Modelling Financial Contagion to Examine Systemic Risks

Marion Deichmann, Laurenz Kaiser, Timo Schäfer

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Outline

1 Introduction and Motivation

2 Model

3 Capital Buffers

4 Bail-outs

5 Summary and Outlook

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5. Summary and Outlook

The recent crisis has shown the interconnectedness of banks as key issue w.r.t. financial stability

1. Which banks are better able to decrease their probability of being exposed to contagious defaults when adjusting their equity ratio?

2. Which bail-out strategy is the most effective w.r.t. impeding contagion and costs?

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Structure of Financial Network

- adjacency matrix A, A_{ij} exposure of i w.r.t. j, A_{ji} liability of i towards j

- types of default (equity< 0):
  1. fundamental default
  2. contagious default

assets	liabilities
interbank assets ($A_i^{IB}(t)$)	interbank liabilities ($L_i^{IB}(t)$)
external assets ($A_i^{E}(t)$)	external liabilities ($L_i^{E}(t)$)
	equity ($E_i(t)$)

Table: Simplified balance sheet.

Network generation (Gabrieli2014)

- use real data from balance sheet
  1. interbank assets
  2. external assets
  3. equity

- core-periphery structure

- for adjacency matrix: assumption of perfectly diversified exposure due to data availability

Fictitious Default Algorithm (Eisenberg2001)

- aim: calculate clearing vector for payment each round
- pure-default based algorithm
- algorithm
  1. assume that in $t = 0$ only banks default due to external shock
  2. round computing starts: solve linear equations for defaulting banks (assets=payment) and get their clearing payment
  3. iterate until no new default occurs

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Two strategies to adjust equity ratio

equity ratio $ER_i(t) = \frac{E_i(t)}{A_i^{IB}(t)+A_i^{E}(t)}$

1. **periphery banks:** sell external assets and pay back external liabilities trying to get to required *ER*
   alternatively: reduce interbank assets and reduce interbank liabilities $\Rightarrow$ interconnectedness decreases
2. **core banks:** can issue equity since more liquid but market with frictions ($\triangle E_i'(t)$ is additional equity amount needed):

$$\triangle E_i(t) = \min\left(\triangle E_i'(t), (E_i(0))^{1/t}\right), \ \forall t \neq 0.$$

Simulation

- two situations: pre (no *ER* before shock) and post (*ER* before shock) crisis
- low ($a = 1, b = 10$) and high-risk ($a = 1, b = 1$) scenario drawn from Beta(a, b)
- simulation steps: 250
- *ER* varies from 0 to 0.4 in 0.01 steps
- those 50 banks with highest number of incoming links (interbank liabilities) are stressed

Low-risk scenario

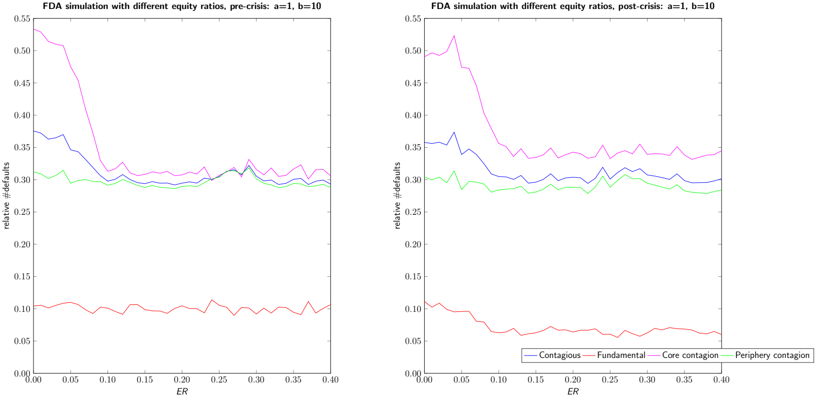
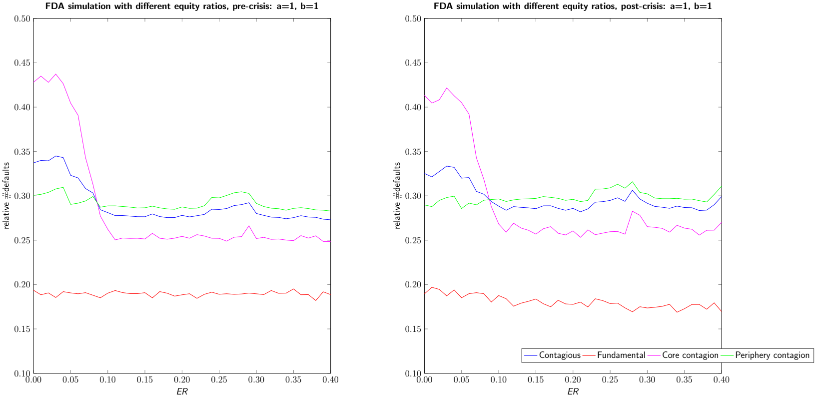


Figure: Plot for default probabilities in dependence of minimum capital requirement *ER*. Core (periphery) contagion means the fraction of core (periphery) banks that default due to contagion. Contagious (fundamental) default means the overall probability of defaults due to contagion (an exogenous shock).

