An Agent-based Stress Testing Framework of Central Clearing

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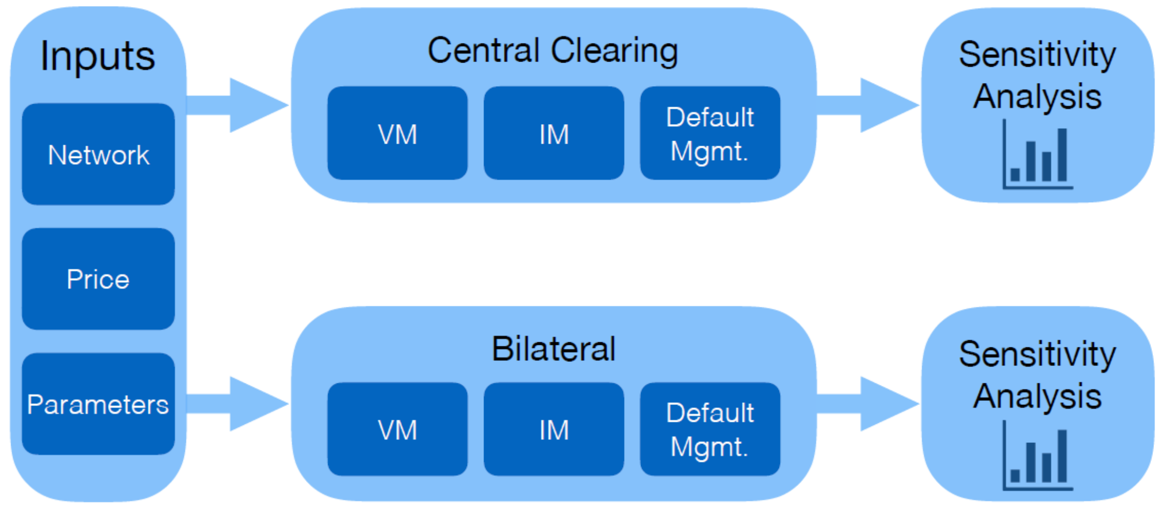
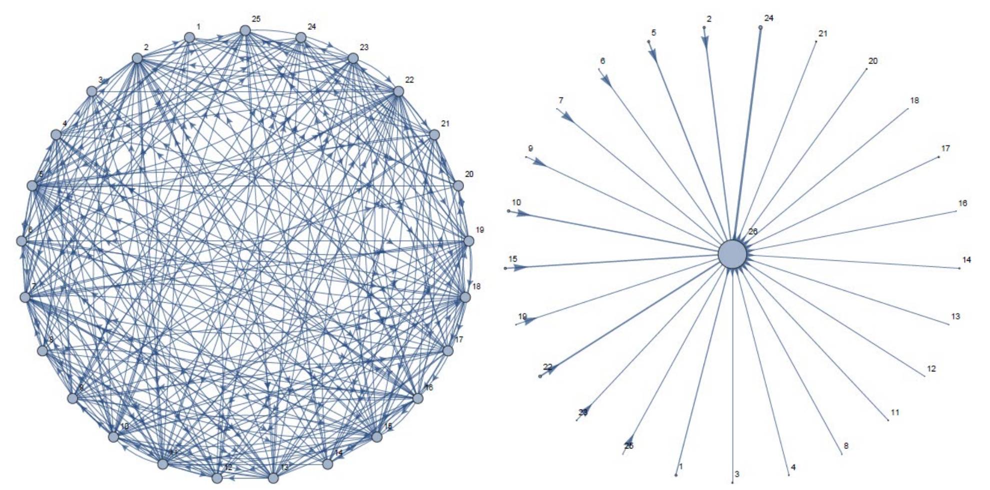
Summary

; We put forward a partial equilibrium model of a central counterparty (CCP) and clearing members (CM). Agents are profit optimizing and are exposed to market risk. We simulate the balance sheets and the leverage of the CCP and the CMs as a result of the market price movements. We also model the margin shortfalls and the entire default waterfall in case of CM defaults. Moreover, we analyse the stability of the network of counterparties in a system with and without a CCP. Ultimately, we aim at analysing i) endogenous feedback effects between CM defaults and market liquidity, ii) the contagion to non-defaulting CM as well as iii) the contagion from service functions that CMs provide to the CCPs, such as liquidity provision or collateral and investment services.



