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Systemic risk, stress testing and financial contagion: Their interaction and measurement

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Systemic Risk, Stress Testing and Financial Contagion: Their Interaction and Measurement

(Work in progress)

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Systemic risk, bank behaviour and regulation over the business cycle, 2010

Outline

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Systemic Risk
Definition

- Systemic Risk is the risk of experiencing an event that threatens the well functioning of the system of interest (payments, banking, financial).
- Systemic risk consists of two main components (Rochet 2009, Marquez & Martinez-Jaramillo 2009):
  - An initial (macroeconomic) shock, and
  - A contagion mechanism.

Stress Testing

From a financial authority point of view, the methodologies for the design of stress tests can be divided in two approaches:

- The bottom up approach and
- The top down approach.

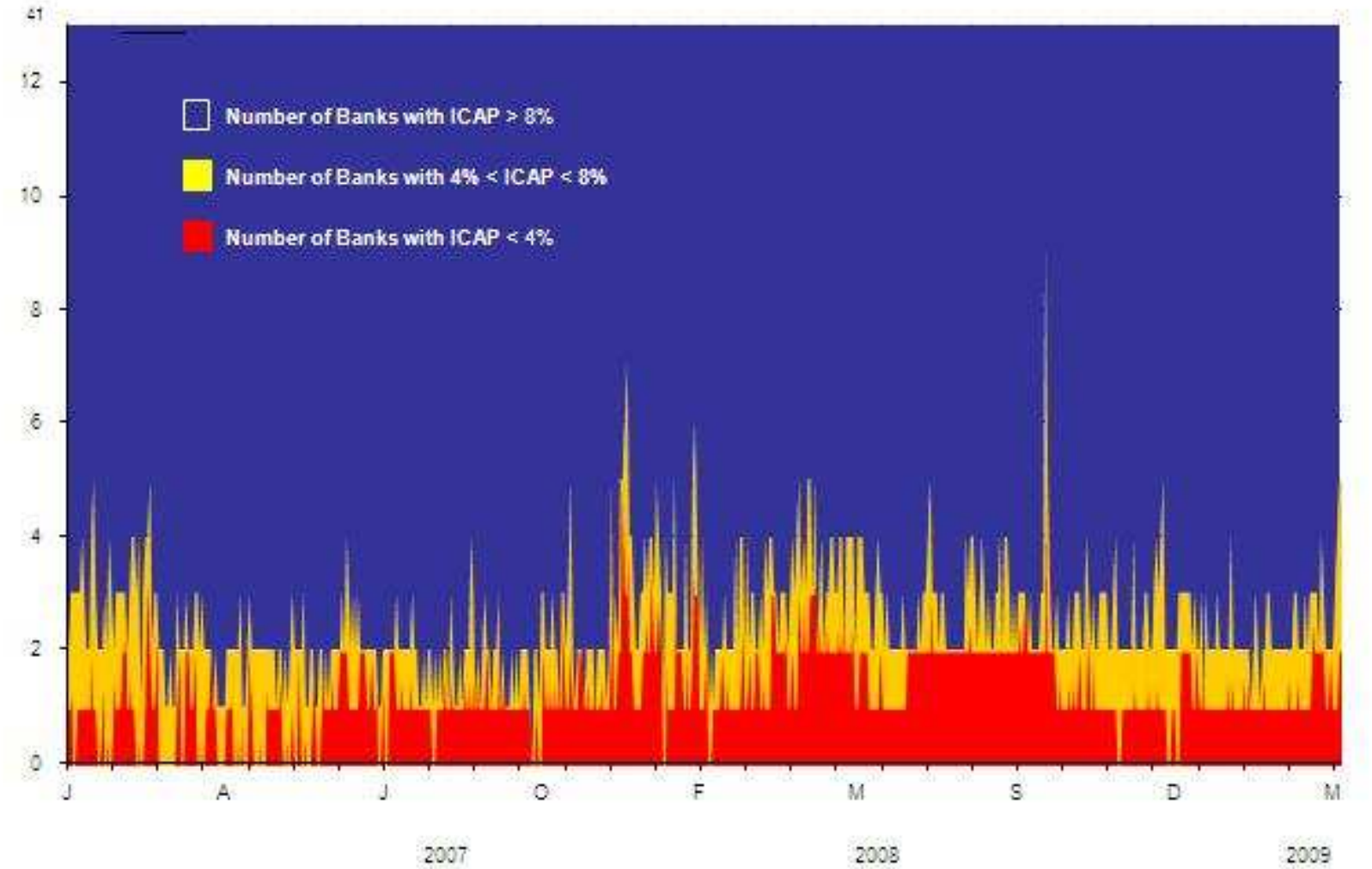
In this work we employ the bottom up approach as we posses relatively good information on the individual banks and the interbank market.

Financial Contagion

Financial contagion is one of the key elements on the definition of systemic risk; in fact, both terms were used in an interchangeable way in the past.
It is necessary to distinguish between two different types of contagion:

- Direct contagion has been studied widely by several central banks.
- Indirect contagion is difficult to estimate due to the inherent information problems.

