Contagion Systemic Risk in Networks

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This paper

- Proposes a measure to contain systemic risk arising from direct interbank exposures.
- Considers three channels of transmission: credit risk, funding risk and runs.
- A policy proposal to contain systemic risk is derived naturally from standard limits for individual risk management.
- Compares results with proposal of limiting interbank exposures among large institutions.

Agenda

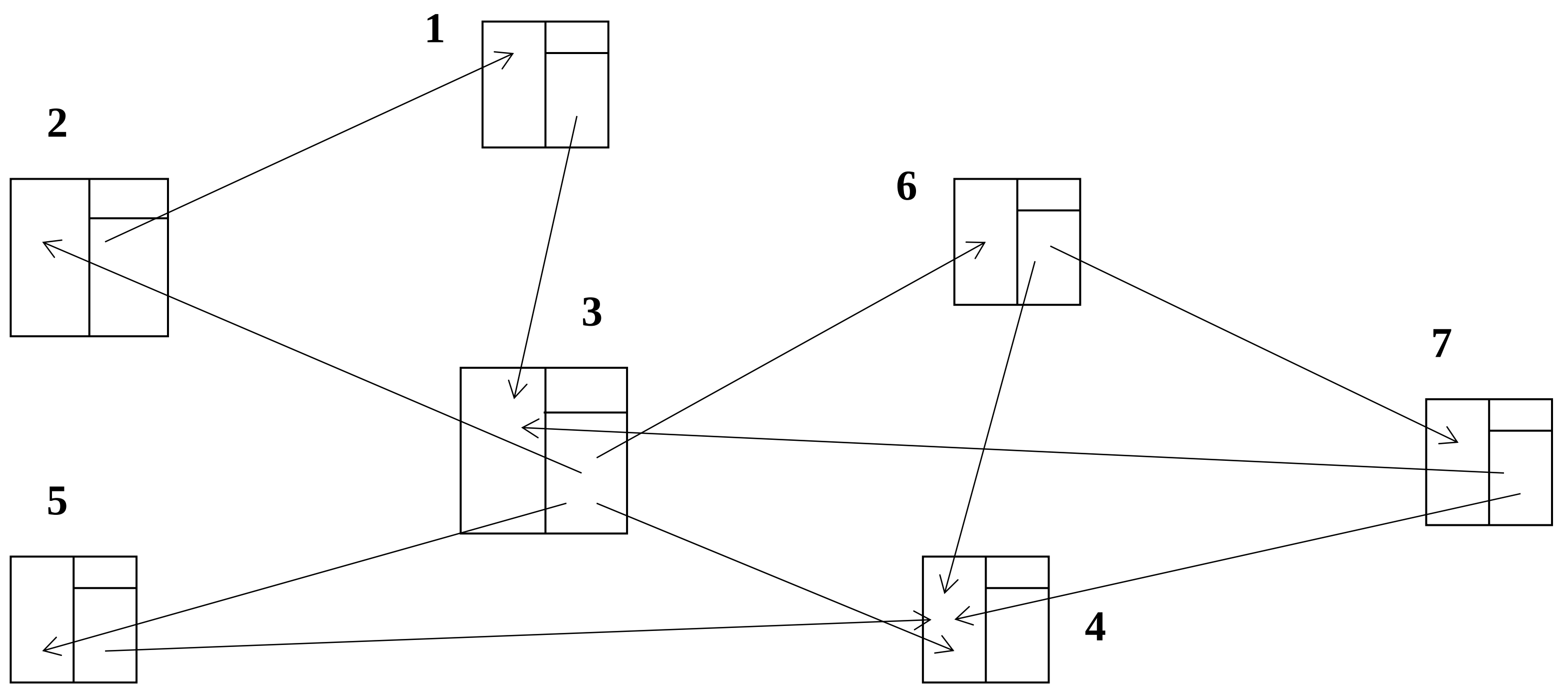
1. Definitions and simulation parameters
2. Interbank market: Risks, limits and policy proposal
3. Simulated Interbank Markets: Methodology
4. Results
5. A real-world case
6. Conclusions

1. Definitions and simulation parameters

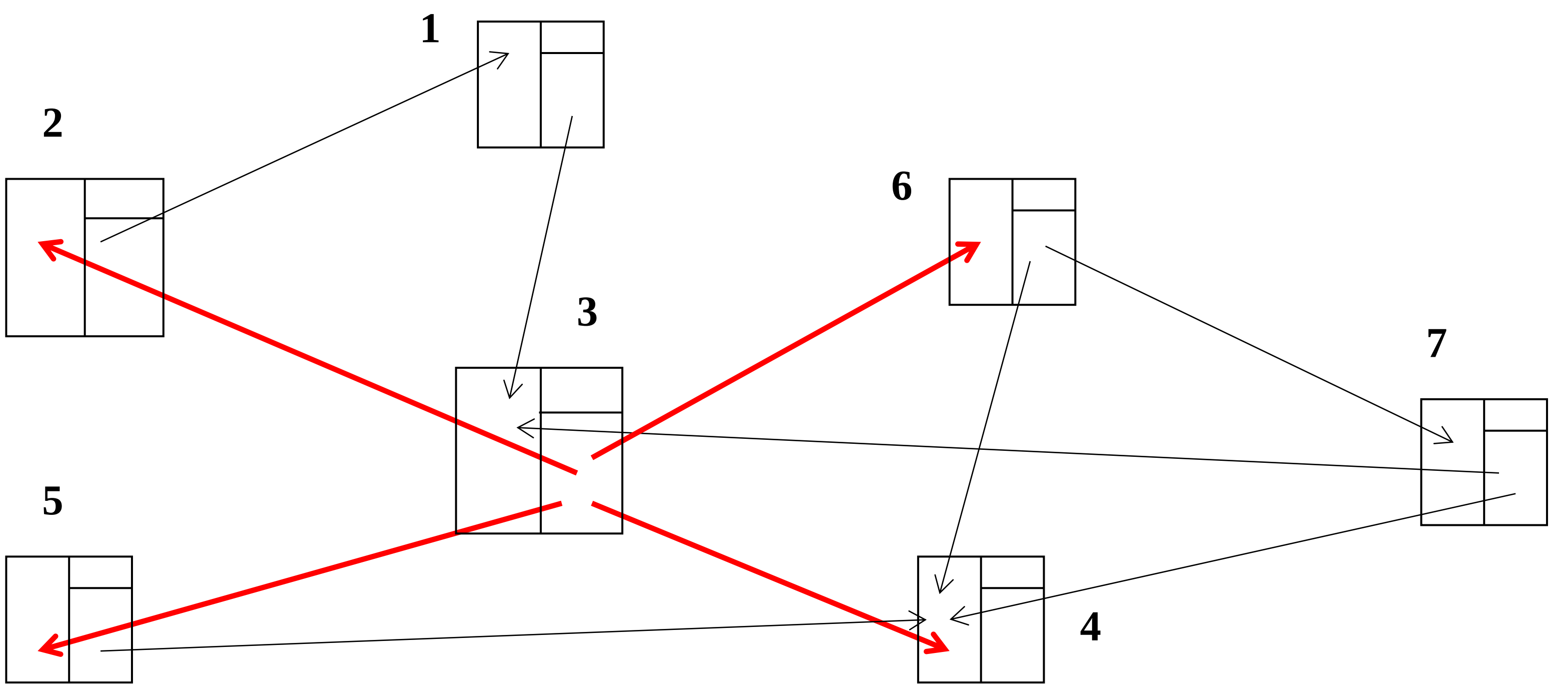
Risks

- Upon the failure of a bank, we propose to channels it can affect others:
  - Credit Risk: A bank cannot pay its obligations. Impact on holders of liabilities of that bank.
  - Funding Risk: A bank that fails does not continue providing funds to others. Recipient banks may face losses.
- In addition, the two may combine in a single institution :
  - Run: As a consequence of losses suffered by a bank due to credit risk, funding risk may materialise in the form of a run.