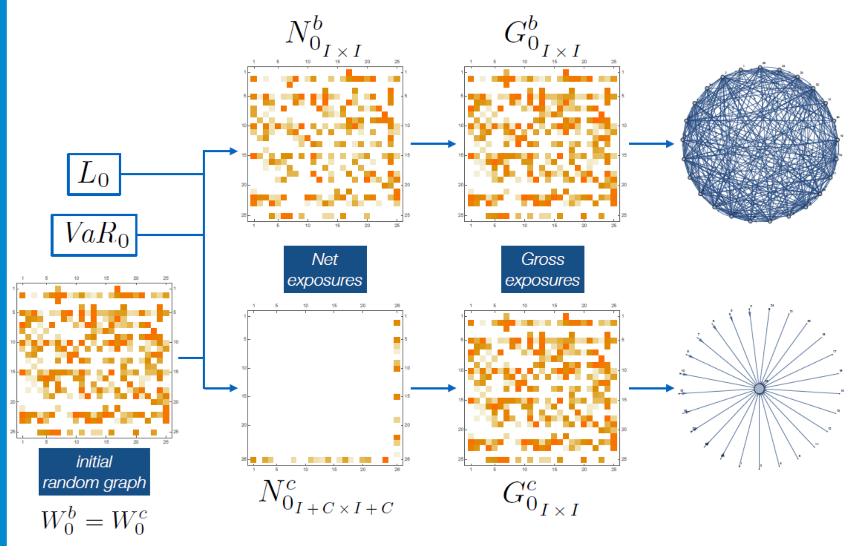
Bilateral — Central



MODEL

We present two versions of clearing systems, one with bilateral and one with central clearing, that share the same three fundamental sources of interaction among agents, namely (A) the provision of initial margin (IM) according to the agent's current open position, (B) the daily settlement of mark-to-market changes in the portfolio values of agents – variation margin (VM) payments, (C) and the default management mechanism in case of a default event.

Construction of Initial Networks



Comparability: Matching Net Exposures

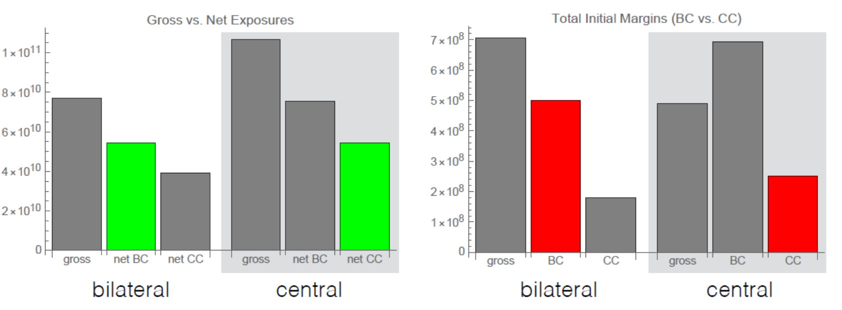
Bilateral

$$n^b_0 = \frac{1}{\eta}\left(\sum_{j=1}^{I}|n_{1j}|,\ldots,\sum_{j=1}^{I}|n_{Ij}|\right)$$

$$\eta = 1$$

Central

$$n^c_0 = \left(\left|\sum_{j=1}^{I} g_{1j} - \sum_{i=1}^{I} g_{i1}\right|,\ldots,\left|\sum_{j=1}^{I} g_{Ij} - \sum_{i=1}^{I} g_{iI}\right|\right)$$