Financial Contagion in the Mexican Banking System



Outline

Financial Contagion.

- Direct contagion in banking systems through the interbank market has been widely studied by central banks in several countries, Upper(2007).
  - Maximum entropy assumption.
  - Individual idiosyncratic failures.
- More recently contagion and systemic risk have been studied recurring to Network Theory, Muller (2006), Nier et al (2006), Babus (2007), Mistrulli (2007), Markose et al (2009).

Stress Testing.

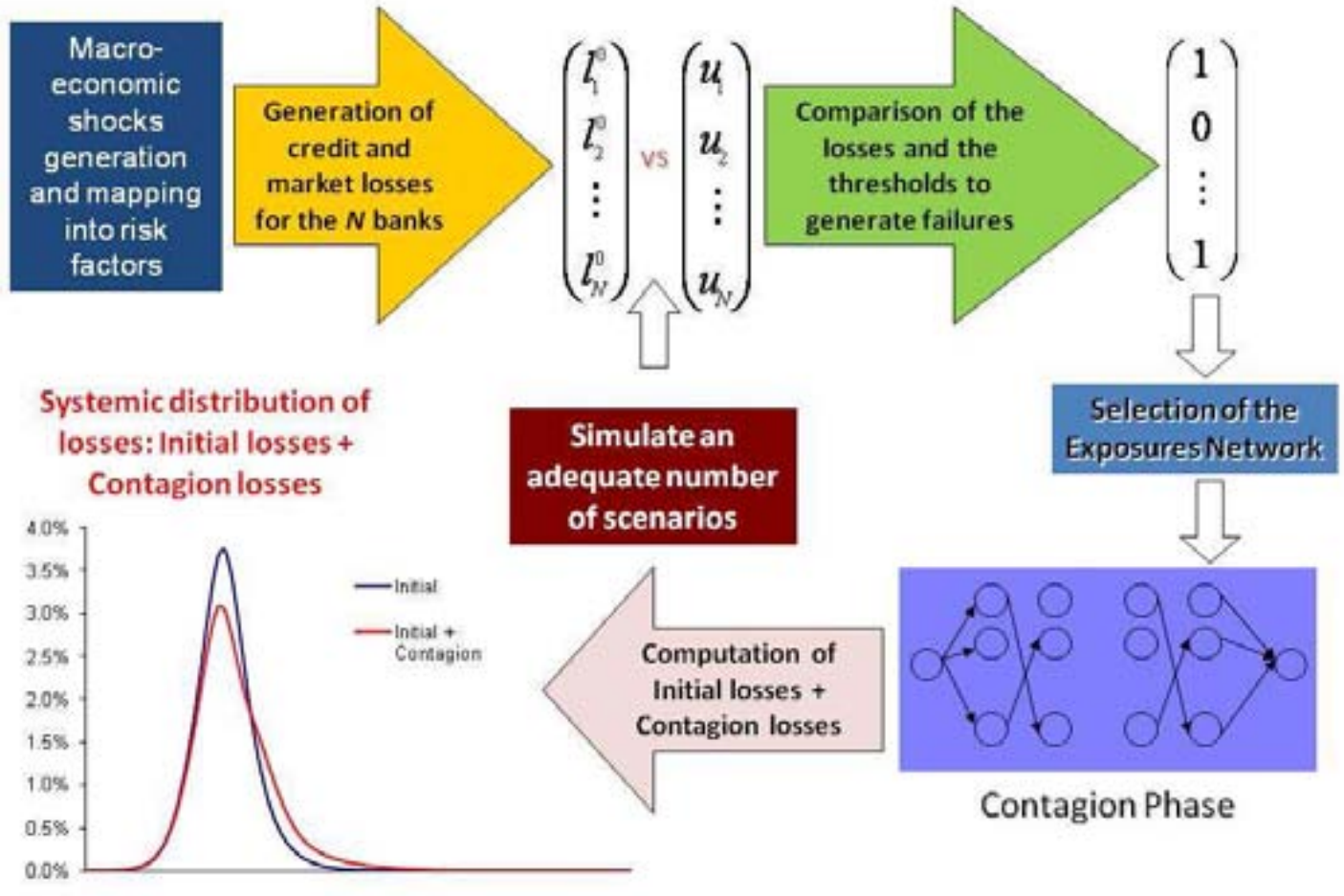
- The proposed simulation model allows for coherent system-wide stress testing including second round effects, Cihak (2007).
- The design of scenarios is a relevant aspect in stress testing; in fact, the result of the stress tests depends heavily on the design of such macroeconomic scenarios.

Systemic risk.

- Goodhart et al. (2006) propose a general equilibrium model which includes heterogeneous agents, endogenous defaults and credit and deposit markets.
- Segoviano and Goodhart (2009) infer the multivariate density, which they use to derive relevant measures of distress for individual banks, groups of banks and the distress on the system due to an individual bank.
- Boss et al. (2006) use a simulation model which they use to estimate the distribution of losses for the system as a whole.
- Aikman et al. (2009) put in place a complex simulation model to study financial stability.

Outline

Graphical Representation.



