Emergence of the EU Corporate Lending Network

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Emergence of the EU Corporate Lending Network

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23/07/2015

Parts based on research with U. Kochańska (ECB) and Ch. Kok (ECB)

DISCLAIMER: This presentation should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.
Motivation

- Recent financial crisis: loss of trust on the interbank market; concerns about failure of one of the key players spreading contagion; small shocks with detrimental effects
- A response from regulators: measures to mitigate the risk ⇒ higher capital standards + reducing bilateral exposures
  - Large Exposure limits;
  - Credit Valuation Adjustment to unlock the risk in OTC exposures and immediately reflect it in the capital
  - Standard settlement practices (CCP framework)
  - ...but usually only interbank market modelled → a large part of the network is neglected
- Our aim:
  - to fill the gap in the literature to improve understanding of:
    - network of linkages (and emergence of links) between banks and the real economy (interbank and non-bank corporate sector)
    - risk stemming from interconnectedness in the complex financial (economic) system
- Approach: modelling of agents’ optimisation-based reactions to the changing macroeconomic environment resulting in a network of direct exposures

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Outline

Modeling framework – agent-based interbank+corporate networks

- Four round model – endogenous formation of links
  1. offers of interbank placements based on individual optimisation of interbank asset structures
  2. funding diversification
  3. negotiation phase: matching preferred structures in a bargaining game
  4. price (i.e. interest rate) adjustment (if demand ≠ supply) – the only indirect contagion channel in the framework

Scope for application

- tracing channels of the propagation of shocks: shocks originated to specific names / sectors spread via the network of exposures
- assessing network effects of credit provision to the real economy (shocks from corporate sector)
- parametrisation of LE and concentration limits (so far only for interbank) and sector RWs
- stress tests and dynamic balance sheet effects
Literature – towards network formation

- Interbank market can be a source of contagion (Allen and Gale, 2000; Furfine, 1999; Upper and Worms, 2004; Nier et al., 2008; Allen and Babus, 2009) – classical network studies in finance

- Networks in other areas: game theory of Jackson and Wolinsky (1996)


- Jackson and Watts (2002) combine stochastic games and matching problems to study general principles of network formation in economics; Acemoglu et al. (2014) create the interbank structure based on equilibrium of lending contracts and repayments

- Agent-based approach to address overly complex equilibria – Markose (2012); Grasselli (2013)

- Matching (Chen, 2013); (Duffie and Sun 2012) and price formation (Eisenschmidt, 2009) ⇒ mechanisms important for us
Figure 1: The sequential four round procedure of the interbank formation (formation of bank-firm links separate but analogous - next slide)

INITIAL PARAMETERS
Aggregate IB lending / borrowing, capital, RWA, CDS spreads, market interest rates

1) OPTIMISATION
Preferred funding structure

2) OPTIMISATION
Preferred asset structure

3) BILATERAL GAMES
Bargaining game

4) PRICE
Interest rate adjustment

NEW PLACEMENTS
Part of unallocated IB assets placed in banks as deposits creating IB linkages

STEPS Repeated until all IB assets are allocated

Unallocated IB assets and liabilities

IB Network Completed

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Figure 2: The sequential four round procedure of the bank-corporate network formation

1) OPTIMISATION
Preferred funding (from banks) structure of corp firms

2) OPTIMISATION
Preferred corp portfolio structure

3) BILATERAL GAMES
Bargaining game

4) PRICE
Interest rate adjustment

INITIAL PARAMETERS
Banks: aggregate corp lending, capital, RWA, CDS spreads of banks
Corp firms: borrowing from banks, average lending rates to corporates, distribution of number of creditors of corp firm

NEW PLACEMENTS
Part of unallocated corp lending portfolios in banks as funding of corp firms from banks -> creating bank-corp linkages

Bank-Corp Network Completed

Unallocated corp loans and bank funding of corp sector

Steps Repeated until all corp loans are allocated

Partial allocation

Full allocation

Next step

4 ROUNDS

REPEATED STEPS

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Table 1: Overview of data inputs

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banks</td>
<td>As identified in 2011 EBA Disclosures; 80 banks from EU countries. + 500 randomly generated banks based on TA</td>
<td>EBA, Halaj and Kok (2014) + Bankscope</td>
</tr>
<tr>
<td>Non-financial corpor-</td>
<td>Members of the benchmark equity indices in the countries covered by EBA Disclosures and Halaj and Kok (2014); total 700 firms</td>
<td>Bloomberg and ECB</td>
</tr>
<tr>
<td>ations</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attributes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banks</td>
<td>Total assets, IB assets, securities, securities MtM, equity, CT1 capital, IB liabilities</td>
<td>EBA</td>
</tr>
<tr>
<td>Banks</td>
<td>Loans to non-fin. corporations: calculated by using avg. country ratio of such loans to TA based on the ECB (MFI) balance sheet dataset</td>
<td>ECB calculations</td>
</tr>
<tr>
<td>Banks</td>
<td>Economic activity code (NACE), CDS of senior debt with 5 maturity, and long-term issuer ratings by Moody’s, Fitch and S&amp;P.</td>
<td>Bloomberg</td>
</tr>
<tr>
<td>Non-financial corpo-</td>
<td>Total assets, total equity, total liabilities, NACE code, CDS spreads of senior debt with 5 maturity, and long term ratings by Moody’s, Fitch and S&amp;P.</td>
<td>Bloomberg</td>
</tr>
<tr>
<td>ations</td>
<td>Loans from banks: calculated by using the average country ratio of loans to total assets of NFCs based on the ECB EA Accounts dataset.</td>
<td>ECB calculations</td>
</tr>
<tr>
<td><strong>Lending relations and other supportive variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lending relationship</td>
<td>Defined as the number of loans with different banks; average figures by country and NACE sector were applied based on the data provided through the Working Group on Credit Registers</td>
<td>ECB calculations</td>
</tr>
<tr>
<td>Interest rates on</td>
<td>Avg. interest rates on loans by size of loan and by country based on the ESCB MIR data; categories of loans as follows: (below 0.25 EUR mn), (equal or above 0.25-1 EUR mn), and (over 1 EUR mn).</td>
<td>ECB calculations</td>
</tr>
<tr>
<td>Loan size and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>country</td>
<td></td>
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<tr>
<td>Expected default</td>
<td>Avg. of expected default frequencies for non-financial corp. by country and NACE.</td>
<td>Moody’s KMV and ECB</td>
</tr>
<tr>
<td>frequencies</td>
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</tbody>
</table>
Sampling of the network