Comparability: Matching Initial Margins

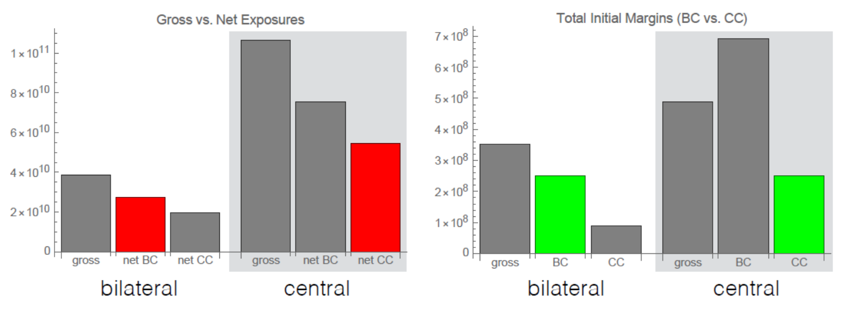
Bilateral

$$n^b_0 = \frac{1}{\eta}\left(\sum_{j=1}^{I}|n_{1j}|,\ldots,\sum_{j=1}^{I}|n_{Ij}|\right)$$

$$\eta = \frac{1}{2}$$

Central

$$n^c_0 = \left(\left|\sum_{j=1}^{I} g_{1j} - \sum_{i=1}^{I} g_{i1}\right|,\ldots,\left|\sum_{j=1}^{I} g_{Ij} - \sum_{i=1}^{I} g_{iI}\right|\right)$$



Balance Sheets

Bilateral

Assets	Liabilities
Cash ($\mathcal{C}^b_{i,t}$)	Liabilities ($\mathcal{L}^b_{i,t}$)
Margin Account ($\mathcal{M}^b_{i,t}$)	
Receivables ($\mathcal{R}^b_{i,t}$)	Equity ($\mathcal{E}^b_{i,t}$)
Total Assets ($\mathcal{T}^b_{i,t}$)	

Figure 3: Balance sheet of MP^b_i

Central

Assets	Liabilities
Cash ($\mathcal{C}^c_{i,t}$)	Liabilities ($\mathcal{L}^c_{i,t}$)
Margin Account ($\mathcal{M}^c_{i,t}$)	
DFC ($\mathcal{D}^c_{i,t}$)	
Receivables ($\mathcal{R}^c_{i,t}$)	Equity ($\mathcal{E}^c_{i,t}$)
Total Assets ($\mathcal{T}^c_{i,t}$)	

(a) Balance sheet of MP^c_i

Assets	Liabilities
Cash ($\mathcal{C}^{ccp}_t$)	Liabilities ($\mathcal{L}^{ccp}_t$)
Receivables ($\mathcal{R}^{ccp}_t$)	Margin Accounts ($\mathcal{M}^{ccp}_t$)
	DFC ($\mathcal{D}^{ccp}_t$)
	Equity ($\mathcal{E}^{ccp}_t$)
Total Assets ($\mathcal{T}^{ccp}_t$)	

(b) Balance sheet of the CCP

Pseudo Code: Bilateral Clearing

- Start economic interaction of settlement period t (t = 1 … 1280)
  - Initialisation
    - set initial network (t=1)
    - set up initial balance sheets according to contractual relationships
  - Settle Variation Margin according to p_t-p_{t-1}
    - payment vector according to Eisenberg/Noe (2001)
    - determine defaulting agents
    - release collateral of counterparties
    - settle non-defaulter's VM
  - Adjust Margin Accounts [200-day VaR]
    - check if margin account meets MMR
    - if not => margin call
    - possibility of close out in case of illiquidity
  - Default Management
    - absorb bilateral losses with IM
    - repay residual IM / release IM of CP
    - close out of defaulting portfolio
- Determine network stability measures
- End of settlement period t