Data

The data used to obtain the systemic distribution of losses for the Mexican banking system consists of:

- The daily interbank exposures,
- The macro economic information used to build the macro models (GDP, interest rates, stock indexes, etc),
- The market portfolio and
- Credit delinquency ratio as a proxy for the evolution of credit losses.
- The Tier 1 capital.

The Link to the Economic Variables.

- Previous versions of this work, Marquez & Martinez-Jaramillo (2009), computed the joint distribution of losses from market and credit operations, and this distribution was used to generate “losses draws” and to determine whether those losses trigger a contagion process.
- Despite the advantages of this method, behind each shock was the idea that “something happened” but there was few to say about what that “something” was.
- Hence, to gain in the interpretation and to ease the stress testing procedure one of the aims is having scenarios with an economic interpretation.

The Link to the Economic Variables II.

- To generate these scenarios linked to real economic variables within a consistent framework, a simple structural VAR was estimated:

$$Y_t = \sum_{i=1}^{p} A_i Y_{t-i} + \sum_{m=1}^{12} \delta_m D_{mt} + e_t. \quad (1)$$

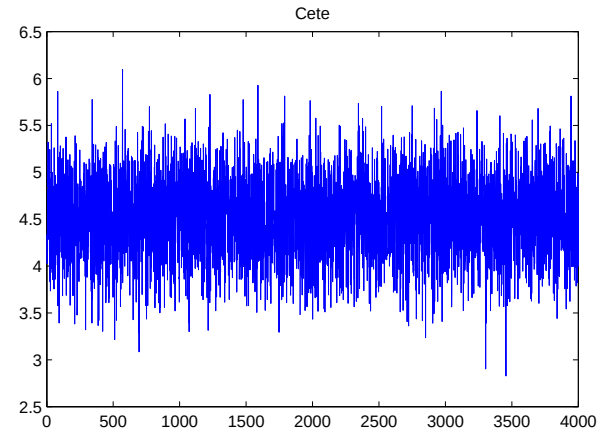
- The variables used are: (all expressed in differences in logs) IGAE, General Economic Activity Index. (y), which is a close indicator of GDP, Cete interest rate (r^c), the consumer price index (π), exchange rate (e), the Mexican stock exchange index (ipc), the delinquency rate in bank loans (DR), treasury bill interest rate (r^{tb}), libor interest rate (r^L), the Dow Jones stock index (DJ), and the Brazilian stock index Bovespa.

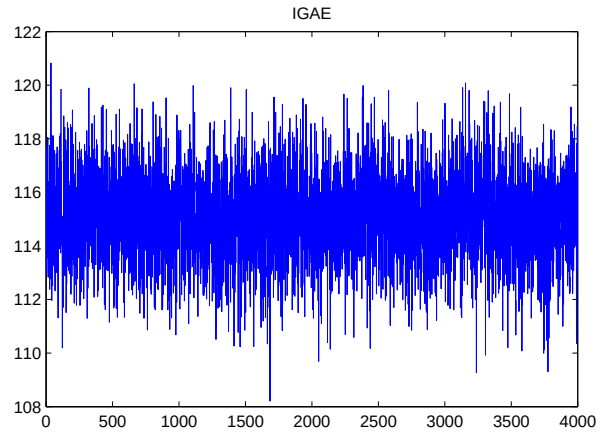
The Link to the Economic Variables III.

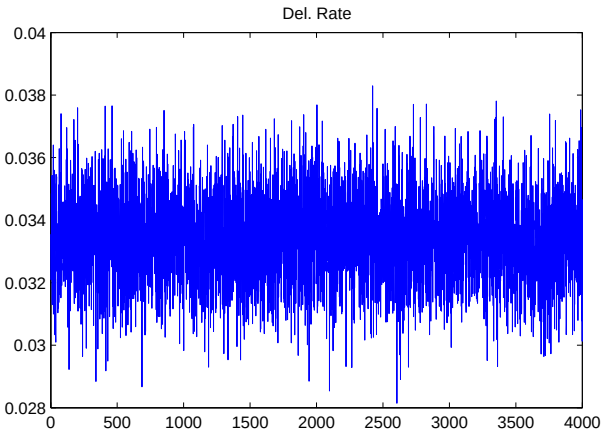
- The precise dependence structure is described in the following list:

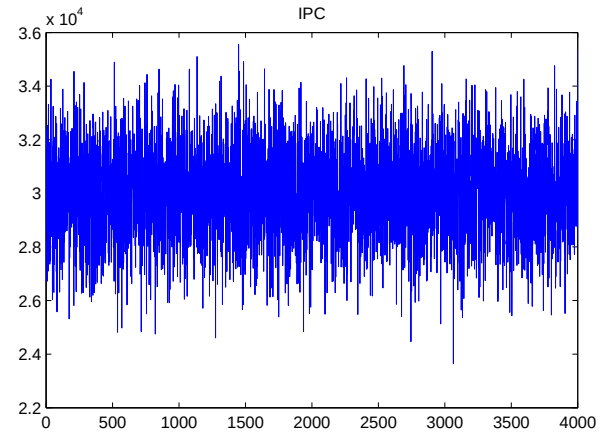
$$
\begin{aligned}
y &= y(y, r^c, \pi, e, DR) && (2)\\
r^c &= r^c(y, r^c, \pi, e, ipc, r^{tb}, r^L) && (3)\\
\pi &= \pi(y, r^c, \pi, e) && (4)\\
e &= e(y, r^c, \pi, e, ipc, DR, r^{tb}, r^L, DJ) && (5)\\
ipc &= ipc(y, r^c, \pi, e, ipc, DR, r^{tb}, r^L, DJ, bov) && (6)\\
DR &= DR(y, r^c, \pi, e, DR) && (7)\\
r^{tb} &= r^{tb}(r^{tb}, r^L, DJ) && (8)\\
r^L &= r^L(r^{tb}, r^L) && (9)\\
DJ &= DJ(r^{tb}, r^L, DJ) && (10)\\
bov = &= bov(DJ, bov). && (11)
\end{aligned}
$$