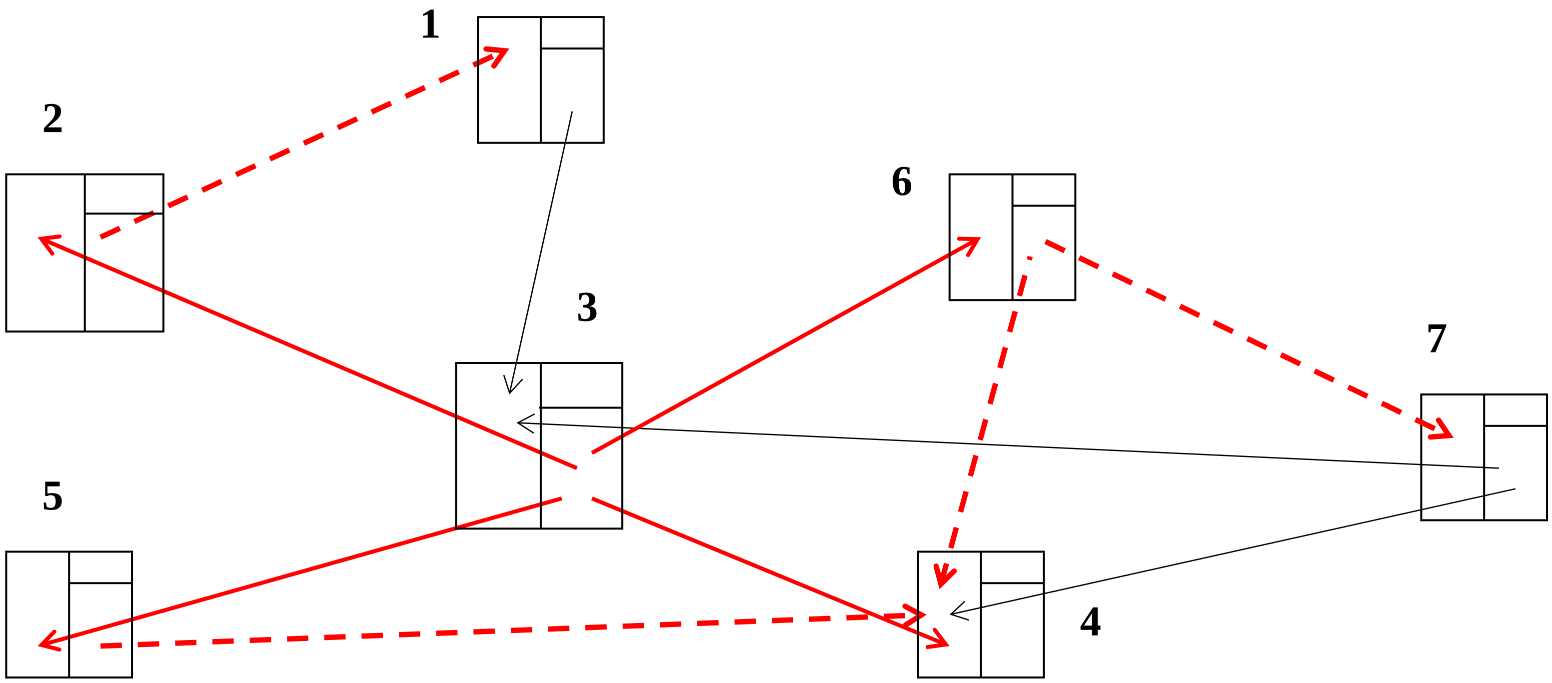
Network: Exposures



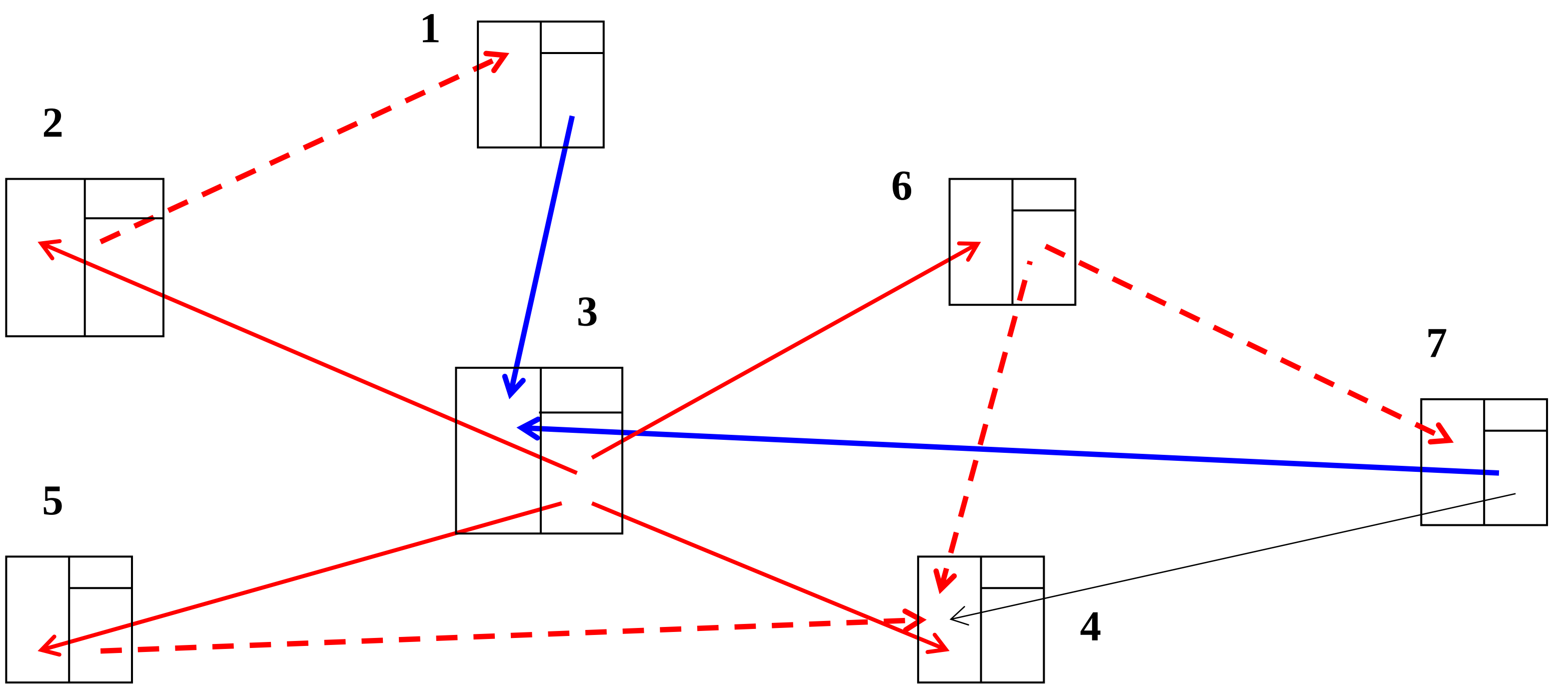
Credit risk



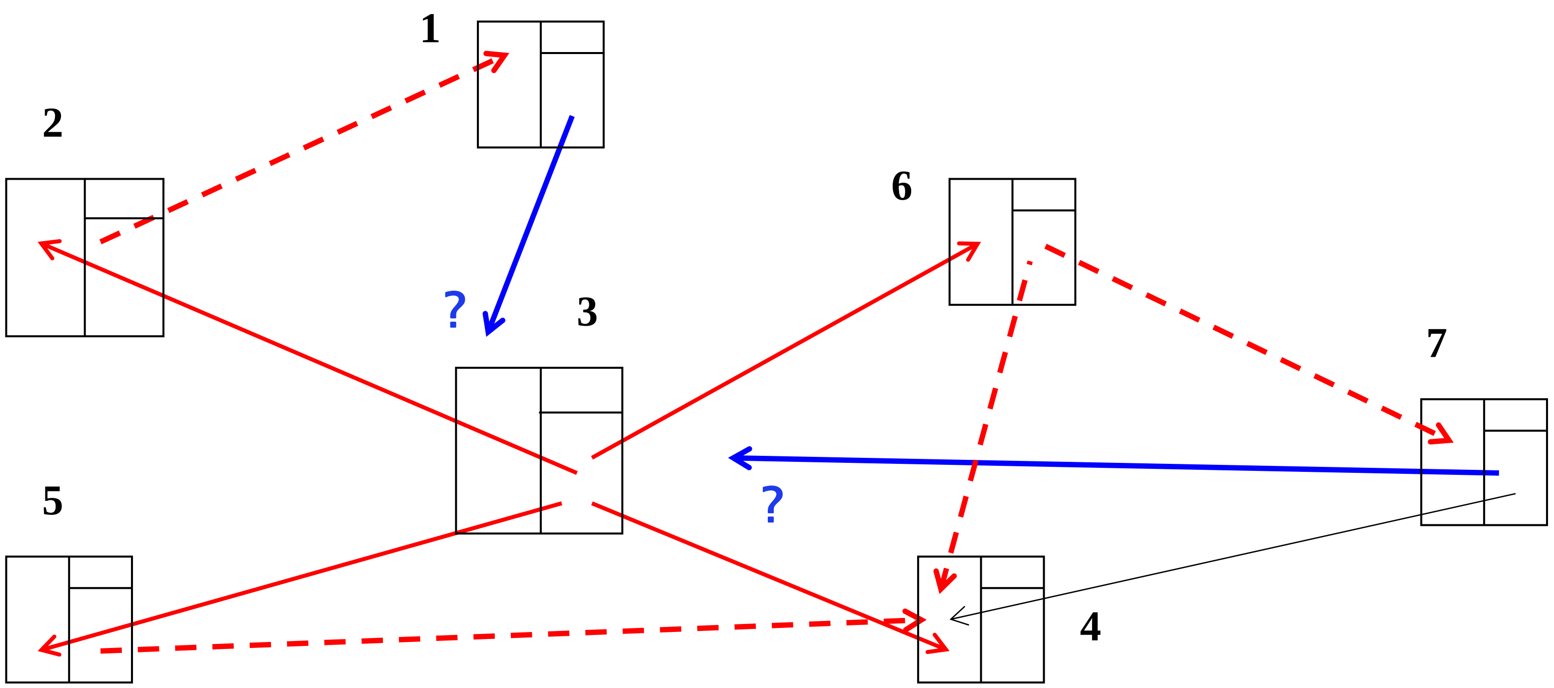
Contagion



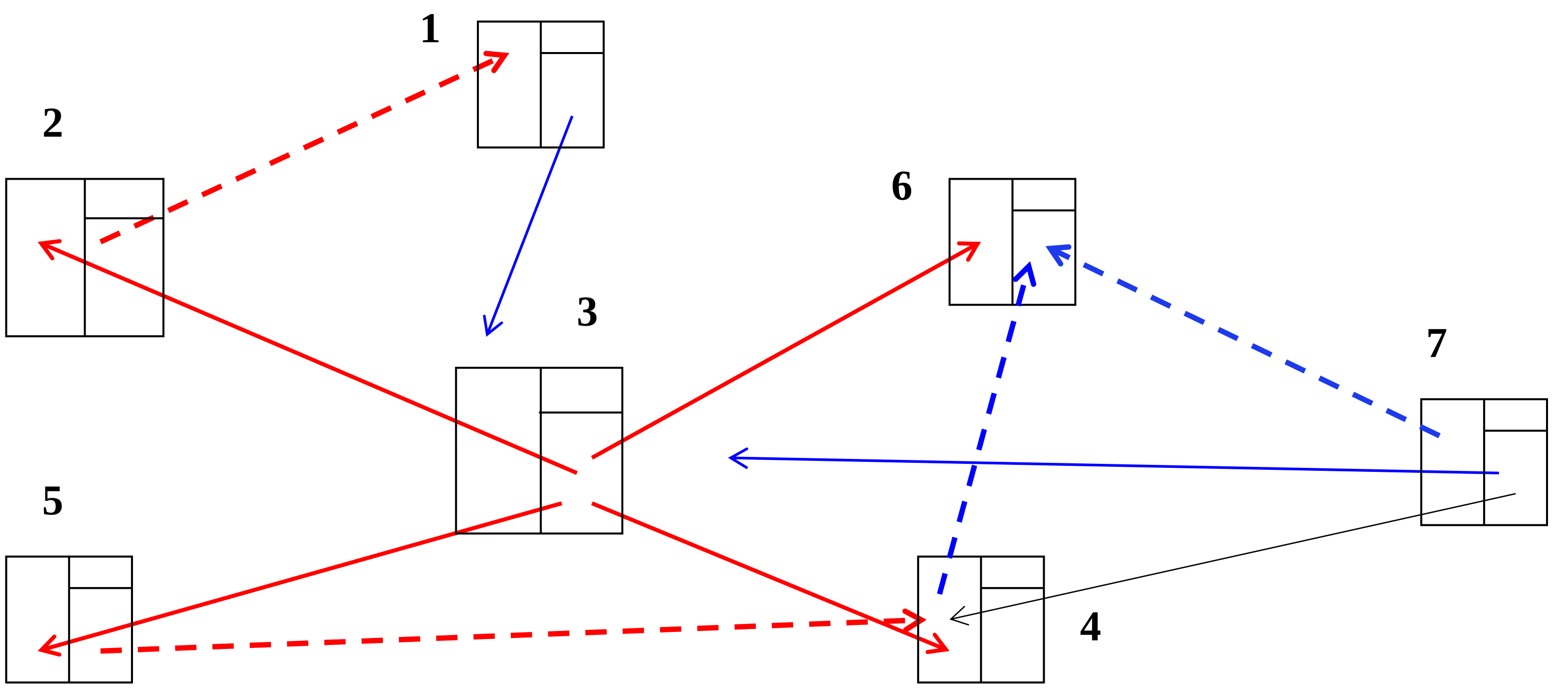
Funding risk



Funding risk



Runs



Parameters

Table parameters.

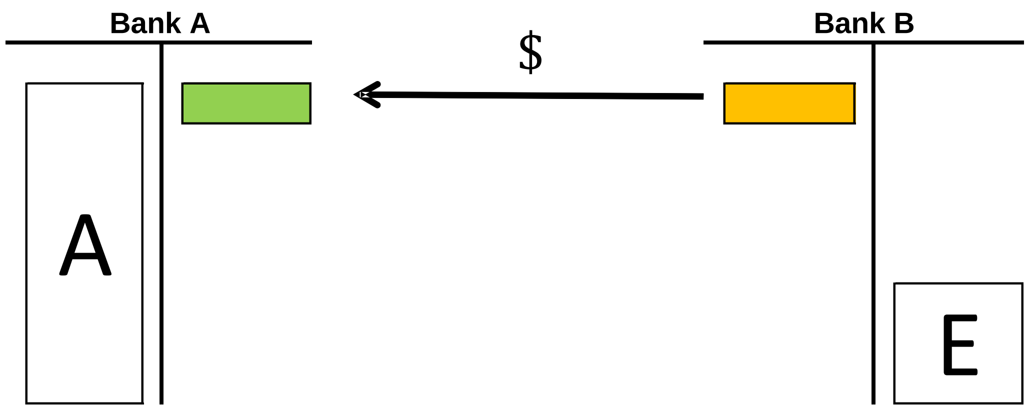
Panel A			
Parameter	**Instrument**	**Contagion**	**Contagion with run**
Loss given default	Derivatives in foreign currency	20	20
	Derivatives in pesos and UF	1.5	1.5
	Other intruments	30	30
Funding replace ratio	All instruments	50	0
Fire-Sales ratios	Cash	90	90
	Financial instruments	70	70
	Commercial loans	60	60
	Mortgages	60	60
	Consumption loans	20	20

Panel B		
Parameters	**Value**	**Description**
Default	*IAC* <8%	If *IAC* falls under the 8% the bank is declared in default.
Runs	*IAC* <11%	If *IAC* falls under the 11% the bank will suffer a run.
Runs*	Loss in capital>5%	If the the bank lost more than 5% and independent of the other conditions, tha bank will suffer a run.

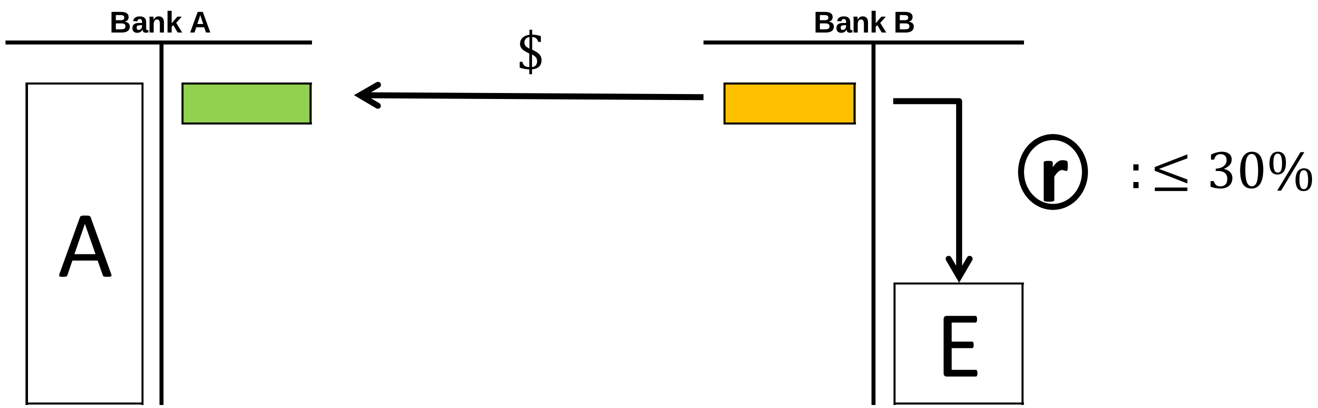
Notes: In runs scenario, if a bank defaults it will not be able to find other funding resources. Therefore, it's funding replacement ratio turn to zero. For the case of fictitious exposure matrix, we create five instruments which try to replicate what we seen in the case of Chile.