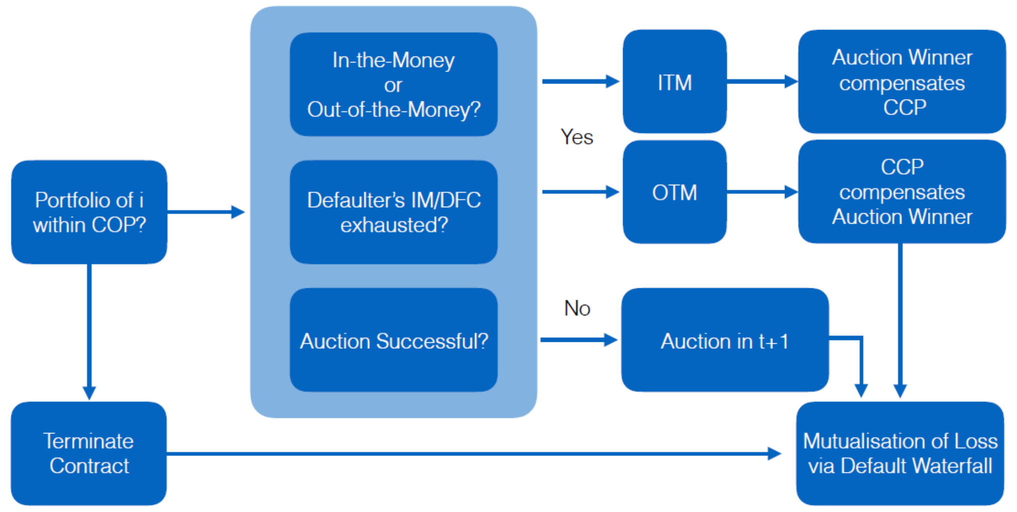
Pseudo Code: Central Clearing

- Start economic interaction of settlement period t (t = 1 … 1280)
  - Initialisation
    - set initial network (t=1)
    - set up initial balance sheets according to contractual relationships
    - Novation of contract
  - Settle Variation Margin according to p_t-p_{t-1}
    - CCP debits margin account of VM debtors
    - determine defaulting agents
    - CCP credits margin account of VM creditors (+VMGH / Rebuild DFC)
  - Adjust Margin Accounts [200-day VaR] and DFC [Cover 2]
    - check if margin account meets MMR
    - if not, margin call
    - possibility of close out in case of illiquidity
  - Default Management
    - auction of defaulting portfolios during close out-period
      - OTM: neg. bid <= VM [CCP pays winner x >= VM]
      - ITM: pos. bid <= VM [winner pays CCP p<=VM]
      - mutualisation of excess losses by default waterfall
- Determine network stability measures
- End of settlement period t