Scenarios Generated under the Normal Distribution.



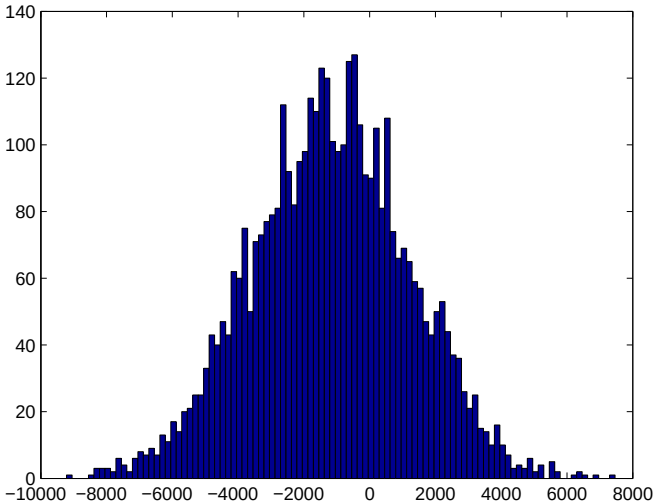




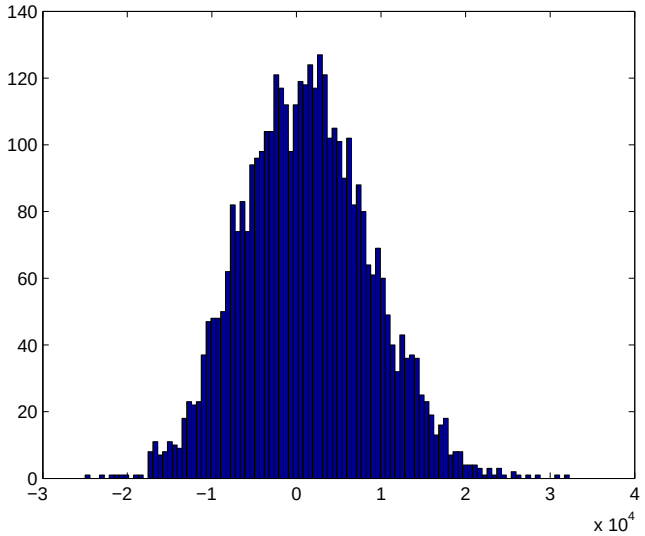


Outline

Market and Credit Distributions.



(a)



(b)

Figure: The systemic distribution of credit (a) and market (b) losses.

Joint Distribution.

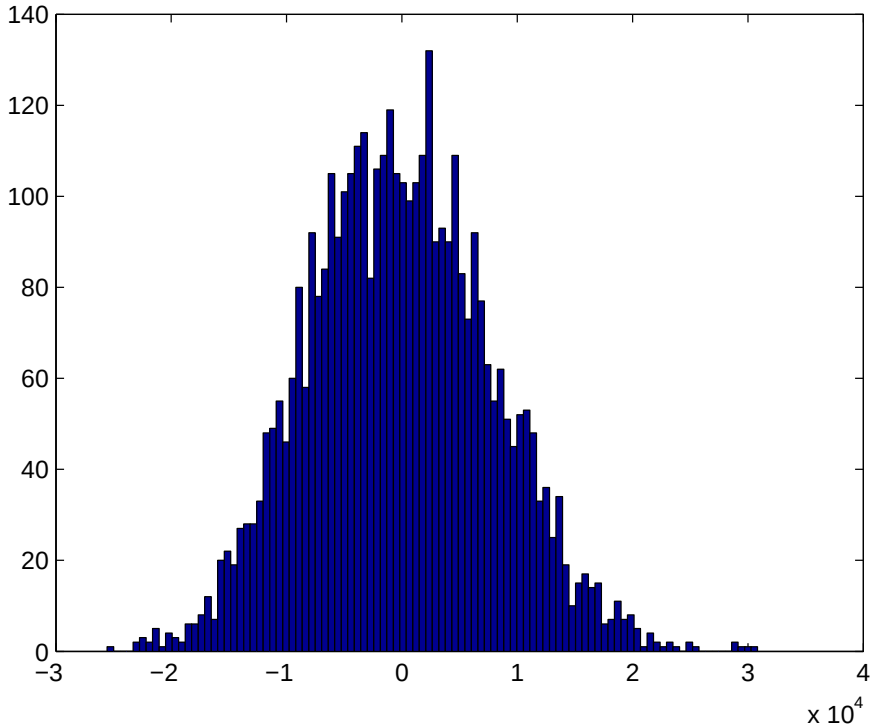


Figure: The systemic distribution of losses for the Mexican banking system.