2. Interbank Credit: Risks, Limits and Policy Proposal

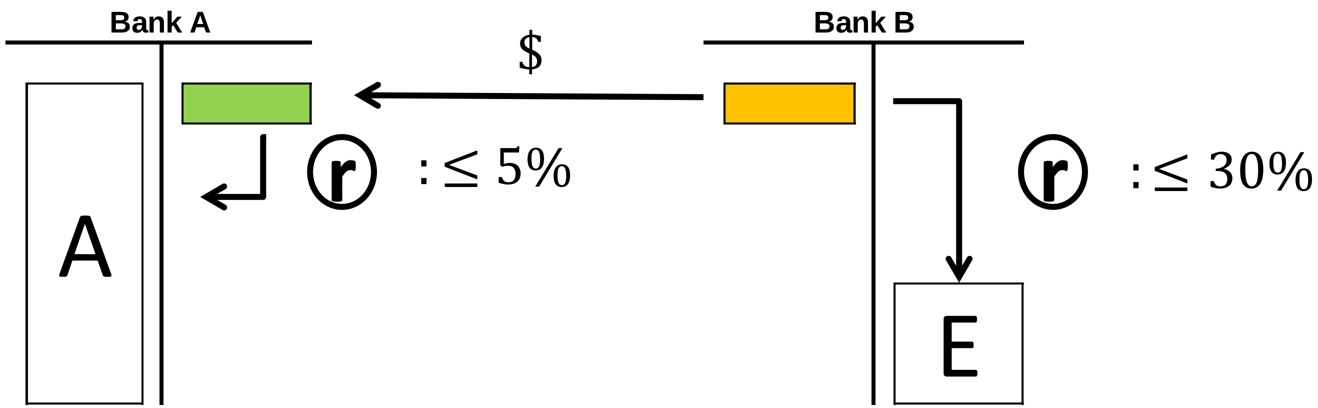
Limits to risks in the interbank market



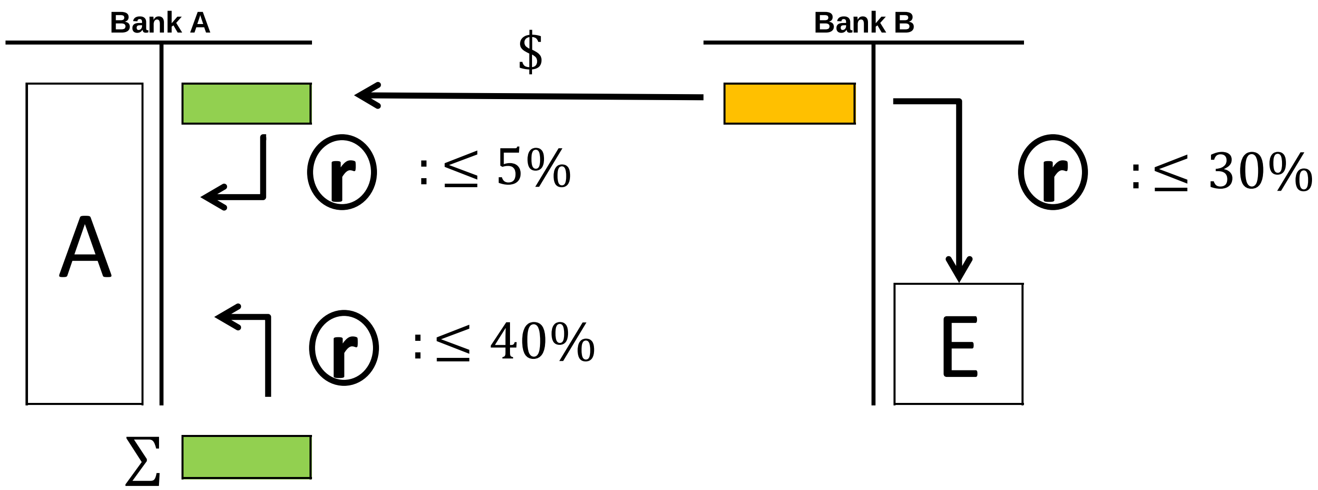
Limits to risks in the interbank market



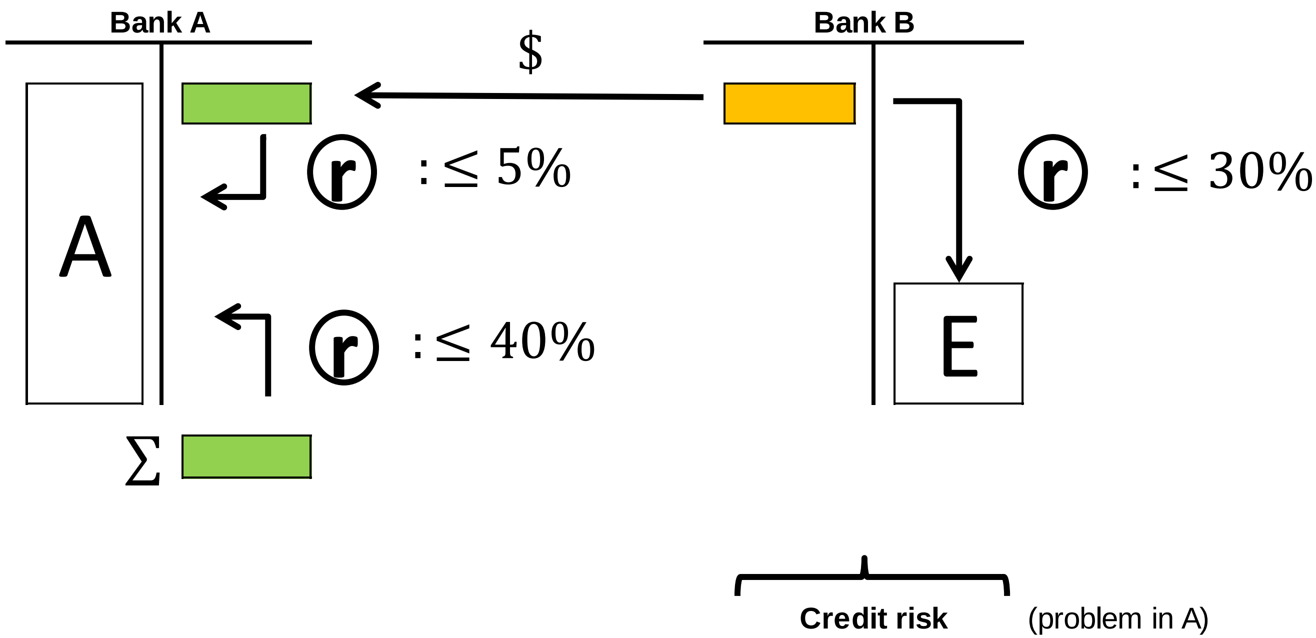
Limits to risks in the interbank market



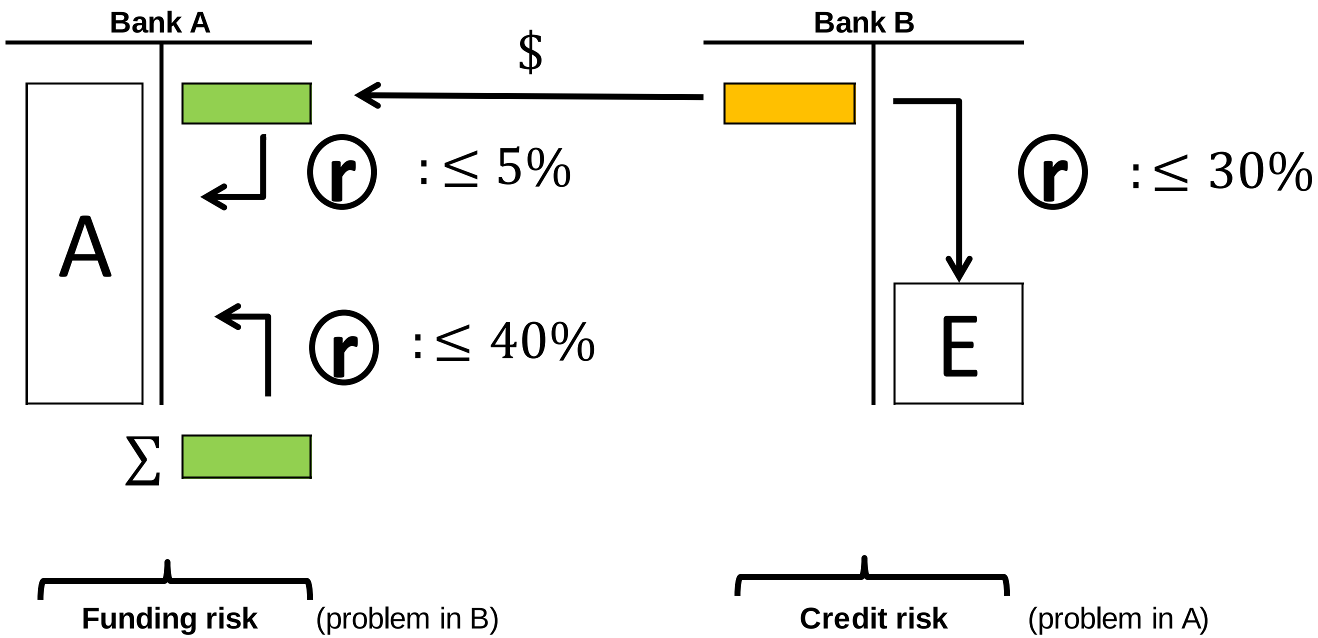
Limits to risks in the interbank market



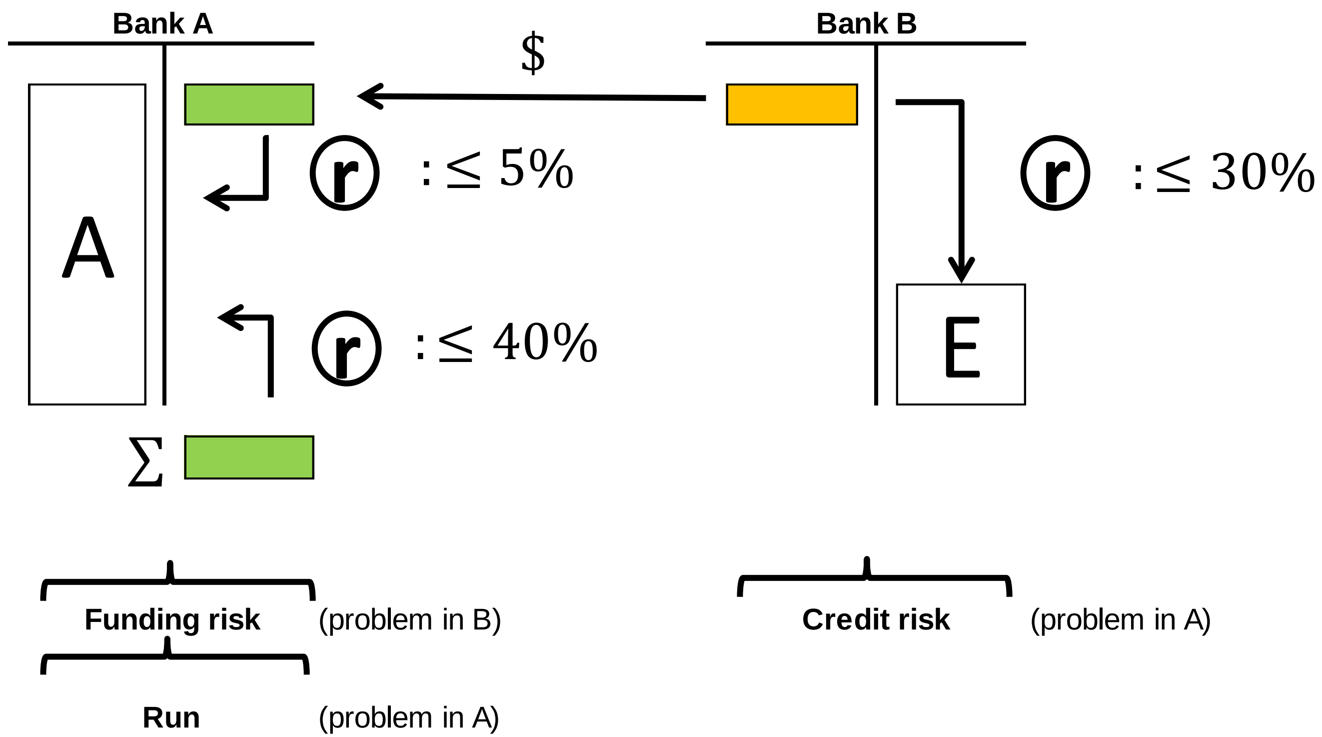
Limits to risks in the interbank market



Limits to risks in the interbank market



Limits to risks in the interbank market



Systemic Rules – Debt with the system

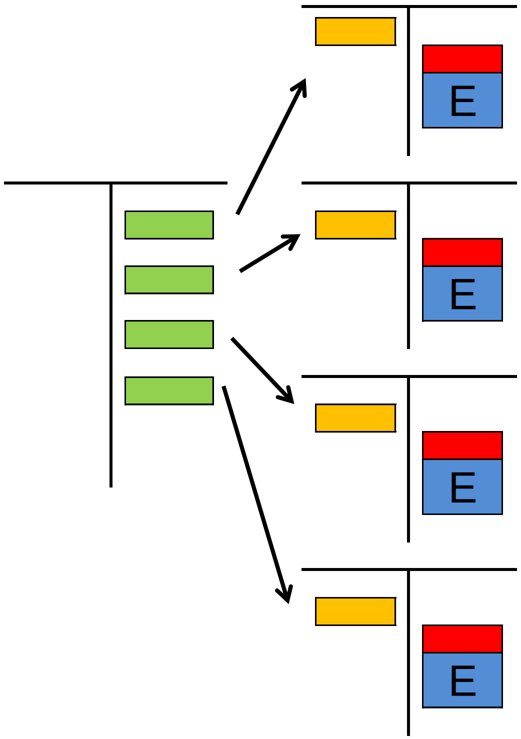
- Following Cifuentes (2003), the systemic rules limit the credit or borrowing of an institution from a system perspective.
- The *Credit Risk Imposure* (CRI) is the relation between the borrowing of a bank and the equity *of the rest of the system*:

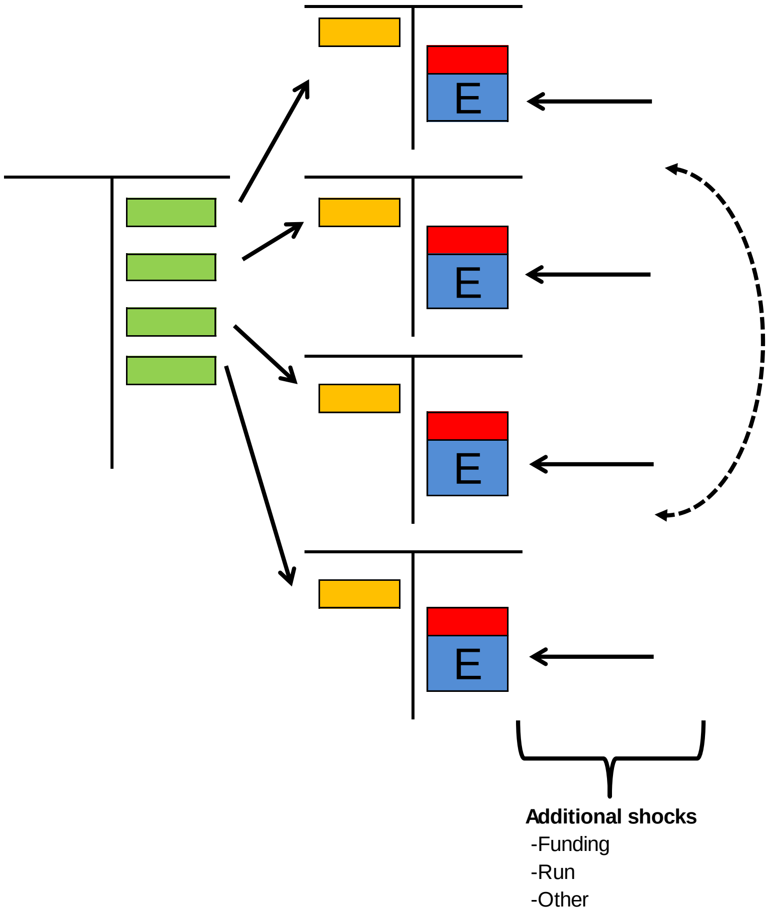
$$CRI_i = \frac{\sum_{\forall j} d_{ij}}{ERS_i} < \theta$$

Where:

- d_{ij} represents the debt of bank i to the bank j,
- ERS_i represents the equity of the rest of the system (total equity of the system minus the equity of the bank i),
- θ indicates the regulatory limit to this measure.

Limit risk exposure of the system by limiting Credit Risk *Imposure*

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Additional shocks
-Funding
-Run
-Other

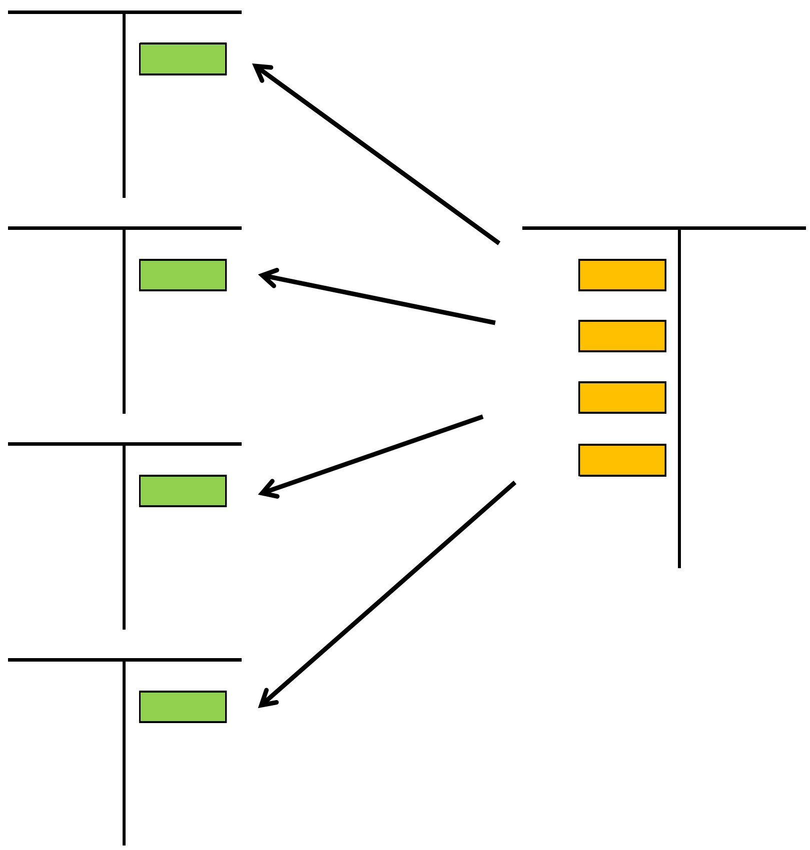
Systemic Rules – Provision of liquidity to the system

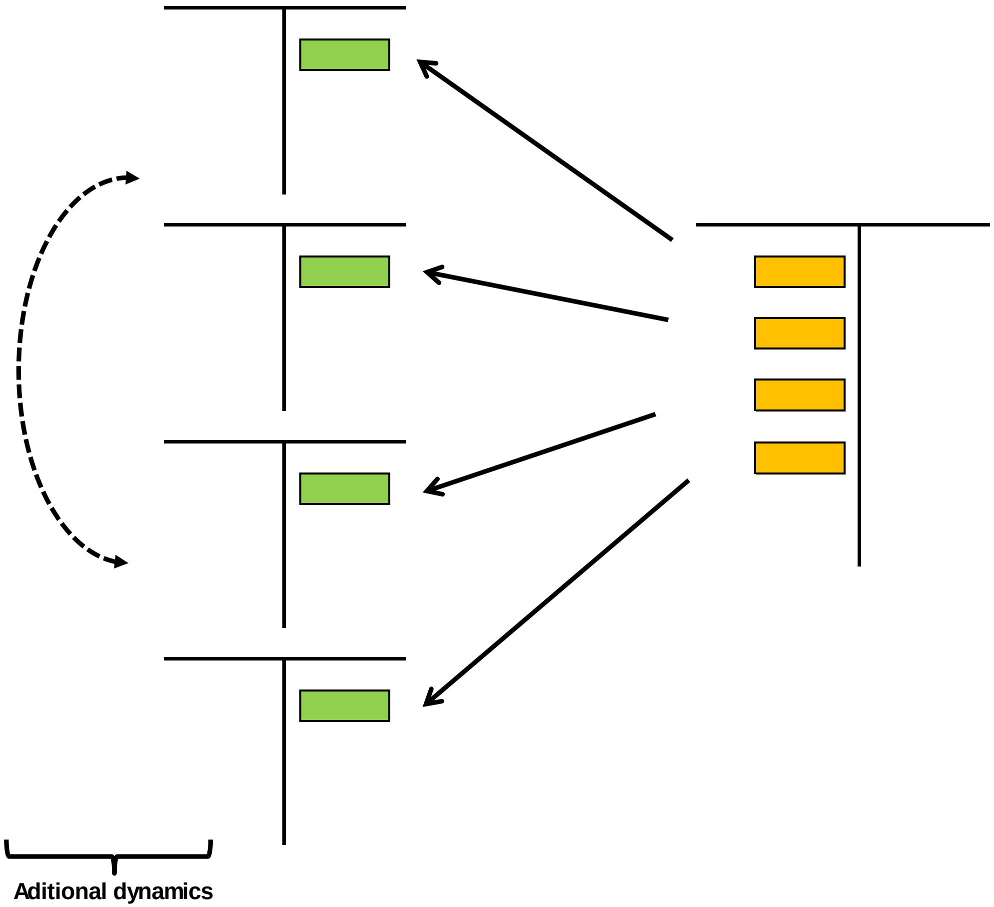
- Similarly, *Liquidity Risk Imposure* (LRI) is the relation between the aggregate provision of liquidity of a bank and the assets of the *rest of the system*.

$$LRI_i = \frac{\sum_{\forall j} d_{i,j}}{ARS_i} < \vartheta$$

Where:

- ARS_i is defined as the total assets of the system minus the assets of bank i.
- ϑ is the regulatory limit.




Aditional dynamics

Systemic Rules – Bilateral position (BIS)

- The systemic rules of the bilateral type (BR) limit the exposure of a systemic bank to another systemic bank in relation to its own equity.

$$BR_j = \frac{d_{ij}}{E_j} \leq BR^{max}$$

Where:

- E_j the equity of bank j, and
- BR^{max} is the threshold.

3. Simulated interbank markets: Methodology

Three cases

Table: Parameters

Case	Description	Panel A		Panel B			Panel C		
		CRI	*LRI*	p^{b_1}	p^{b_2}	p^{b_3}	W^L	W^M	W^S
1	Two peaks	[15%-20%]	[2.5%-3.0%]	90%	60%	40%	90%	60%	40%
2	Big borrower	[15%-20%]	Below 1.5%	90%	60%	40%	90%	60%	40%
3	Big lender	Below 10%	[2.5%-3.0%]	90%	60%	40%	90%	60%	40%

Notes:

- CRI and LRI are the targeted values for Credit Risk Imposure and Liquidity Risk Imposure, respectively.
- Panel B shows the probability of a link between big banks (block 1), small banks (block 3) and medium banks (block 2), which include all other possible combinations.
- Panel C shows our parametrization of the size of the credit relationship in relation to its regulatory maximum. It depends on the bank's size (large, medium and small).

Model simulated to create different exposure matrix

In each iteration, the process used to create fictitious banking systems (matrix IM) is the following:

- **Balance sheet**: We obtain a draw for the distribution of *total assets* from a Chi-square distribution. Both equity and current assets are defined as a percentage of total assets.
- **Regulatory matrix:** We define $R1$ (nxn matrix) as the maximum credit between each pair of banks:

$$r1_{ij} = \min(0{,}05xA_i; 0{,}3xE_j)$$

- and $R2$ ($nx1$ vector) that defines the maximum aggregated borrowing for every bank:

$$r2_i = 0{,}4xA_i$$

Model simulated to create different exposure matrix

- **Link matrix:** We define PB (binary matrix nxn) of random links among banks (*Erdos–Renyi*), where big banks have a higher probability. For case 2 (3), we consider the lower (upper) triangular matrix of PB to be zero.
- **Matrix proposed**: We define the element im_{ij} of matrix IM as:

$$im_{ij} = r1_{ij} * W^{size} \qquad if \;\; pb_{ij} = 1$$

where W^{size} is a weight that takes values between 0 and 1 depending on the size of the bank.

Three cases

Table: Parameters

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- Panel C shows our parametrization of the size of the credit relationship in relation to its regulatory maximum. It depends on the bank's size (large, medium and small).

Model simulated to create different exposure matrix

- **Condition 1**: If $\sum_{\forall j} im_{ij} \leq r2_i \;\; \forall_i$, we proceed to the next condition. If not, we drop IM and the process starts again.
- **Condition 2:** Depending on the simulated case, the *Credit Risk Imposure* and the *Liquidity Risk Imposure* must be consistent with the desired target. If not, we drop IM and the process starts again.
- **Condition 3:** Similarly, if the implied *size of the interbank market* is consistent with the desired size, we keep IM. If not, we drop IM and the process starts again.

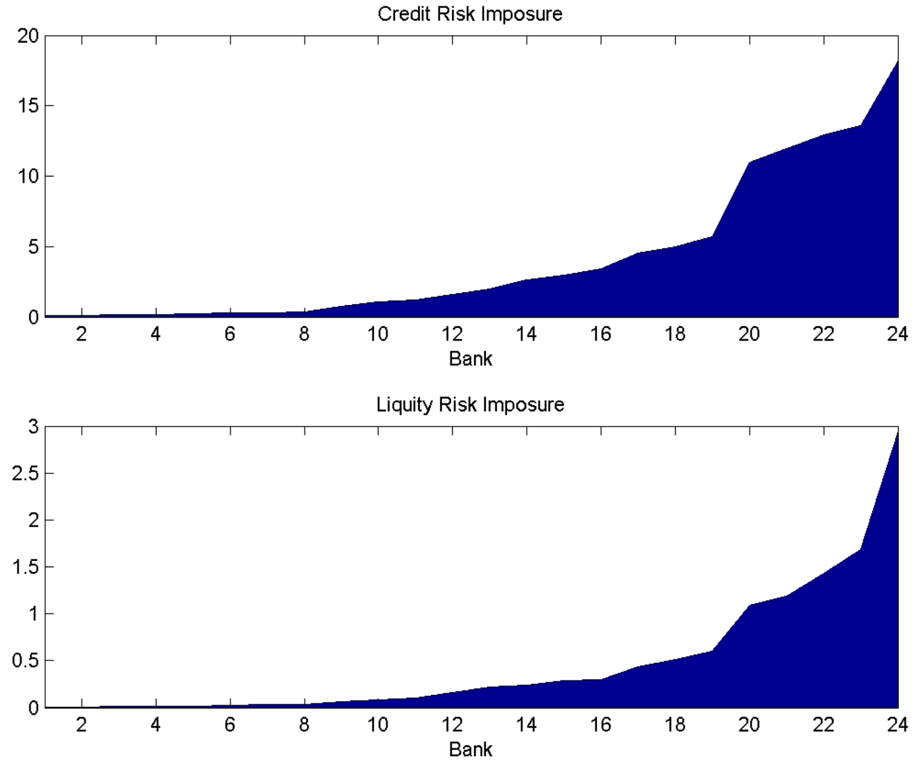
Parametrization

Table: Other parameters relevant for simulations

Parameters	Value	Description
N° banks	24	Number of banks in Chile.
Banks Balance sheet		
Equity	10%	Percentage of total assets of the bank.
Current assets	95%	Idem.
Risk-weighted assets	80%	Idem.
Liquid assets	60%	Idem.
Limits to interbank Assets and Liabilities		
Limit to Credit Risk Exposure	30%	Percentage of own equity.
Maximum funding from a given bank	5%	Percentage of own current assets.
Maximum interbank funding	40%	Percentage of own current assets.
Interbank Market		
Size of the interbank market	[7%, 10%]	Percentage of total assets of the system.

