Risk Assessment for Banking Systems

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Introduction

- If banking systems are monitored for the analysis of systemic financial stability a traditional approach of supervising institutions at an individual basis is insufficient.

- Systemic financial stability analysis requires to **recognize potential events of joint failures** – the large scale breakdown of financial intermediation – rather than individual bank probabilities of default.

- Systemic risk monitoring therefore requires a **system approach to banking supervision**.

This Paper

- **Correlated exposures:**
  - Adverse economic shock might affect a large number of banks.
  - Banks have similar credit or market risk exposure.
- **Domino effects / Contagion:**
  - Complicated network of inter-bank liabilities links individual institutions.
  - Failure of one bank might directly cause failure of another bank.
- **Important:** Analyze both effects simultaneously.

Main Findings

- Most crisis scenarios occur because of correlated exposures.
- Contagion is a low probability high impact event.
- High Bankruptcy costs increase contagion.
- Central Bank volume of liquidity assistance to eliminate contagion is low.
- Greater diversification on the inter-bank market does not decrease contagion.

Related Literature

- **Interbank market:** How many banks are dragged into insolvency if one bank fails? (Angelini, Maresca and Russi, 1996, Furfine 1999, Upper and Worms 2002, Wells 2002, Degryse and Nguyen 2004)

- **Theory of systemic risk:**

  - Eisenberg and Noe 2001: Static clearing in a network model.

  - Acharya 2001: Correlation in asset portfolios to exploit regulation.

  - Allan and Gale 2000: Contagion.

- **Credit Risk:** Focus on individual institutions.

Outline of the Talk

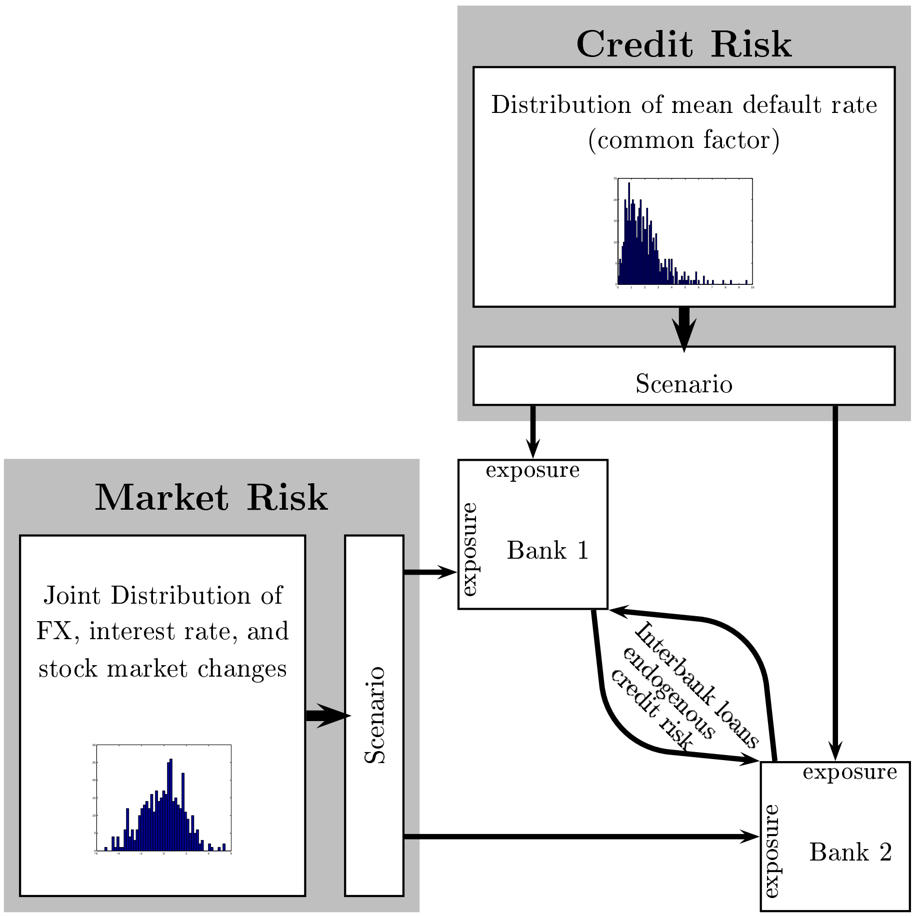
- Overview of the model.
- Network model of the inter-bank market.
- Estimating inter-bank liabilities.
- Generating scenarios.
- Data.
- Results.