Systemic Relevance of an Institution.

There are recent attempts to measure the systemic relevance of a financial institution. For example:

- Based on the Shapley value (Borio et al 2009).
- Based on several measures like size, interconnectedness, lack of substitutability (BIS, FSB and IMF)
- Based on the CoVaR(Adrian et al 2009)

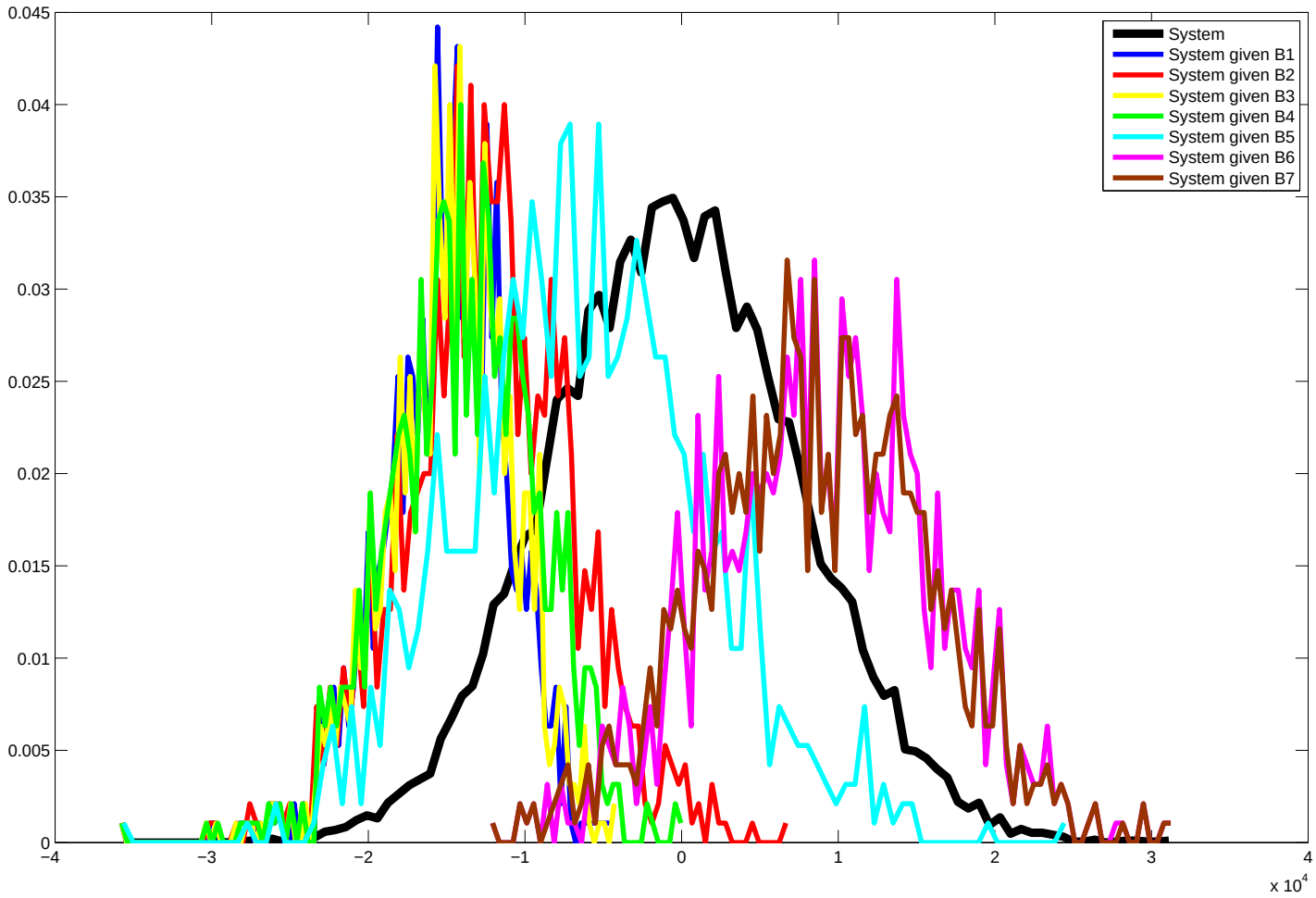
CoVaR definition(Adrian et al 2009).

Institution i's CoVaR relative to an institution j (the system) is defined as the VaR of the institution j (or the whole financial sector) conditional on institution i being in distress.

$$Pr(X^j \leq CoVaR_q^{j|i} \mid X^i = VaR_q^i) = q.$$

The difference between the $CoVaR$ and the unconditional financial system VaR, $\Delta CoVaR$, captures the marginal contribution of a particular institution to the overall systemic risk.