Interbank markets – Case 1

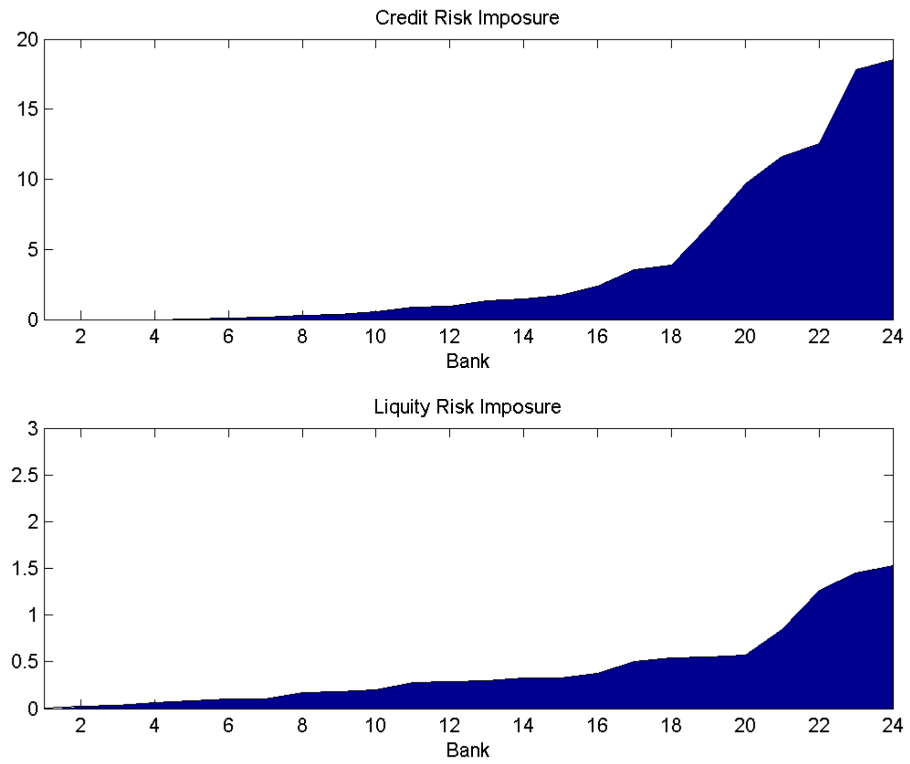
Figure: Twin peaks – Big borrowers, Big lenders
(percentage of ERS and ARS, respectively)



Source: author's simulations.

Interbank markets – Case 2

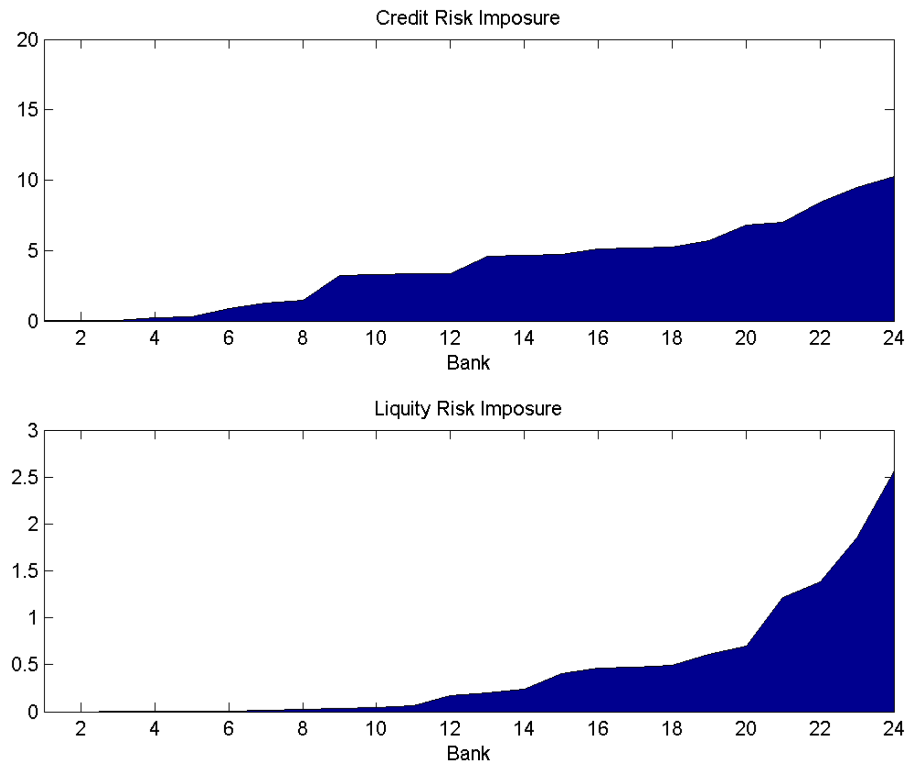
Figure: Big borrower (percentage of ERS and ARS, respectively)



Source: author's simulations.

Interbank markets – Case 3

Figure: Big lender (percentage of ERS and ARS, respectively)



Source: author's simulations.

4. Results

Definition of Systemic Risk

- We consider that a bank causes systemic damage if its failure causes losses in other banks above 5% of total equity of the system.
- We call "Systemic losses" those caused by all banks in a given simulated interbank market.
- We report average SL and p95.

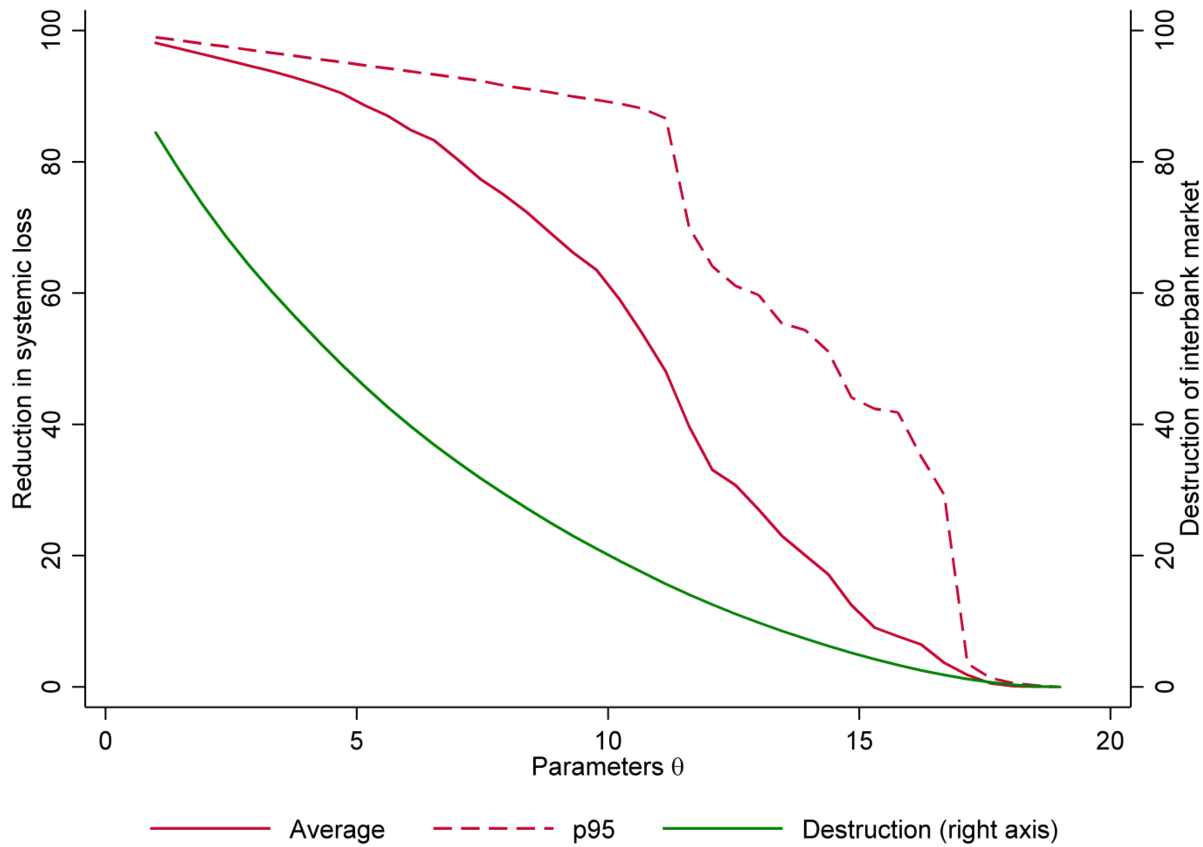
Effectiveness of Policies

- We measure the effectiveness of a policy as the reduction in the losses described.
- Relative to initial loss: $E1 = 100 * (\frac{\overline{SL}^{BP} - \overline{SL}^{AP}}{\overline{SL}^{BP}})$
- Relative to equity of the system:

$$E2 = 100 * (\frac{\overline{SL}_t^{BP} - \overline{SL}_t^{AP}}{E})$$

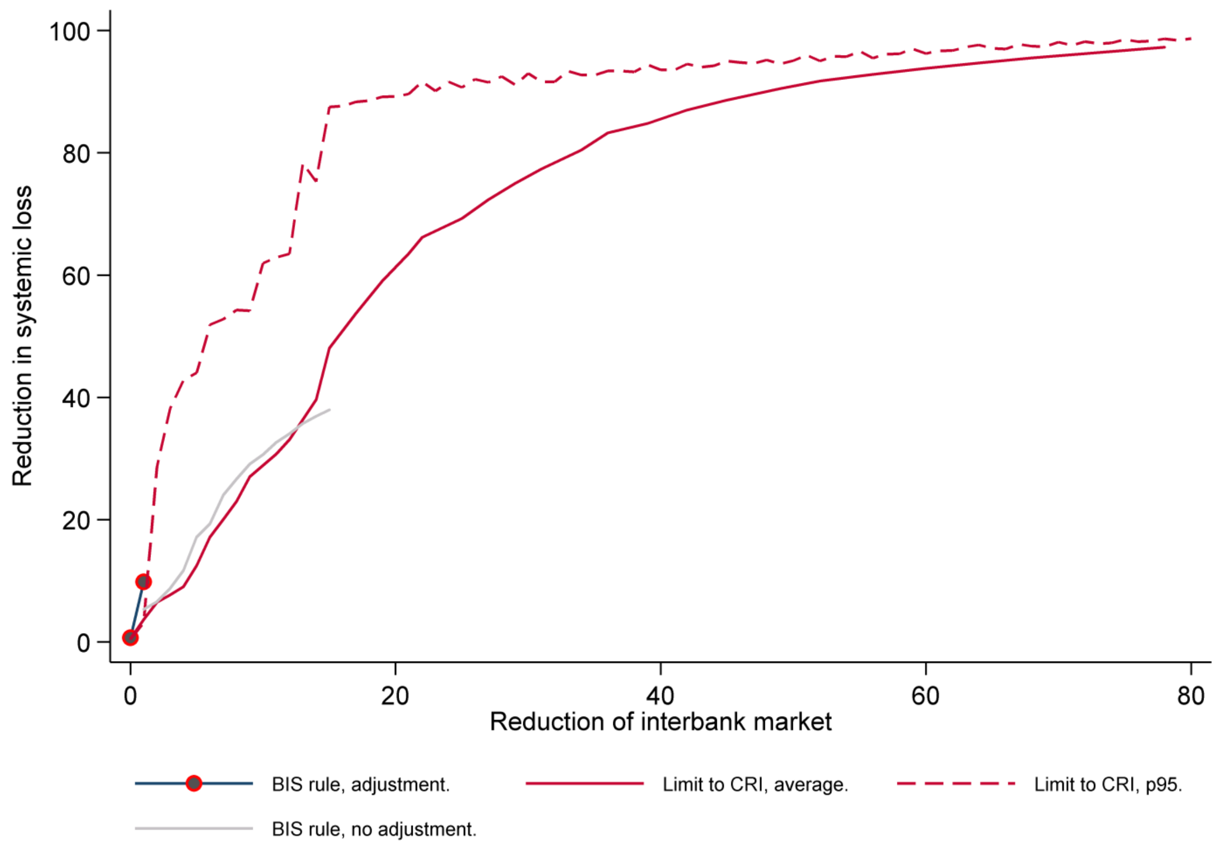
Case 2: Average effectiveness of Limit to CRI policy

