Central Clearing and Systemic Risk: A Network Approach

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May 26, 2015
Benefits of Central Clearing

- Novation and netting
- Elimination of counterparty credit risk
- Transparency of OTC derivatives markets
- But: many participants argue that credit risk is replaced by liquidity risk

The question is: what are the benefits of central clearing for financial system stability?
Network approach

- Simulation-based
- Maximally realistic construction of hypothetical systems
- Networks of CMs and their clients
- Compare default characteristics of a hypothetical system with and without CCP
Why networks?

**Figure**: Example of a financial system
Network approach

- "Skeleton" of the network: nodes (FIs) and (directed) links
- "Weights" of the links: size of lending/borrowing and derivatives exposures
- Type of external shock the network is exposed to
- Sources of systemic risk: contagion due to connections AND simultaneous shock to assets
Types of Networks/Graphs

- **Complete Networks** - homogeneous; used in past empirical studies.

- **Random Networks** (Erdős-Rényi Graphs): each edge is present with probability $p$ - homogeneous.

- **Tiered random networks**: two types of nodes (highly connected / less connected) - non-homogeneous.

- **Core-Periphery structure**: extreme interconnectedness of core nodes.
Random Networks

**Figure**: Erdős-Rényi Graphs: $n = 25$

(a) Random $p = 0.2$

(b) Tiered Structure $p_t = 0.5, p_s = 0.16$
Random Networks Cont.

Figure: Erdös-Rényi Graphs: $n = 100$

(a) Random $p = 0.2$

(b) Tiered Structure $p_l = 0.5, p_s = 0.17$
Core-Periphery Networks

Figure: Core-Periphery Structure: $n = 25$, assume that 10% of GCMs control 80% of the OTC derivatives market
Figure: Core-Periphery Structure: \( n = 100 \), again, assume that 10% of GCMs control 80% of the market.

(a) Tiered Structure

(b) Core-Periphery Structure
Types of Networks

- Random homogeneous networks, e.g., $p = 0.2$
- Tiered networks: 10% of FIs are "large" and well-connected ($p_l = 0.5, p_s = 0.16$ so that $p = 0.2$)
- Core-periphery networks: assume e.g., that 10% of FIs control 80% of derivatives market. Then e.g., for $p_l = 0.6$, $p_s \approx 0.02 - 0.03$.
- Total size of the banking system, derivatives market and overall connectivity is the same for all networks - this is important for comparison
**Typical FI’s Stylized Balance Sheet**

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Assets $A^F_i$</td>
<td>Capital $L^C_i =: c_i$</td>
</tr>
<tr>
<td>Liquid Assets $A^L_i$</td>
<td>Deposits $L^D_i$</td>
</tr>
<tr>
<td>Interbank Assets $A^I_{IA}$</td>
<td>Interbank Liabilities $A^I_{IL}$</td>
</tr>
<tr>
<td>Margins $M_i$</td>
<td></td>
</tr>
</tbody>
</table>
Clearing what: Interest Rate Swaps

- For each FI, we determine a portfolio mix of interest rate swaps (e.g., 5 tenors)
- A 1:1 relation between size of FI and portfolio size
- IRS values are determined from the simulated IR curve: choose your favorite IR curve model
- Each FI has 50% chance of holding fixed or floating leg of a swap
- Counterparties are chosen randomly, but taking into account tiering structure
Swap Value Simulation

Figure: Simulated path of $V_{\text{swap}}(t,T)$

External shock: to IR curve, until first FI defaults (3 or more $\sigma$s)
CCP’s default waterfall

Figure: Robust default waterfall as applied by e.g., SwapClear
Variation margins

Initial margins: based on 99% 5-day VaR, held in segregated (CM) or omnibus (clients) accounts

Default fund contribution: stressed market conditions; fixed percentage of initial margins (10%), held in omnibus account

CCP has limited own capital (≤ 5%)

CCP can opt for top-up to DF if needed; only operating CMs are considered
Default Dynamics

- At time $t$ there is a shock to the balance sheet of party $i$ (e.g., via an adverse IR change).
- FI $i$ defaults if its required collateral ($VM_{i,t} + IM_i + DFC_i$) is greater than its capital.
- We call this fundamental default (can be more than one at any time).
- Losses are absorbed by $VM_i$ and $IM_i$, then by the default fund (own contribution, then that of the rest).
- CCP transfers all IRSs of the defaulted FI to other FIs (at the market value), charging new $IM$s, $VM$s and possibly extra DF contributions.
- This can lead to further (contagion) defaults and the process is repeated.
All the results are CONDITIONED on the first fundamental default, so all probabilities are CONDITIONAL probabilities!

In 2-d figures: Blue lines: CCP cleared situation, Red: bilateral system.
Motivation
The setup of the study: Financial System
CCP and Default Mechanisms
Simulation Results
General observations

Random Graphs
Tiered Structure
Core-Periphery Networks

Homogeneous Network

Figure: Defaults as a function of $n$

(a) # of defaults

(b) Average Total Capital Loss
Figure: Probability of CCP Failure vs. $n$
Tiered Network

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Tiered Network: Conditioning on a default of a LARGE CM

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Figure: Probability of CCP Failure vs. $n$
Core-Periphery Networks: Conditioning on a default of a LARGE CM

Figure: # of defaults vs. system size $n$ and shock size

(a) Central Clearing

(b) Default rates (Bilateral)
Core-Periphery Networks:
Conditioning on a default of a LARGE CM

Figure: Average Total Capital Loss vs. system size $n$ and shock size

(a) Central Clearing

(b) Bilateral
Core-Periphery Networks:
Conditioning on a default of a LARGE CM

Figure: Probability of CCP Failure vs. system size $n$ and shock size
To summarize:

- The effect of CCP clearing on the financial system is complex, highly dependent on the system’s structure and the source of fundamental default (SIFI or not).
- Our simulation results indicate that smaller, peripheral FIs are generally sacrificed (unevenly punished) for financial stability.
- For financial stability, it seems more useful to focus on the capitalization of core CMs, to prevent their (fundamental) default, rather than to debate RM measures for CCPs.
Building a real financial network

- Two-layer network: interbank balance sheet exposures and derivatives contracts
- Balance sheet exposures: some information, but mostly in aggregate form
- Algorithms such as Maximum Entropy allows us to fill in exposure matrix, preserving CP structure and overall characteristics of real financial networks
EMIR: registration of all derivatives transactions in TRs as of Feb 2014.

Sources: DTCC, other TRs, AFM, ...

In theory: an ideal source of information on derivatives transactions (counterparty, type, size, maturity, collateral, â)

In reality: a total mess: gaps, errors, identifiers.

But also legal: e.g., DNB observes only contracts of participants located within Dutch jurisdiction
Solutions

- Qualitative or semi-quantitative information: central banks questionnaire
- TARGET II: all interbank payments
- Possible to separate payments that correspond to derivatives transactions
- Build interbank network according to aggregated daily interbank payments
Further information

- s.a.borovkova@vu.nl
- *Systemic Risk and CCPs: A Network Approach*, SSRN white paper
- http://www.mejudice.nl/video/detail/svetlana-borovkova-over-een-nieuw-systeemrisico