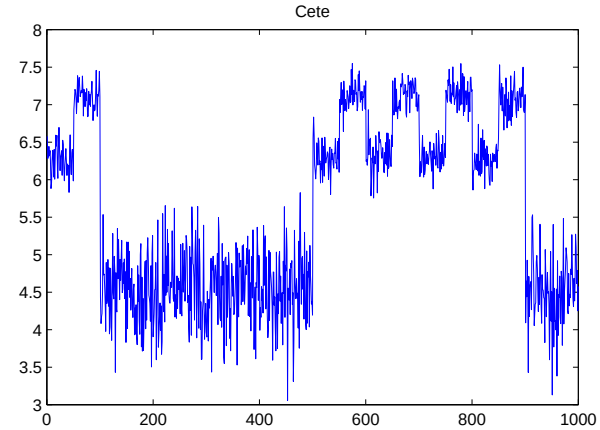
CoVaR example.

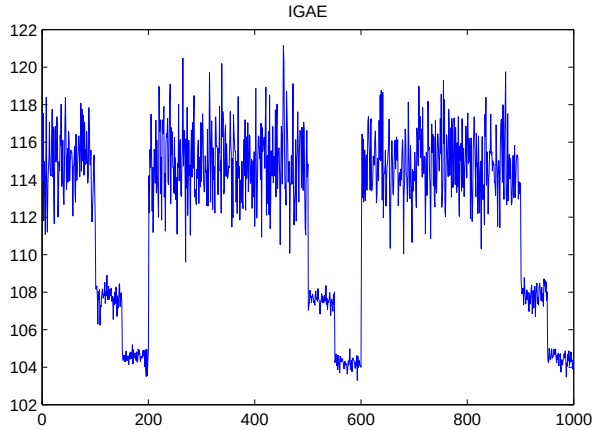


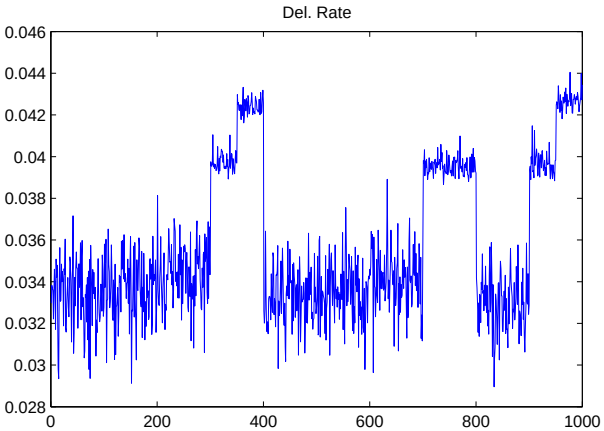
Systemic events.

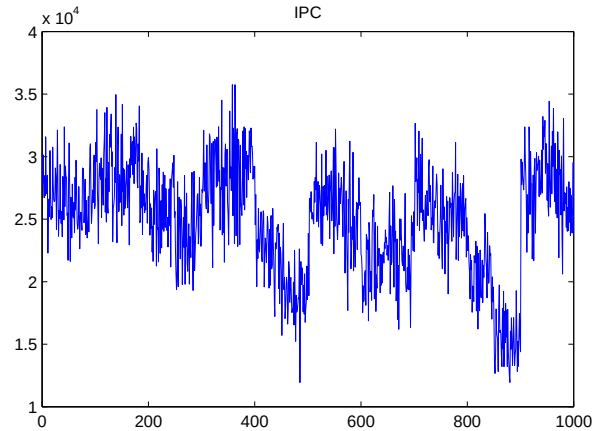
- Contagion did not happen under the previous 20k simulations.
- Contagion did happen under Montecarlo simulation (5m).
- Systemic events are located on the tail.

“Tail Scenarios”