Figure: Equity recovered as a fraction of initial systemic loss

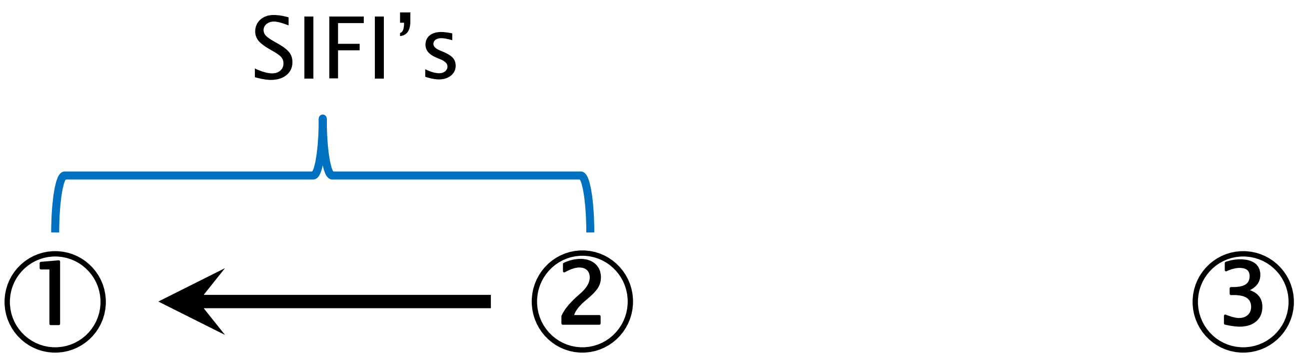


Case 2: Reduction in interbank market of Limit to CRI policy

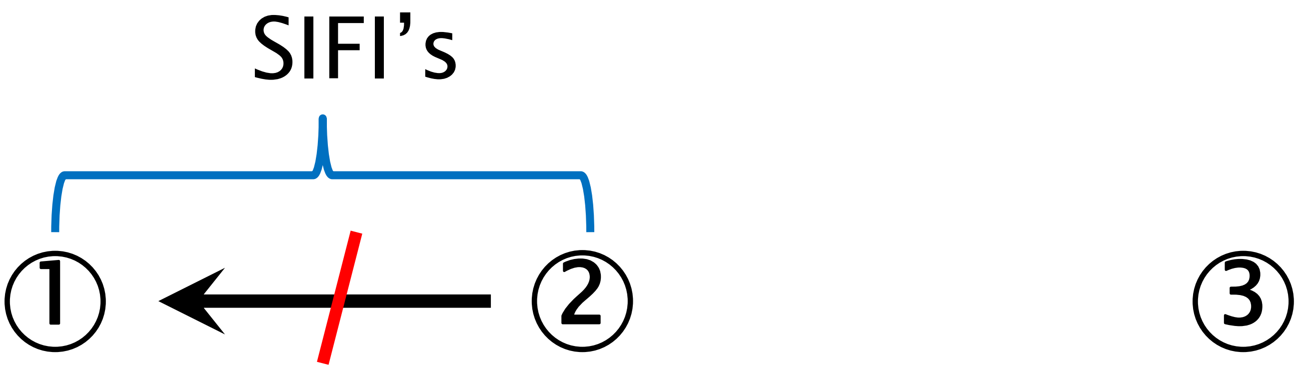
Figure: Equity recovered as a fraction of initial systemic loss