Overview of the model

$+$ claims from banks
$-$ liabilities to banks
$+$ value of other assets/liabilities
$=$ Net Value of a bank

- Expose assets/liabilities to shocks from market and credit risk.
- Some banks default because of credit and market risk $\rightarrow$ **fundamental default**.
- Consequence: other banks will be dragged into insolvency $\rightarrow$ **contagious default**.
- Look how bank defaults propagate through the system.

Overview of the model



A network model of the inter-bank market

- Extend work of Eisenberg and Noe 2001.
- Find state of the system where all interbank promises are consistent.
- Defines a unique **clearing payment vector**
- consistent with:
  - banks' asset/liability values.
  - limited liability.
  - proportional sharing in case of default.

Network model 2

- Consider a banking system with three banks with a given structure of inter-bank liabilities. Describe this structure by a matrix

$$L = \begin{pmatrix} 0 & 0 & 2 \\ 3 & 0 & 1 \\ 3 & 1 & 0 \end{pmatrix}$$

- The total gross inter-bank liabilities of nodes are $d = (2, 4, 4)$.

Network Model 3

- All other income streams $e = (1, 1, 1)$.

- Question: Can all banks fulfill their promises? Answer: No.

- Normalize the liability matrix by promised payments to

$$\Pi = \begin{pmatrix} 0 & 0 & 1 \\ \frac{3}{4} & 0 & \frac{1}{4} \\ \frac{3}{4} & \frac{1}{4} & 0 \end{pmatrix}$$

Network Model 4

- Assume all banks fully honor their promises and pay $(2, 4, 4)$. Then we have

$$\underbrace{\underbrace{\begin{pmatrix} 0 & \frac{3}{4} & \frac{3}{4} \\ 0 & 0 & \frac{1}{4} \\ 1 & \frac{1}{4} & 0 \end{pmatrix}}_{\substack{\text{Inter Bank promises} \\ \Pi}} \underbrace{\begin{pmatrix} 2 \\ 4 \\ 4 \end{pmatrix}}_{d}}_{\text{Payments from other banks}} + \underbrace{\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}}_{\text{net income}} - \underbrace{\begin{pmatrix} 2 \\ 4 \\ 4 \end{pmatrix}}_{\text{promised payment}} = \underbrace{\begin{pmatrix} 5 \\ -2 \\ 0 \end{pmatrix}}_{\text{bank value}}$$

- Bank 2 has negative value and is insolvent.

Network Model 5

- Bank 1 and Bank 3 are getting paid off proportionally.

- Bank 2 can only pay 2. Banks pay $(2, \mathbf{2}, 4)$.

$$\underbrace{\begin{pmatrix} 0 & \frac{3}{4} & \frac{3}{4} \\ 0 & 0 & \frac{1}{4} \\ 1 & \frac{1}{4} & 0 \end{pmatrix} \begin{pmatrix} 2 \\ \mathbf{2} \\ 4 \end{pmatrix}}_{\text{Payments from other banks}} + \underbrace{\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}}_{\text{net income}} - \underbrace{\begin{pmatrix} 2 \\ \mathbf{2} \\ 4 \end{pmatrix}}_{\text{promised payment}} = \underbrace{\begin{pmatrix} \frac{7}{2} \\ 0 \\ -\frac{1}{2} \end{pmatrix}}_{\text{bank value}}$$

- Bank 2 drags bank 3 into insolvency.

- Default of bank 2: Fundamental default, Default of bank 3: Contagious default.

Estimating Interbank Liabilities

- banks report positions **due to and from banks** as separate items.

- Information only partial:

0	x	x	2
x	0	x	4
x	x	0	4
6	1	3	10

- Take advantage of sectoral organization of Austrian banking sector.

- 72% of all entries in L known exactly.