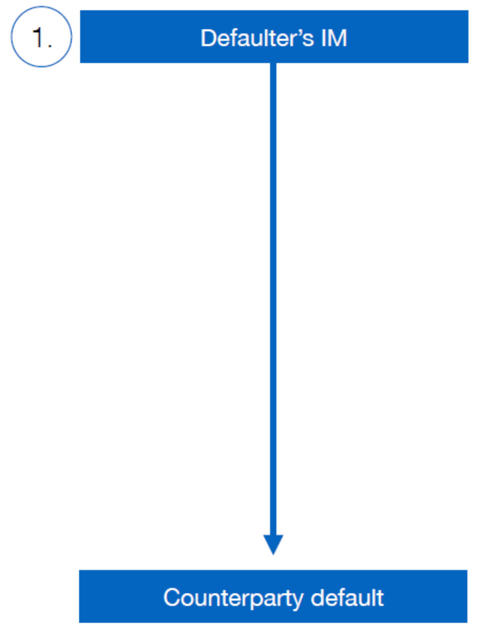
Simulation Experiments And Key

Default Management: Auction

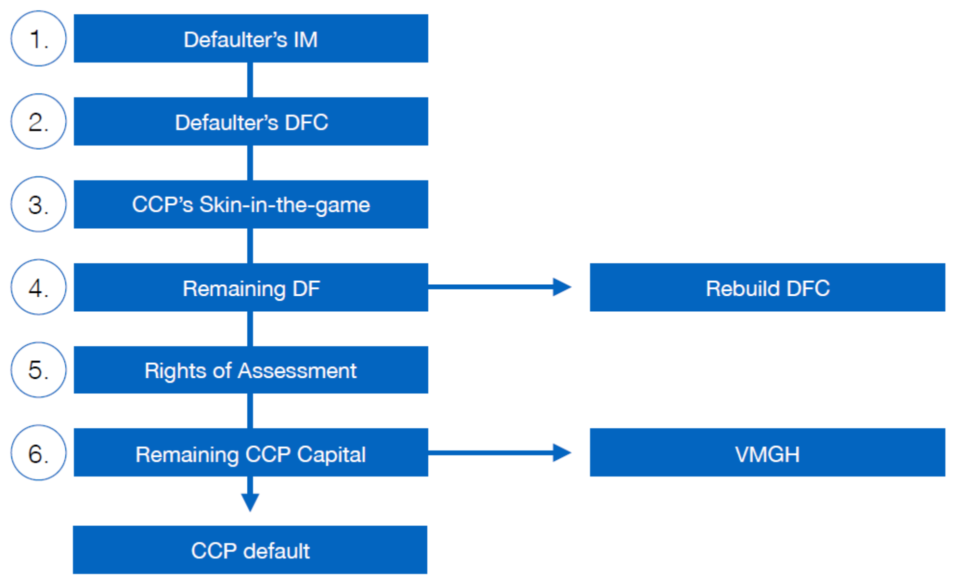
- Defaulted portfolios are auctioned contract-by-contract
- We assume bids that fully exhaust defaulter's default resources
- IMT: random auction winner pays less
- OTM: random auction winner receives more