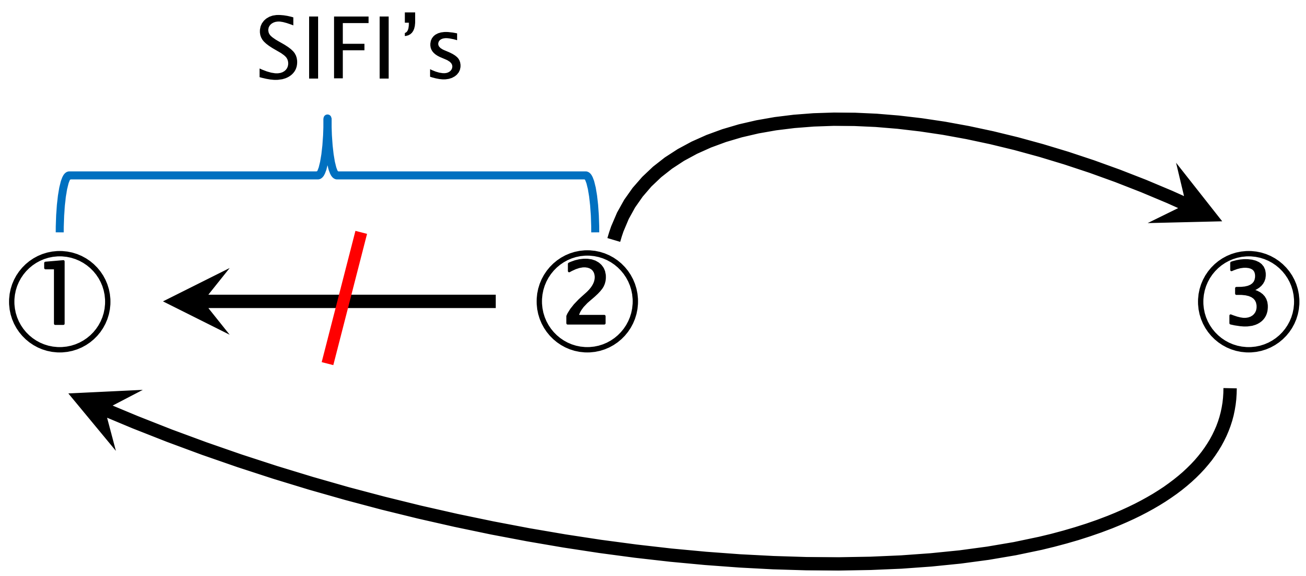
Bilateral Systemic Rule



Bilateral Systemic Rule

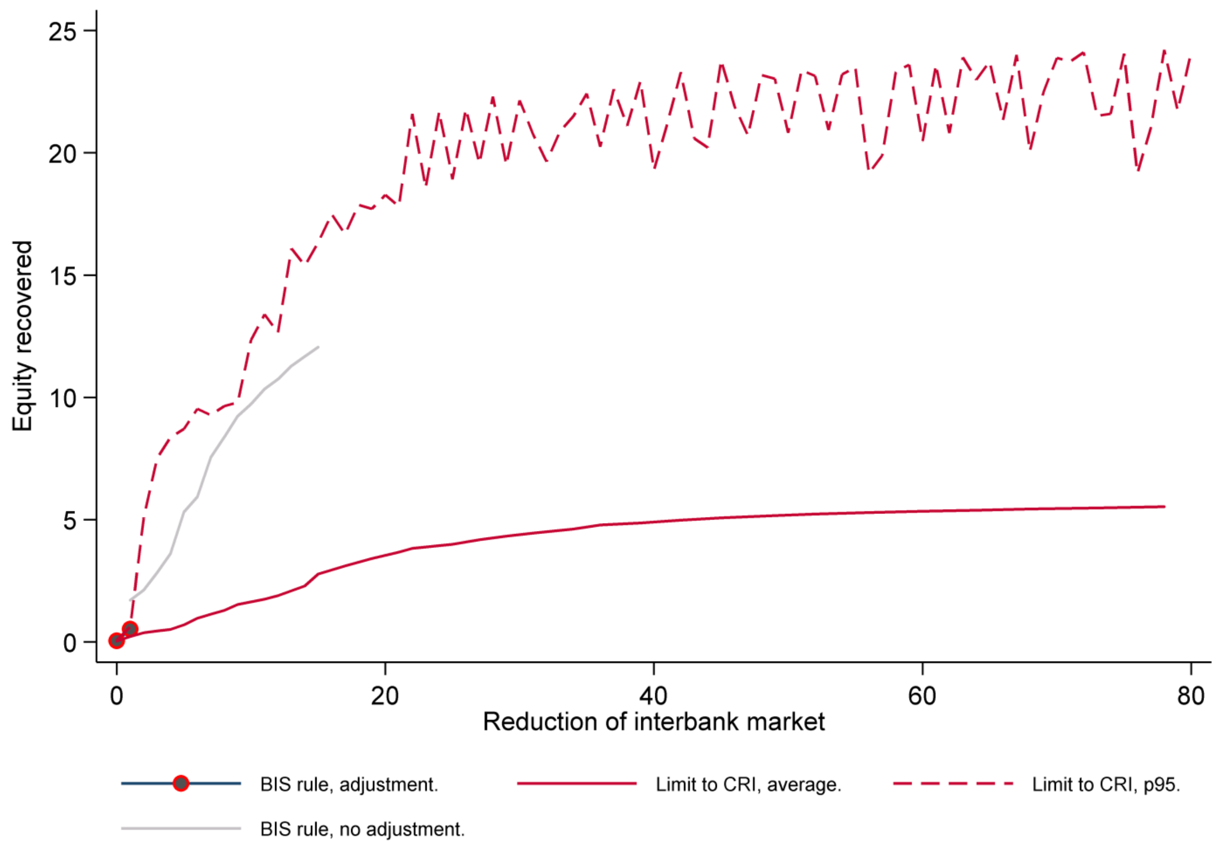


Bilateral Systemic Rule



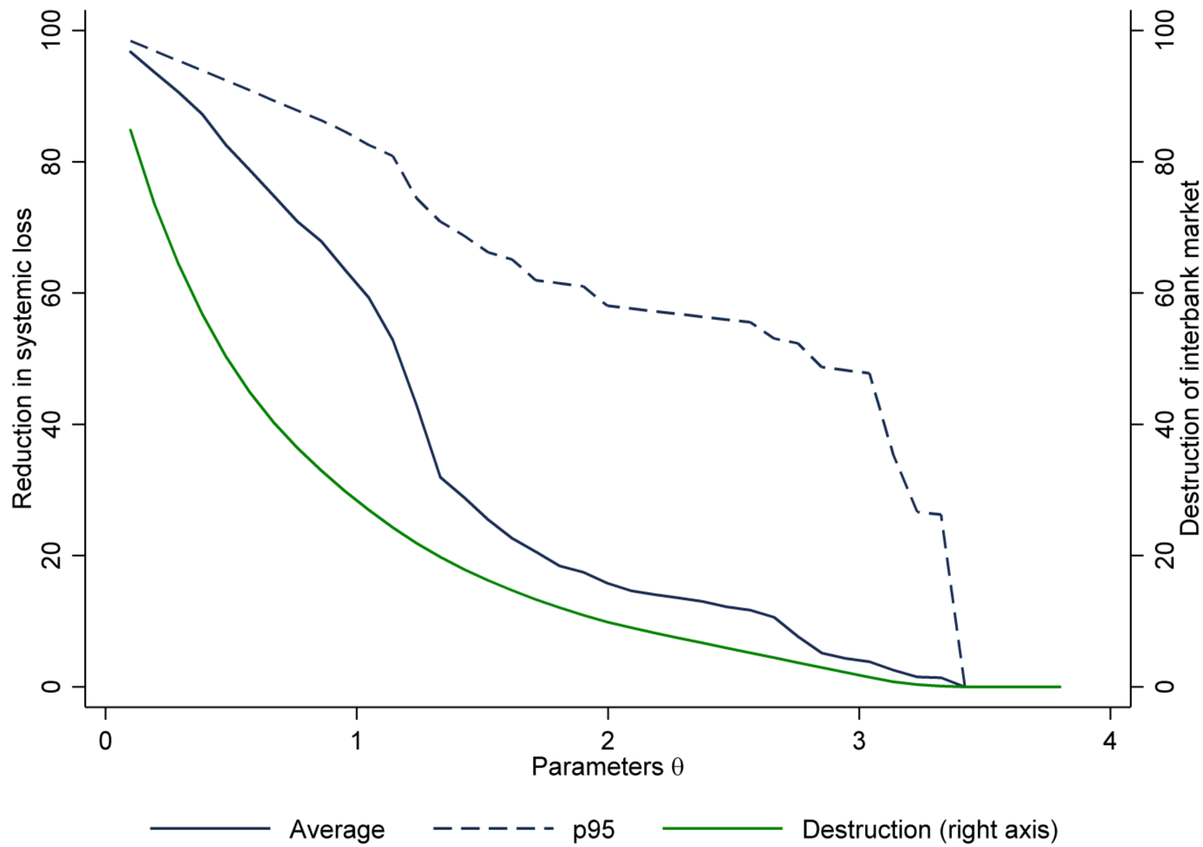
Case 2: Equity recovered is significant

Figure: Equity recovered as a fraction of total equity



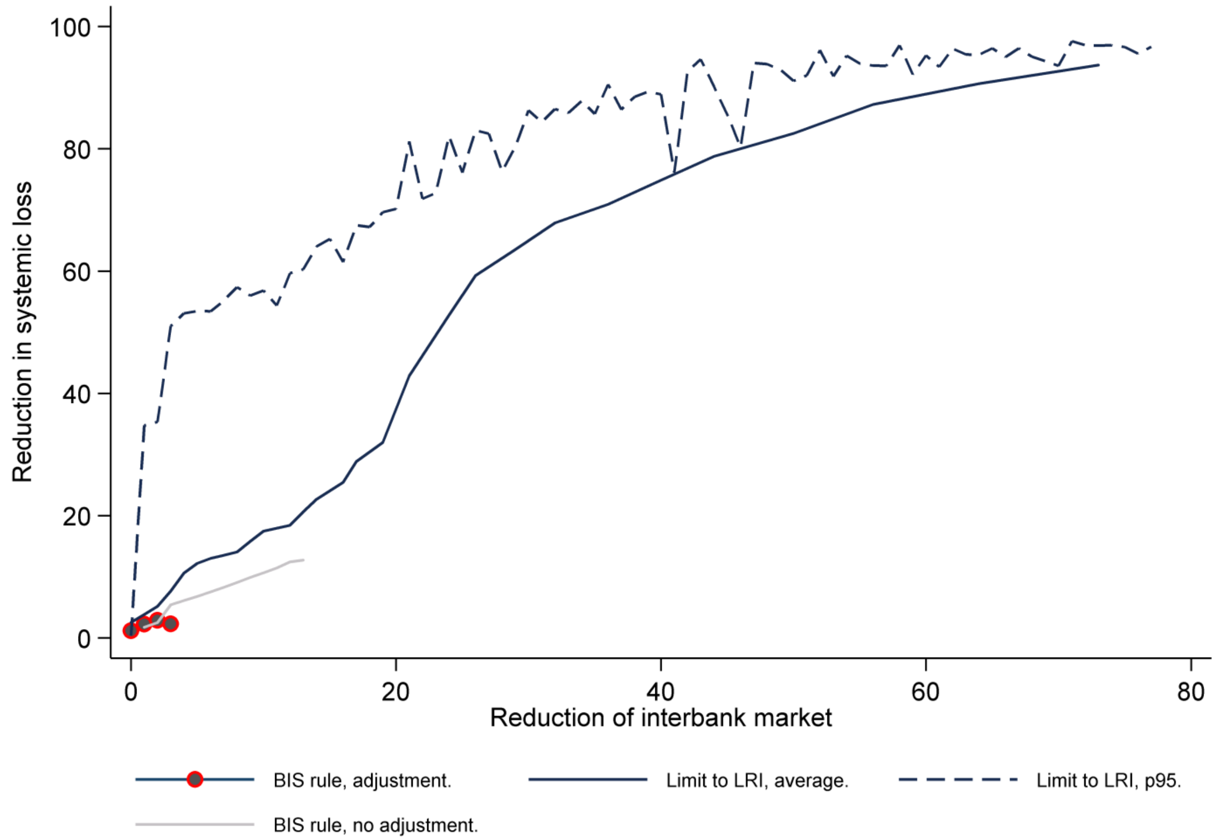
Case 3: Average effectiveness of Limit to LRI policy

Figure: Equity recovered as a fraction of initial systemic loss



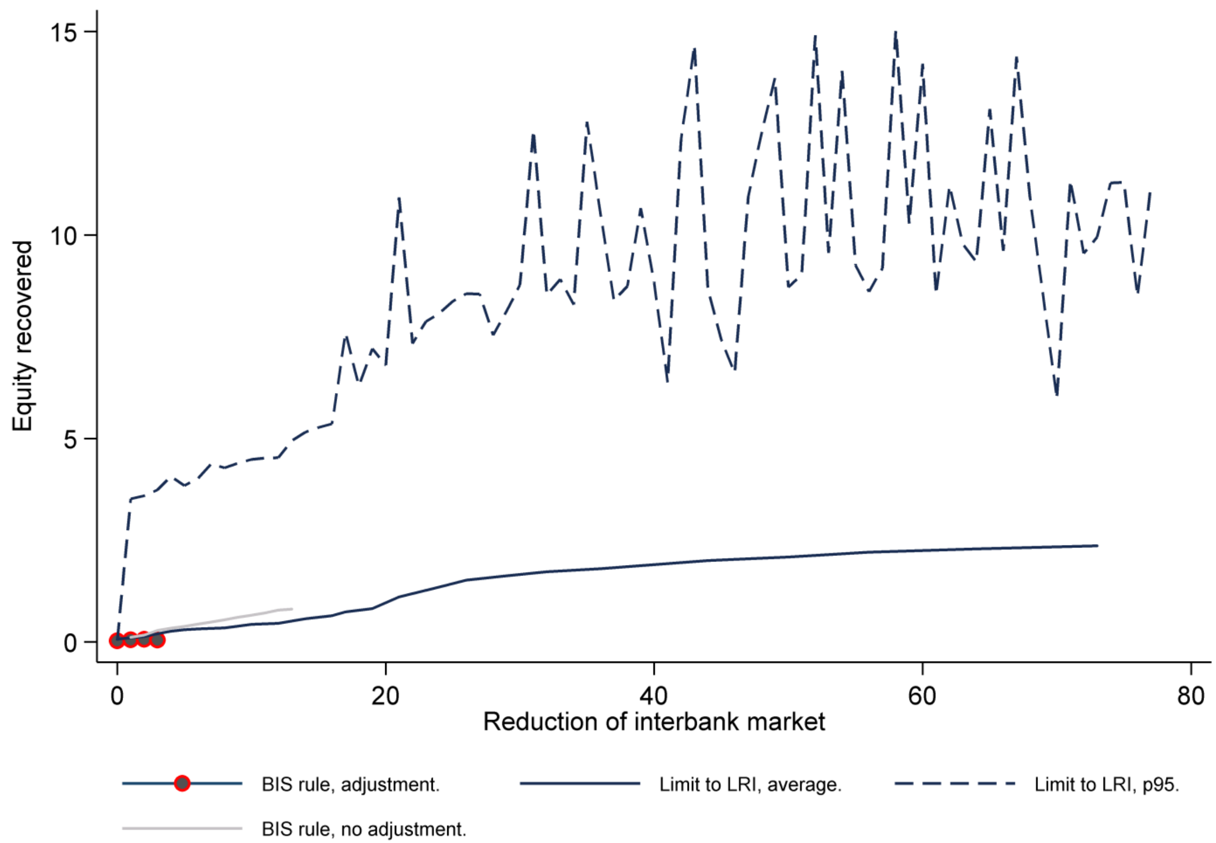
Case 3: On average, policy has to be more restrictive to attain results

Figure: Equity recovered as a fraction of initial systemic loss



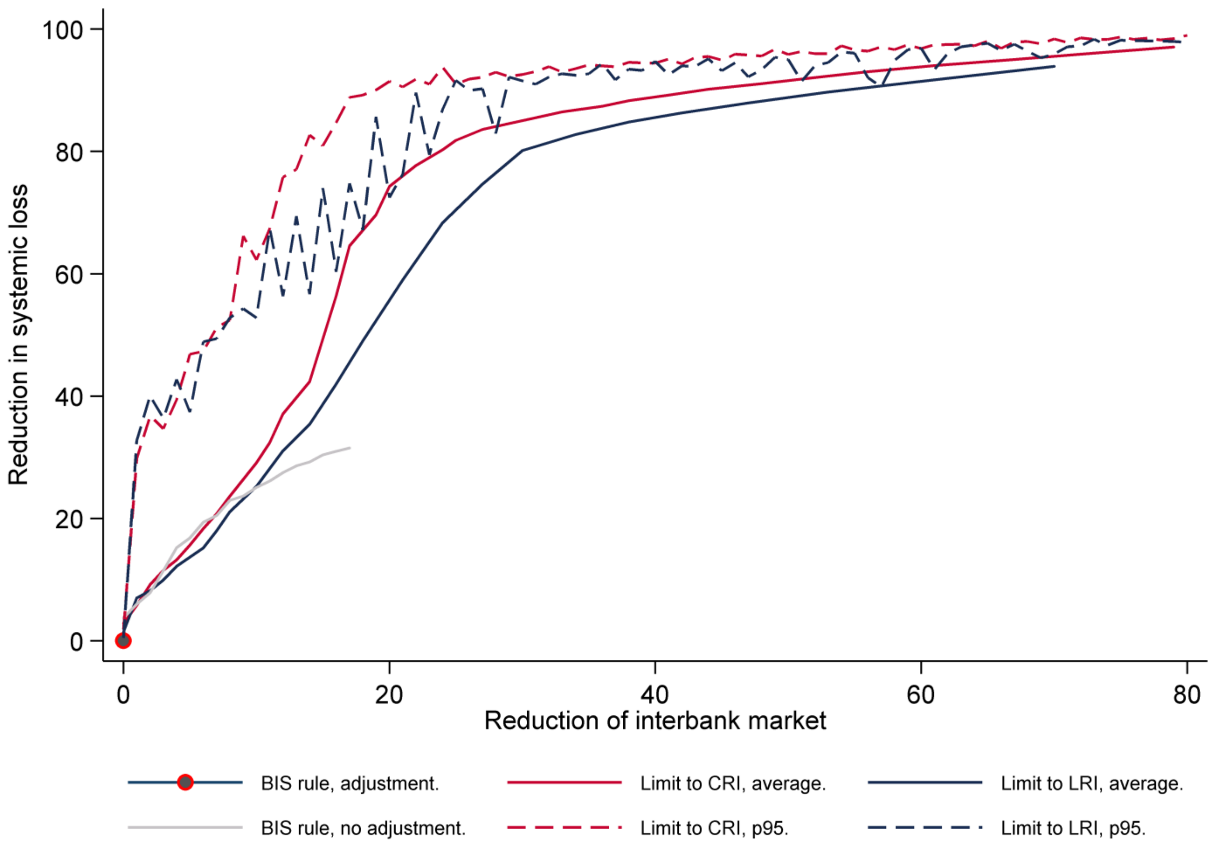
Case 3: Under the parameterizations studied, damage is lower than Case 2

Figure: Equity recovered as a fraction of total equity



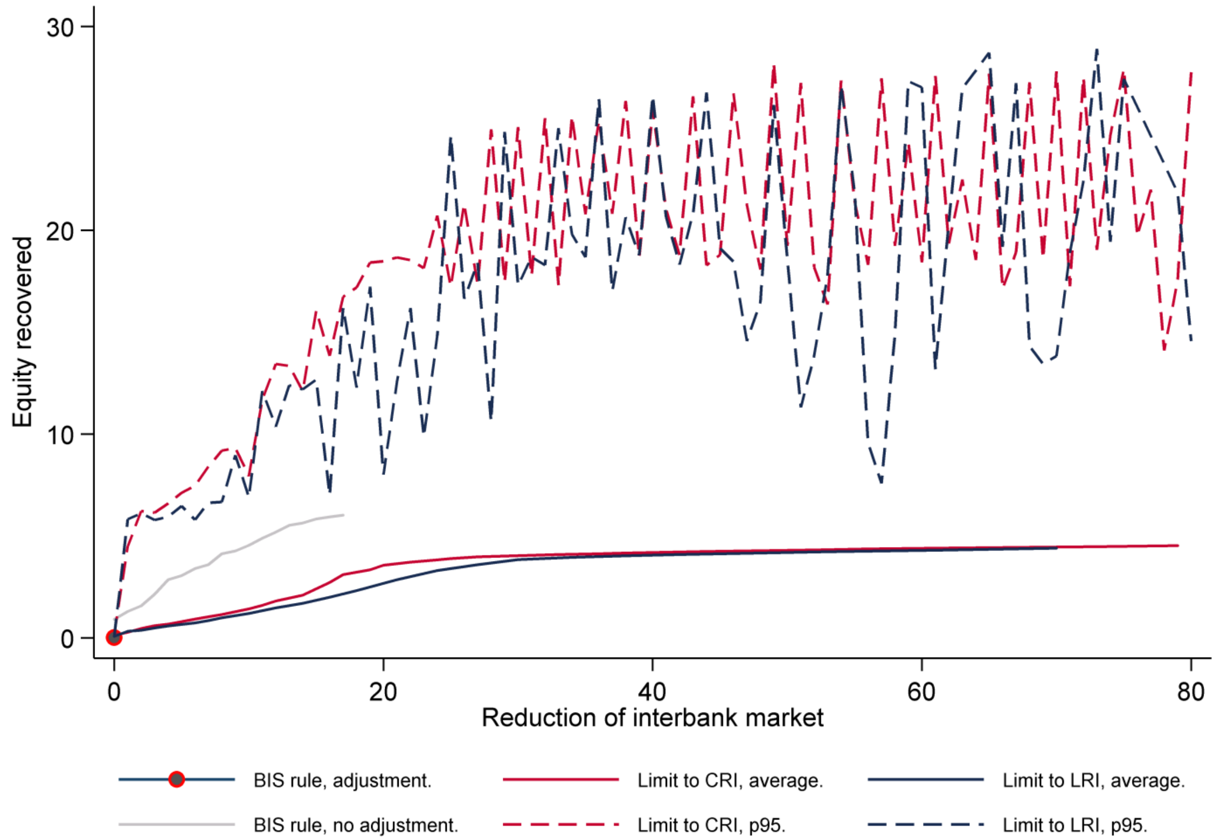
Case 1: Both limits to CRI and to LRI are relevant policies

