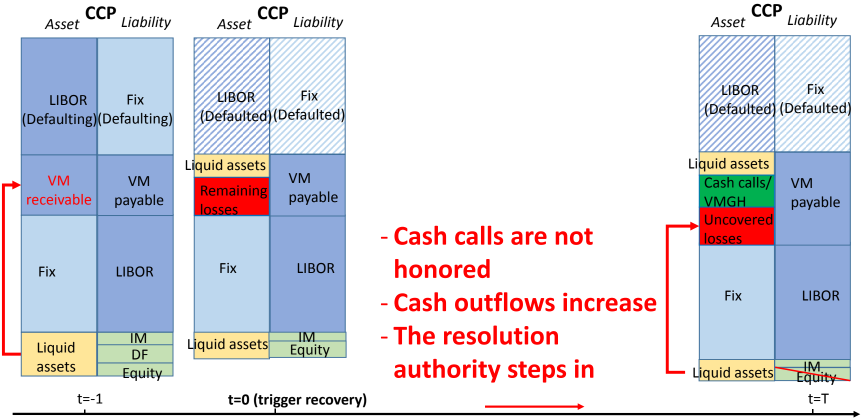
- When $\frac{X_t}{\tilde{R}_t}$ is large, the CCP is less likely to recover
  - Derivatives market get more volatile $\Longrightarrow \sigma_t$ is large
  - Participants are less willing to provide liquidity $\Longrightarrow \lambda_t$ is large

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

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

- 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

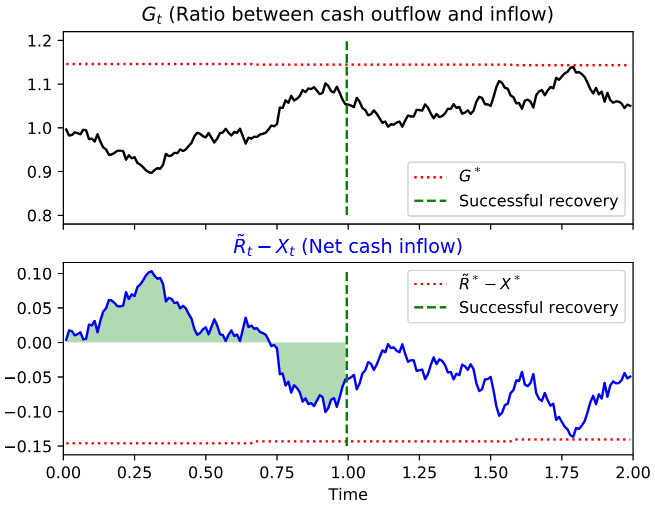
$$F(u_t) = \max\{\underbrace{\pi(u_t)dt + F(u_t) + E[dF(u_t)]}_{\text{recovery/continuation}}, \quad \underbrace{\Omega(u_t)}_{\text{resolution/stop}} \quad \}$$

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: $G_t = \frac{X_t}{\tilde{R}_t}$



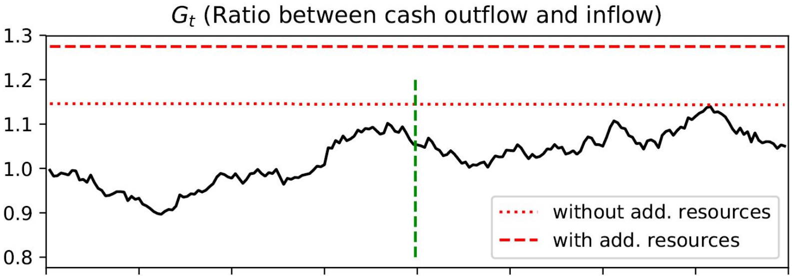
Additional resources dedicated to resolution

> **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

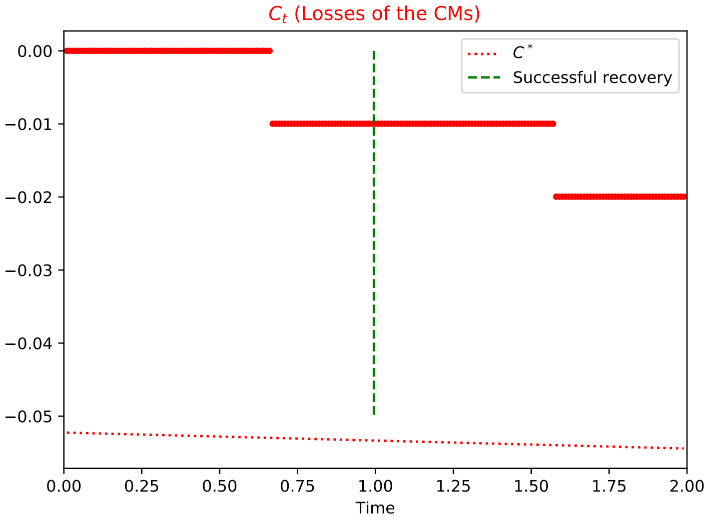
The resolution authority solves the following stopping problem

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

- 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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