Financial Linkages, Macroprudential Policy, and Systemic Risk

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Two dimensions of systemic risk

1. Systemic risk slowly builds in tranquil times and abruptly unravels in times of crisis
   ⇒ time-dimension

2. Systemic risk can be transmitted through various channels
   ⇒ cross-sectional dimension

Systemic risk channels:
- common shocks: Acharya and Yorulmazer (2008)
- informational spillovers: Acharya and Yorulmazer (2008b), Nier et al. (2007)
  Ahnert and Georg (2012)
Four reasons why modelling systemic risk is a challenge for economists:

1. **Heterogeneous agents** → No representative agent(s)

2. Complex interactions

3. Dynamic structural change

4. Deviations from rationality
Financial Intermediaries are Heterogeneous

Figure: Concentration of the UK and US banking system. Source: Gai, Haldane and Kapadia (2011).
Modelling Systemic Risk is a Challenge

Four reasons why modelling systemic risk is a challenge for economists:

1. Heterogeneous agents
2. Complex interactions $\rightarrow$ incomplete markets
3. Dynamic structural change
4. Deviations from rationality
Figure: A scale-free network \((k = 4)\) of contracts amongst 50 banks.
Four reasons why modelling systemic risk is a challenge for economists:

1. Heterogeneous agents
2. Complex interactions
3. **Dynamic structural change** → Processes on different time scales
4. Deviations from rationality
The Financial System is Highly Interconnected

Figure: Interconnectedness of the international banking network in 1980 (left) and 2007 (right). Source: Minoiu and Reyes (2011) using BIS data.
Modelling Systemic Risk is a Challenge

Four reasons why modelling systemic risk is a challenge for economists:

1. Heterogeneous agents
2. Complex interactions
3. Dynamic structural change
4. **Deviations from rationality** → Agent behaviour matters
Modelling Systemic Risk is a Challenge

Four reasons why modelling systemic risk is a challenge for economists:

1. Heterogeneous agents
2. Complex interactions
3. Dynamic structural change
4. Deviations from rationality

Multi-Agent Simulations can help understand systemic risk
Figure: The building blocks for a simulation of the financial system
Figure: The building blocks for a simulation of the financial system
Microfoundations of Banks Determine Model

- Liabilities: $D$, $L$, $LC$, $BC$
- Assets: $I$, $E$, $L$
- Households
- Commercial Banks
- Central Bank
- Firms

$\lambda$
Agent Behaviour (and Model Dynamics)

- Banks optimize their **portfolio structure and -volume** according to CRRA preferences

\[ u = \frac{1}{1 - \theta} \left( V(1 + \lambda \mu - \frac{1}{2} \theta \lambda^2 \sigma^2) \right)^{(1-\theta)} \]

where \( \theta \) is risk-aversion parameter, \( \mu \) and \( \sigma^2 \) expected return and variance of risky assets

- **Deviation from Rationality**: agents become more (less) risk averse if there are (no) bank defaults in previous period

\[ \Rightarrow \text{Information Contagion} \]

Possible extensions:

- Bayesian updating for expected return and variance of real (and financial) assets

- Agent behaviour is key: alternative implementation with risk neutral agents (see e.g. Baltensperger (2002))
Figure: The first part of the update algorithm.
Figure: The second part of the update algorithm.
Model Dynamics – The Update Algorithm

Figure: The third part of the update algorithm.
**Model Parameters**

**Upside:** model is very flexible – 26 parameters  
**Downside:** model will be hard to calibrate (if at all possible)

<table>
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<tr>
<th>Parameter type</th>
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<td>Regulation</td>
<td>r, <strong>sifiSurchargeFactor</strong>, <strong>leverageRatio</strong>, requiredCapitalRatio</td>
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*Table:* Overview of model parameters
Channels of Systemic Risk

Interbank contagion

- Interbank contagion is a source of systemic risk, but not the major one.

Fire-sale

- Common shocks are quantitatively the greater threat.
- Fire-sales can be caused by cash-in-the-market pricing:

\[ p(\gamma, t, l(t)) = \exp\left(-\gamma \cdot \frac{(l(0) - l(t) + l(t))}{l(0)}\right) \]

where \(\gamma\) is the liquidationDiscountFactor.

Information contagion

- Risk aversion \(\theta\) depends on history of loan repayments.
Endogenous Fire Sales – No Information Contagion

Figure: Number of active banks over time for different strengths of fire sales.
Information Contagion – No Fire Sales

Figure: Investment level over time for different strengths of risk aversion discount and amplification.
Macroprudential Tools to Alleviate Systemic Risk

A number of tools has been proposed to alleviate systemic risk:

- **Time-dimension:** countercyclical capital buffer, leverage ratio, dynamic risk-weights, dynamic provisioning, liquidity ratios: LCR, NSFR, reserve requirements

- **Cross-sectional dimension:** higher capital requirements, concentration limits, SIFI surcharge

How these measures are implemented:

- **LCR:** highly liquid assets → limit on liquidationDiscountFactor
- **NSFR:** stable funding sources → limit on scaleFactorHouseholds
- Countercyclical capital buffer → varying required capital during simulation
- Leverage ratio → limit on portfolio expansion when banks are euphoric
- SIFI surcharge → additional capital requirements based on interconnectedness
Figure: Number of active banks over time with a countercyclical capital buffer.
Figure: Amount of interbank lending over time with countercyclical capital buffer.
Leverage Ratio

Figure: Investment in risky assets over time for different leverage ratios.
Is a SIFI Surcharge Better than Higher Capital Ratios?

Figure: The effect of a SIFI surcharge vs. a flat increase in capital requirements.
Conclusion

- Heterogeneous agents, complex interactions, and dynamic structural change calls for a more flexible set of models ⇒ Multi-Agent Network Models

- Network models to assess systemic risk can be used to analyse recently proposed macroprudential measures:

- Going forward: consistent agent behaviour and clear notion of equilibrium
Heterogeneous agents, complex interactions, and dynamic structural change calls for a more flexible set of models ⇒ Multi-Agent Network Models

Network models to assess systemic risk can be used to analyse recently proposed macroprudential measures:

Going forward: consistent agent behaviour and clear notion of equilibrium

All simulations done with black rhino: open source MAS
http://cabdyn.ox.ac.uk

⇒ Thank you!