Figure: Equity recovered as a fraction of initial systemic loss



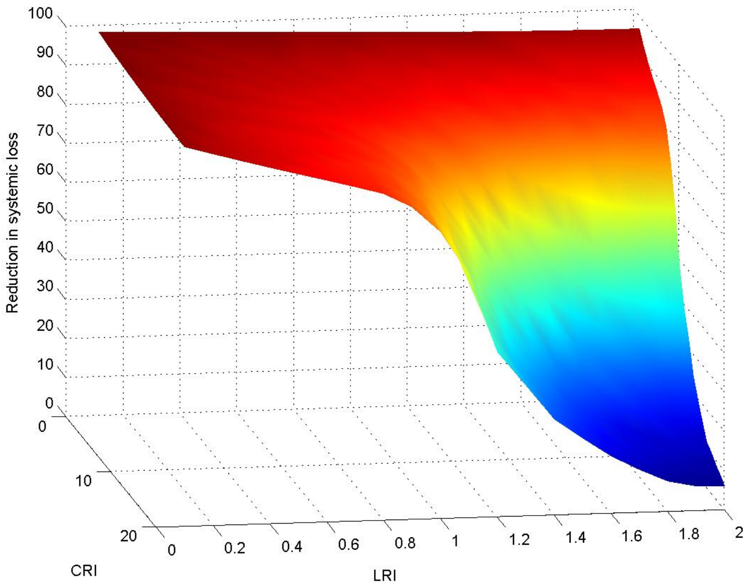
Case 1

Figure: Equity recovered as a fraction of total equity

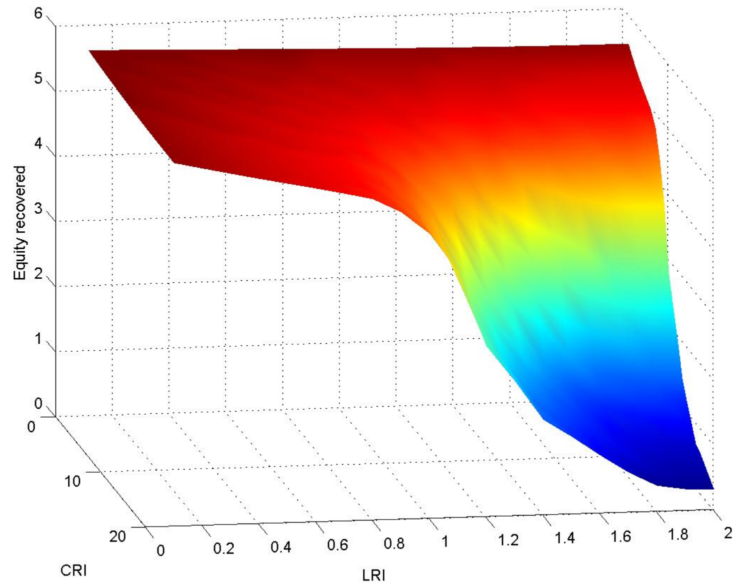


In order to determine the optimal combination of policies we need to do a grid search

Figure: Grid search systemic rules.



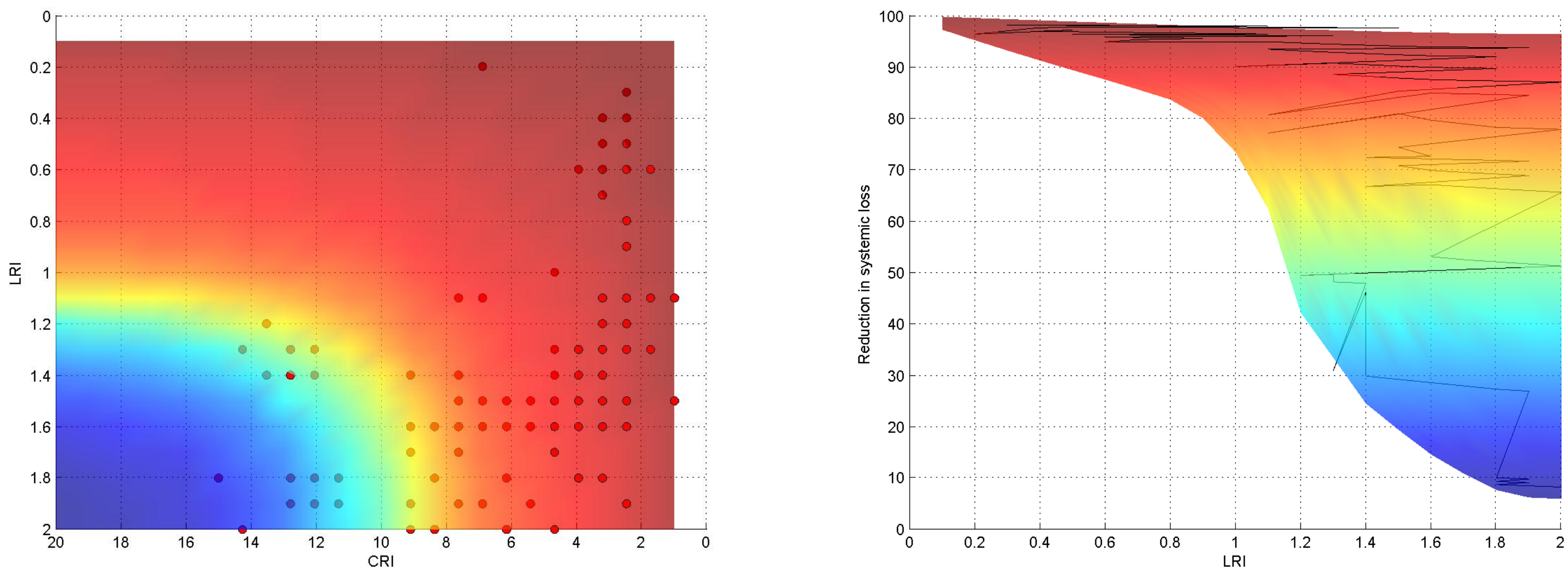
(a) Reduction of losses in equity



(b) Equity recovered

Optimal policy, for a given reduction in IB market, focuses more on limiting CRI, while LRI only at end

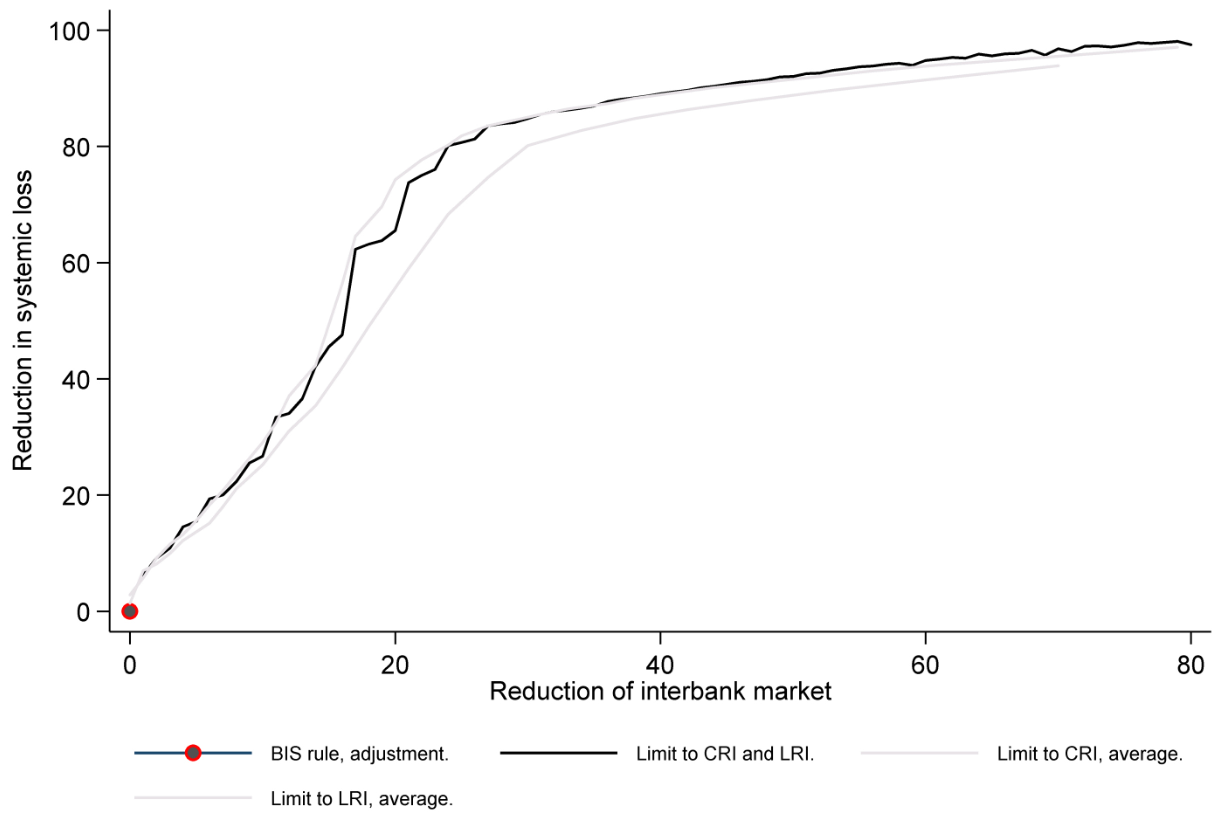
Figure: Grid search systemic rules.



(a) Alternative 1 **(b) Alternative 2**

Case 1– Optimal policy combination

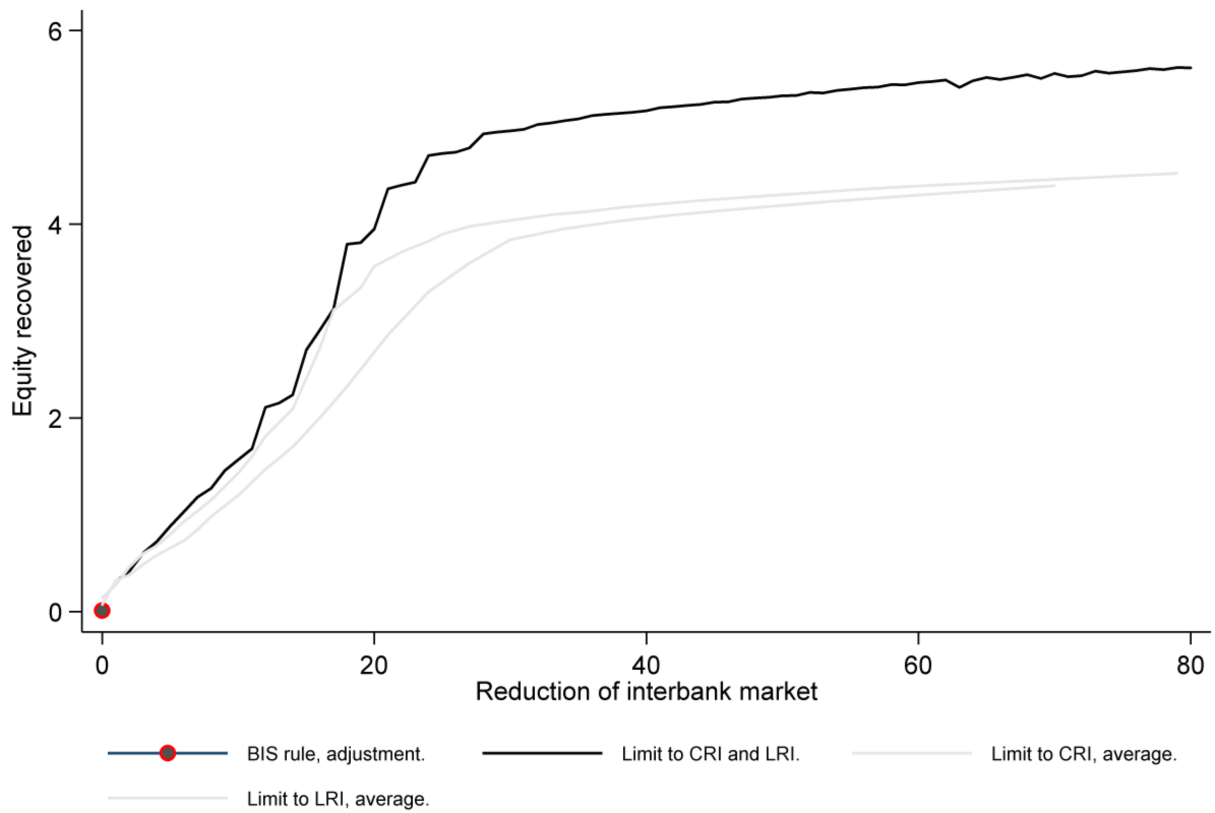
Figure: Equity recovered as a fraction of initial systemic loss



Source: authors's simulations.

Case 1

Figure: Equity recovered as a fraction of total equity



Source: authors's simulations.

6. Conclusions

Conclusions

- In order to limit systemic risk, it seems more effective to limit the overall participation of large banks in the interbank market, rather than focusing on the relations between large institutions.
- For the range of parameters described here, limit to CRI seems more effective than limits to LRI when both are relevant.
- A simulation framework can provide a rich environment for policy analysis.

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