- Observed nodes (banks + non-bank corporate firms) and +500 generated banks
  - generated banks: based on the total assets and proportional allocation of other attributes

- Lending relationship:
  - \{\text{bank}\} – \{\text{firm}\}: based on aggregate Credit Register data
    - \to \text{out-degree distribution (for each NACE sector)} \to \text{the cardinal number of set } B^k_j \text{ of firms } k \text{ to which a bank } j \text{ grants loans is constrained by a number } m_j \text{ drawn from the out-degree distribution, i.e. } \#B^k_j \leq m_j

  - \to \text{probability that a bank in a given country lends to a firm from a given country and a given (NACE) sector}
    - \{EBA \text{ sample bank}\} – \{EBA \text{ sample bank}\}: EBA disclosures
    - \{small bank\} – \{EBA \text{ sample bank}\}: arbitrary [small] probability of connection (\(= 0.01\))
Applications – policy implications

Event-driven contagion (realised)
Deterioration of credit quality in a given sector (NACE) – corporate loan losses trigger contagion

Risk weights – policy tool to limit exposures to risky sectors (realised)
Specific sectors can be targeted to force banks to use more capital for more risky sectors

Large Exposure limits – compactness of the networks (realised)
lower bilateral exposures allowed $\Rightarrow$ more connections

Network reactions to adverse market conditions (planned)
passing macro scenarios via dynamic BS model (Hałaj, 2013):
baseline macro scenario $\Rightarrow$ optimising behaviour of banks $\Rightarrow$ change in banks’ preferred aggregate interbank lending and borrowing $\Rightarrow$ endogenous formation of the interbank under specified regulatory regime $\Rightarrow$ adverse macro shock $\Rightarrow$ banks defaults $\Rightarrow$ contagion
Contagion mechanism – cascade triggered by a deterioration of credit quality of loan portfolios to companies in a given NACE sector (manufacturing in DE) imposing 5% PD and 50% LGD.

“Spectral” graph shows impact of the contagion losses of 500+ banks (the darker the bar, the higher the fraction of capital wiped out by contagion)
Figure 5: Contagion simulation for different deterioration of credit quality

- Contagion mechanism – cascade triggered by a deterioration of credit quality of loan portfolios to companies in a given NACE sector for (y-axis) \( PD \in \{5\%, 10\%, \ldots, 100\%\} \) and 50\% LGD
- “Spectral” graph of contagion losses of 500+ banks (the darker the bar, the higher the fraction of capital wiped out by contagion)
Figure 6: Risk-weight policy impact on contagion triggered by deterioration credit quality

“Spectral” graph of contagion losses of 500+ banks (the darker the bar, the higher the fraction of capital wiped out by contagion)

a) baseline case ($PD \in \{60\%, \ldots, 90\%\}$)
b) risk weights increased by a factor of 1.5 for all exposures to the manufacturing sector in Germany
Figure 7: Defaults of banks in the cascade of contagion spreading triggered by losses in the portfolio of loans to the manufacturing sector in DE.

- Defaults of banks triggered by banks failing to pay back their obligations as a result of losses related to decreasing credit quality of manufacturing loan portfolio in (counterfactual example!) Germany.
- Each bar indicates a defaulting bank under $\lambda \in \{3\%, 5\%, \ldots, 25\%\}$. 

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Figure 8: Second round defaults of banks in the cascade of contagion spreading triggered by losses in the portfolio of loans to the manufacturing sector in DE

- Defaults of banks triggered by banks failing to pay back their obligations as a result of losses related to decreasing credit quality of manufacturing loan portfolio in Germany
- Each bar indicates a defaulting bank only because their debtors defaulted under $LE \in \{3\%, 5\%, \ldots, 25\%\}$
Where may the predefined volumes of interbank assets and liabilities come from? Endogenous balance sheet

They may be related to a general ALM-based budgeting for different business lines.

Hałaj (2013, 2015) provides a framework to determine the balance sheet composition based on ROE maximisation subject to solvency and funding constraints.
Conclusions

- Endogenous interbank networks give an important insight into the role of banks’ investment and funding strategies in shaping the interbank market and non-bank firms’ funding channels. The simple, mechanistic cascade models are too simplistic in assuming that banks do not react to the unwinding cascade.

- It is easier to introduce heterogeneity of agents if the network approach is taken rather than macroeconomic (e.g. general equilibrium) framework.

- In the proposed framework, we are able to analyse different policy measures addressing the systemic risk – their ultimate impact on the market structure and efficiency in reducing the contagion risk.

- Scalable model – more agents easy to introduce.

- Still, a more consistent clearing mechanism would be warranted.

- The model needs to be calibrated to the observed interbank / lending networks. How far are we from the truth? (Target 2 data to be used)