High-risk scenario



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Model

- aim: stabilise interbank network
- bailing out starts if 5% of banks fail due to both fundamental and contagious defaults
- selection scheme comparison: random vs. eigenvector centrality
- banks cannot be bailed-out twice (moral hazard)
- the equity injection is added onto external assets, so that the regulatory equity ratio of ER=4.5% can be accomplished

$$\text{injection}_i(t) = \frac{L_i^{IB}(t) + L_i^{E}(t) - (1 - ER)\left(A_i^{IB}(t) + A_i^{E}(t)\right)}{(1 - ER)}$$

Bail-out default simulation, high stress scenario

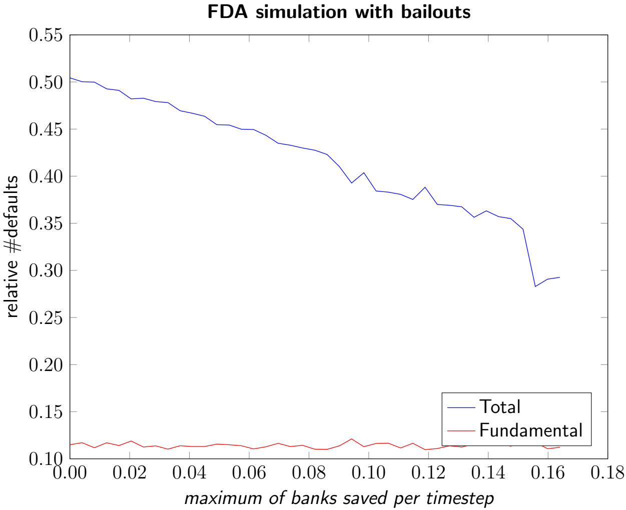

Figure: Plot for total defaults using **eigenvector centrality** as selection scheme in dependence of **maximum fraction of total number of banks** bailed-out per timestep.

Bail-out cost simulation, high stress scenario

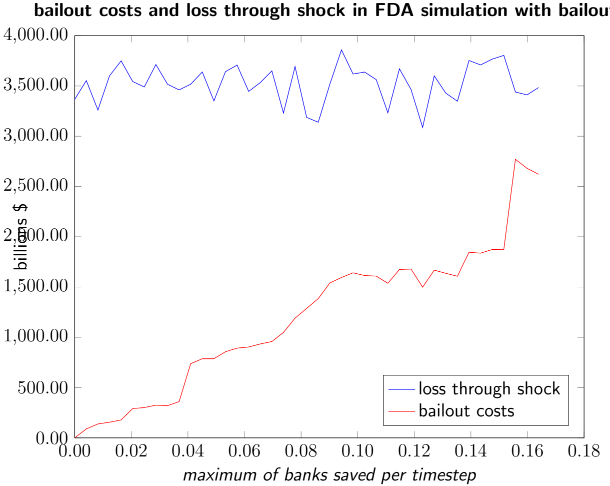

Figure: Plot for total bail-out cost and the loss from the initial shock using **eigenvector centrality** as selection scheme in dependence of **maximum fraction of total number of banks** bailed-out per timestep.

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Policy implications I

- core banks better able to pursue a strategy to lower their risk of contagious default
- does not hold for periphery banks: alternative strategy
- policy makers have to specifiy how banks should adapt to capital requirements

Policy implications II

- bail-out: no significant differences w.r.t. bail-out costs in terms of selection scheme
- effect of an increase of max number of banks to save per time step is significant
- use mixed strategies, conduct simulation in a non pure-default model, e.g. DebtRank algorithm

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Data summary

country	count	Average tot asset	Min	Max	Sum
AT	7	68	22,5	189,1	472,7
BE	7	135	33,5	275,2	943,5
CH	15	151	20,0	884,7	2270,0
DE	34	245	21,6	2240,7	8324,5
DK	11	110	20,5	464,6	1215,4
ES	18	196	20,0	1266,3	3528,0
FI	4	134	29,7	346,2	537,0
FR	43	292	20,1	2077,8	12535,1
GB	39	277	20,5	1746,8	10803,1
GR	4	88	72,9	115,5	353,2
IE	8	52	20,9	129,8	419,5
IT	25	115	20,1	844,2	2864,8
LU	8	40	20,3	85,5	320,7
NL	8	302	20,0	828,6	2418,3
PT	6	82	22,5	189,1	492,4
SE	7	148	24,7	299,9	1032,8
	244				48530,9

Table: Summary statistics on banking data from Bankscope. Interbank market characterisation w.r.t. total asset position in $bn.