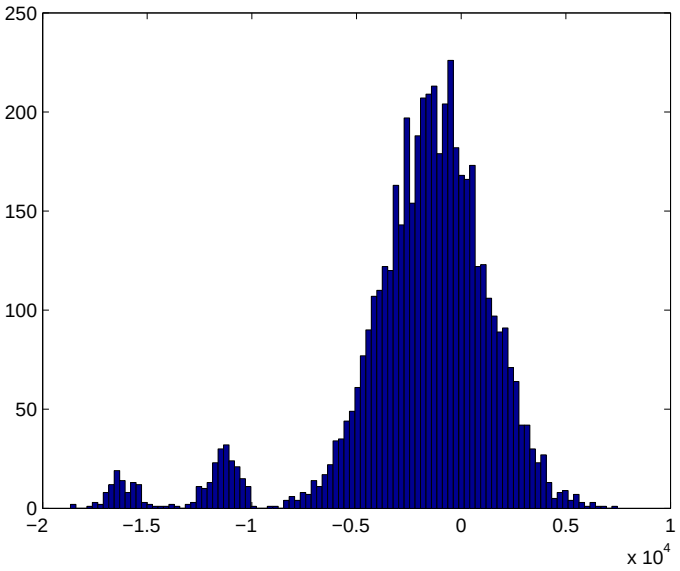




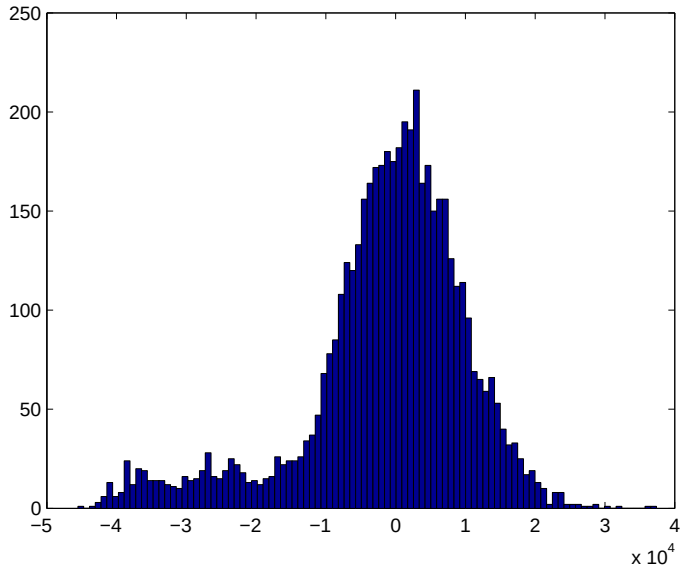




Tail Market and Credit Distributions.



(a)



(b)

Figure: The systemic distribution of credit (a) and market (b) losses 5000 scenarios including 1000 biased scenarios on the tail.

Joint Tail Distribution.

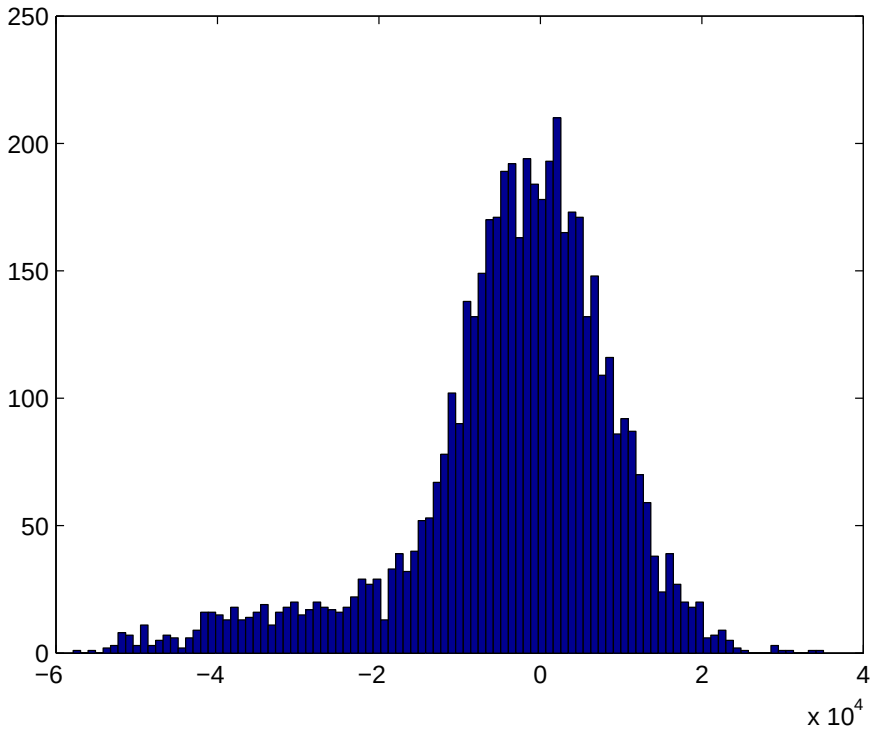
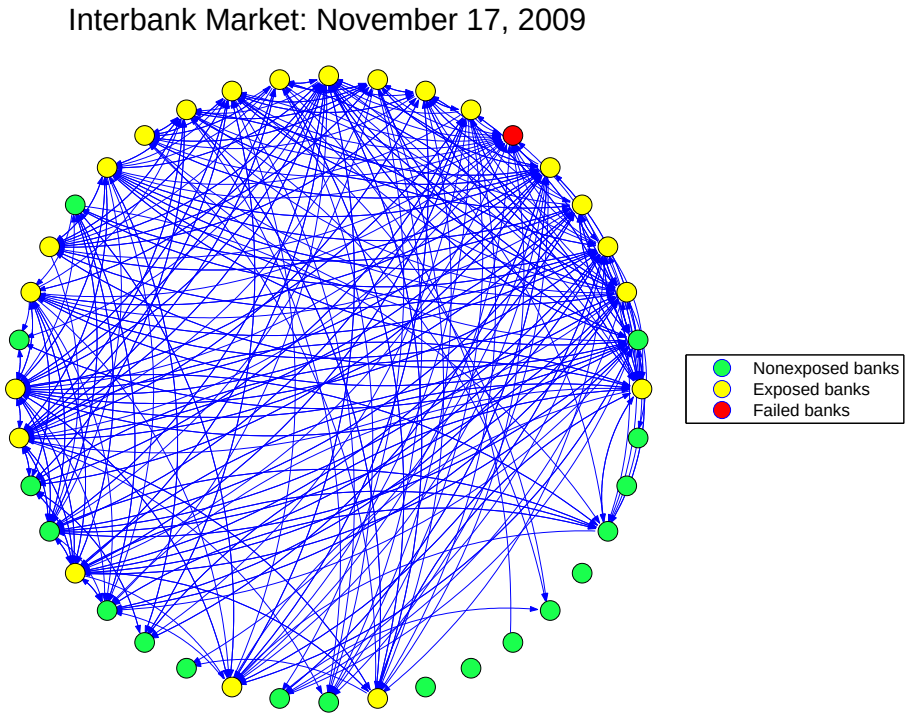