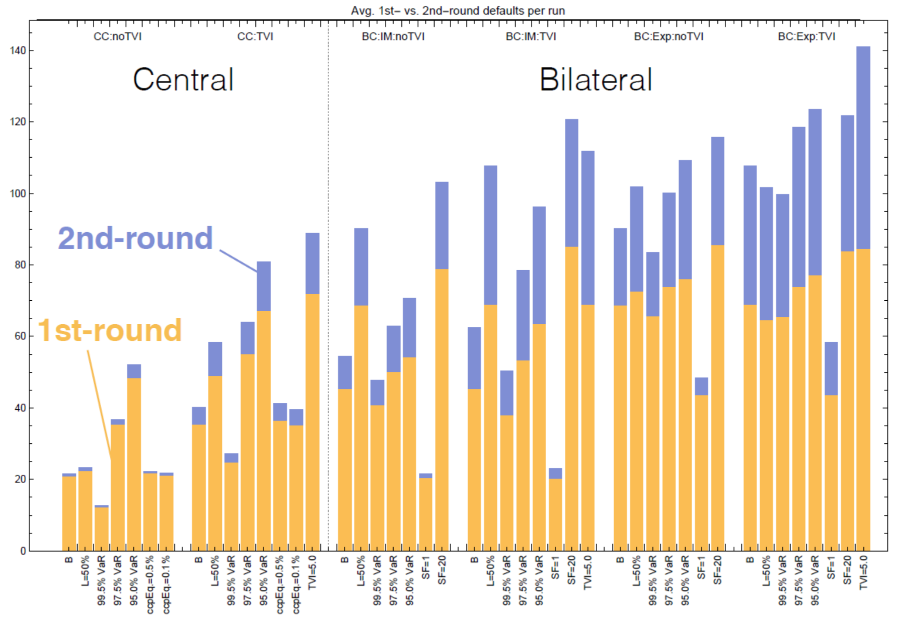
Loss Absorption: Bilateral Case



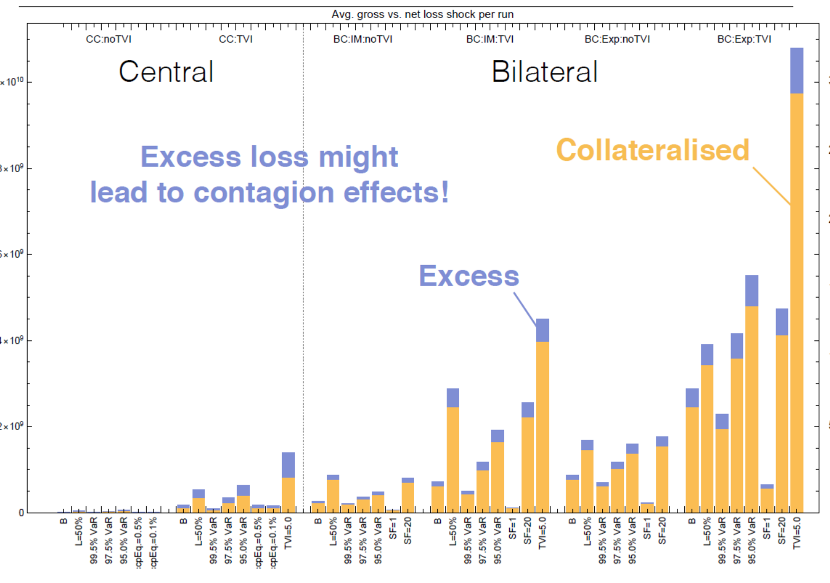
Loss Absorption and Recovery Mechanism



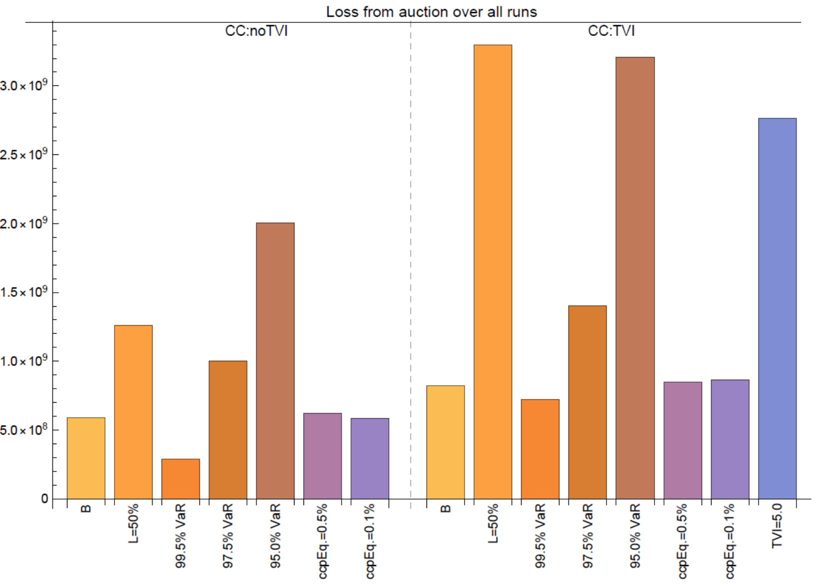
Sensitivity Analysis: Avg. 1st & 2nd-round Defaults



Sensitivity Analysis: (Un)Collateralised Losses



Sensitivity Analysis: Cum. Mutualised Losses from Auction



Findings and Conclusion

In this paper, we assess the stability of the system based on clearing collateral exposures via a CCP versus a system of bilateral counterparty exposures. To this end, we put forward a partial equilibrium model of a CCP and clearing members and analyse the propagation of a stochastic market price shock on the stability of the system. We simulate all the layers of the CCP default waterfall and analyse possible feedback loops emerging from the allocation of losses suffered by the CCP on its clearing members. We also demonstrate how a default of a clearing member influences the stability of the network of counterparty exposures and market liquidity in a system with and without a CCP.

Conclusion

Given a single CCP network:

- Less defaults overall
- Less 2nd-round defaults (CCP mitigate contagion)
- Price feedback has considerable impact on stability
- Mutualisation of Losses has strong stabilising effect
- Results maybe less bold in less idealised world (multiple CCPs / multiple asset classes etc.)
- Framework leads to consistent results

Sounds interesting?

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