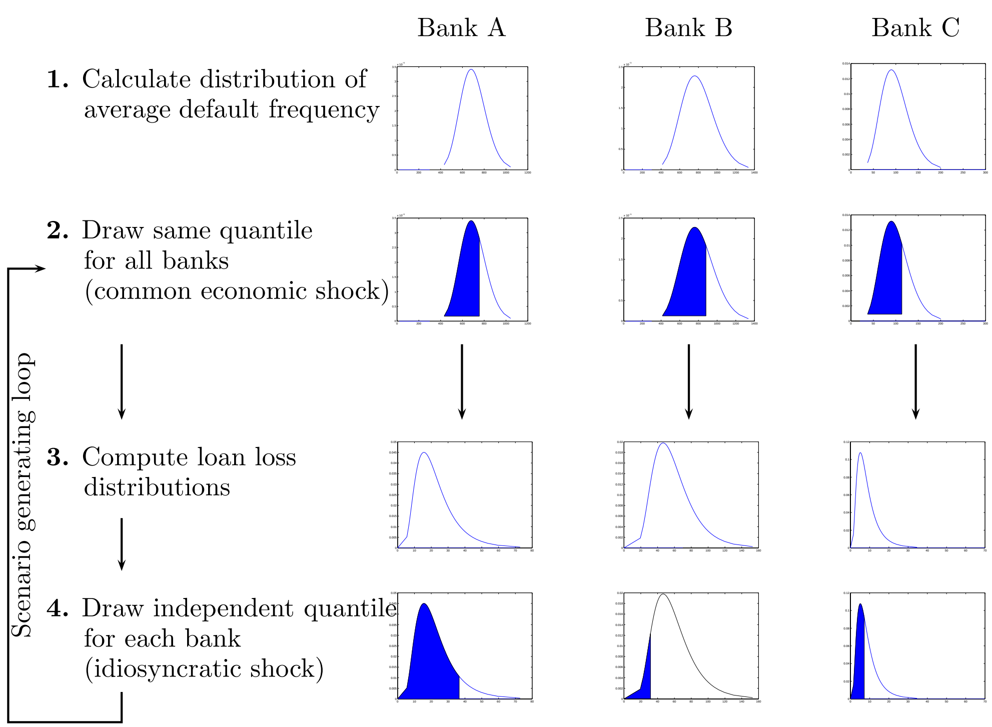
- Unknown entries estimated by entropy maximization.

Scenarios

The creation of scenarios rests on two main building blocks:

- **Market Risk:** Historical simulation
  - No parametric distribution assumed.
  - Use empirical distribution of past returns.
  - Includes: FX, Interest rate and stock market risk.
- **Credit Risk:** Credit risk model
  - CreditRisk+ from Credit Suisse (1997)
  - Adopted for group of loan portfolios.
  - Includes: all loans except inter-bank loans

Credit risk model



Data

- Filings of all 881 banks to Austrian National Bank for September 2002.

- Austrian major loan register.

- Insolvency statistics for industry groups classified. according to NACE standard. Source: Kreditschutzverband von 1870.

- Market data from Datastream.

Short-run and long-run

- **Short run perspective:**
  - Failed banks stop all payments on the inter-bank market.
  - Netting allowed.
  - No crisis intervention policy.

- **Long run perspective:**
  - Residual value of a failed bank transferred to creditors.
  - Efficient crisis intervention by regulator.

- Remainder of presentation: Long term perspective.

Scenarios with contagion

Grouping by fundamental defaults:

	No contagion	Contagion	Total
0-10	88.17%	0.01%	88.18%
11-20	4.43%	0.02%	4.45%
21-30	2.20%	0.03%	2.23%
31-40	1.36%	0.10%	1.46%
41-50	0.90%	0.06%	0.96%
51-60	0.52%	0.10%	0.62%
61-70	0.36%	0.06%	0.42%
71-80	0.20%	0.13%	0.33%
81-90	0.19%	0.15%	0.34%
91-100	0.11%	0.08%	0.19%
more	0.21%	0.61%	0.82%
Total	98.65%	1.35%	100.00%

Default probabilities / recovery rates

Default probabilities:

	10% Quantile	Median	90%Quantile
Entire banking system	0.00%	0.10%	2.60%

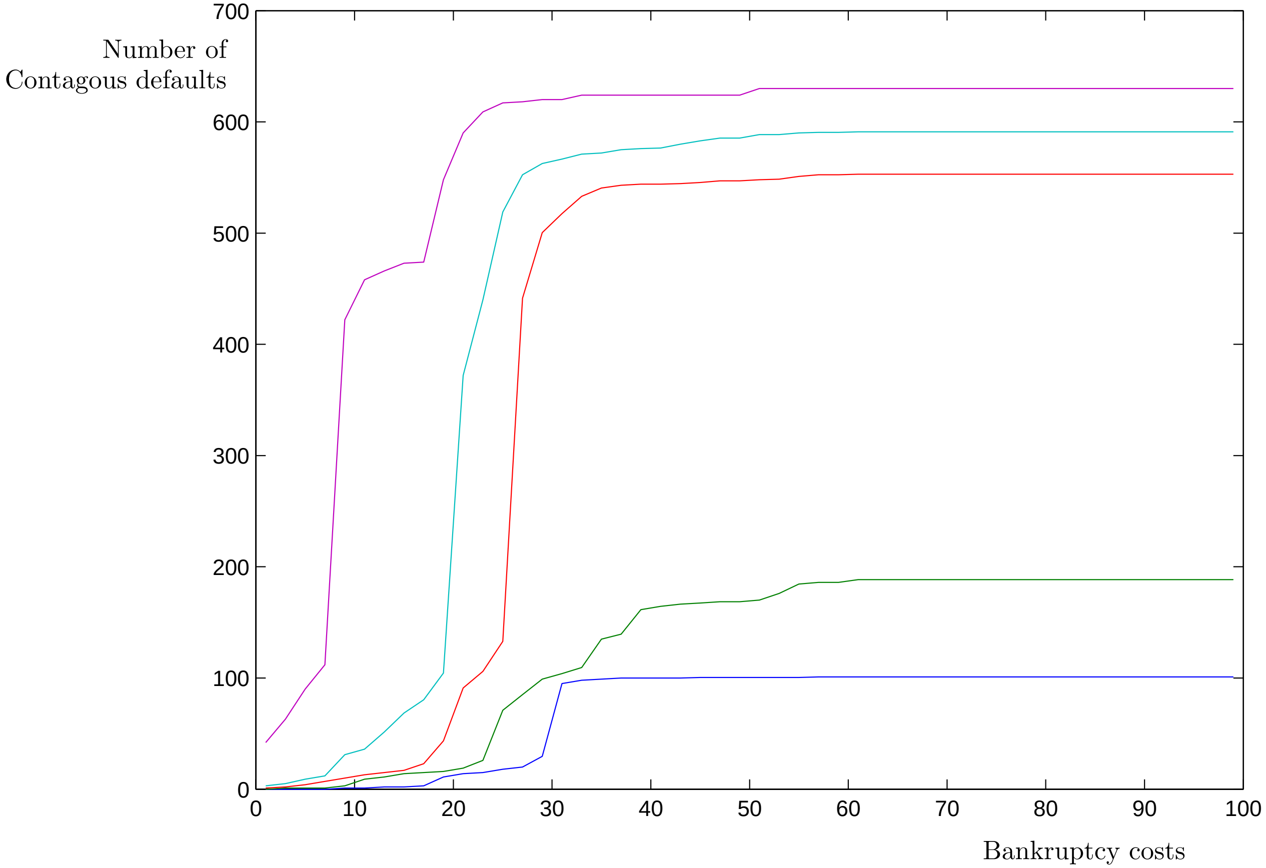
Probabilities of contagious default:

	10% Quantile	Median	90%Quantile
Entire banking system	0.00%	0.00%	0.01%

Endogenous Recovery rates:

	10%-Quantile	Median	90%-Quantile
Entire banking system	0.00%	65.83%	95.54%

Bankruptcy costs and contagious defaults



Volume of liquidity assistance to avoid default

Quantiles	90%	95%	99%	100%
Fundamental Default (mill €)	61.82	194.85	895.51	5666.89
in % of all assets	0.01%	0.03%	0.16%	0.98%
Contagious Default (mill €)	0	0	0.12	20.01
in % of all assets			0%	0.003%

Diversification in the inter-bank market

- Do not change bank's interbank loans / deposits
- Diversify borrowers as much as possible
- Ignore all structural information in our dataset
- Probability of states with contagion increases from 1.35% to 4.2%

Summary

- Measure risk at the **level of the banking system**

- Combine:
  - Macroeconomic shock
  - Network of credit obligations

- Develops application to existing datasources

- **Correlated exposures more important** source of systemic risk **than contagion**.