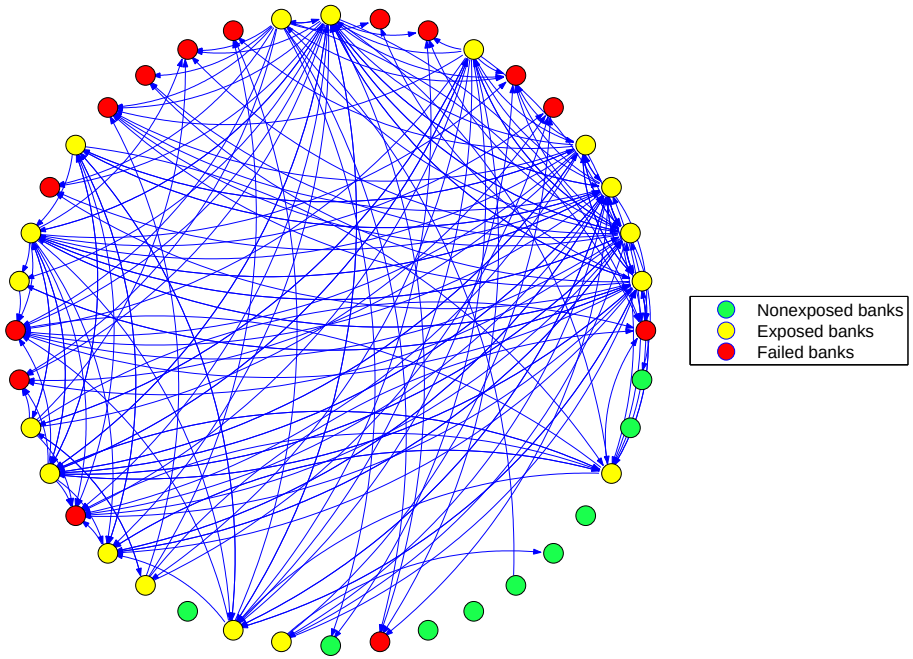
Figure: The systemic distribution of losses for the Mexican banking system 5000 scenarios including 1000 biased scenarios.

Contagion I.

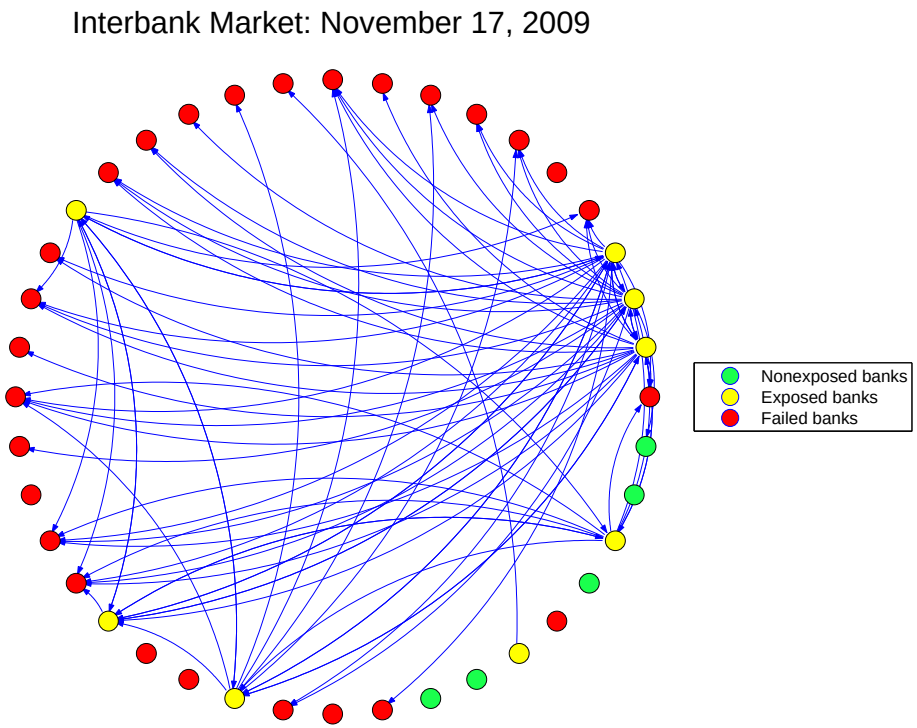

Interbank Market: November 17, 2009
Nonexposed banks
Exposed banks
Failed banks

Contagion II.

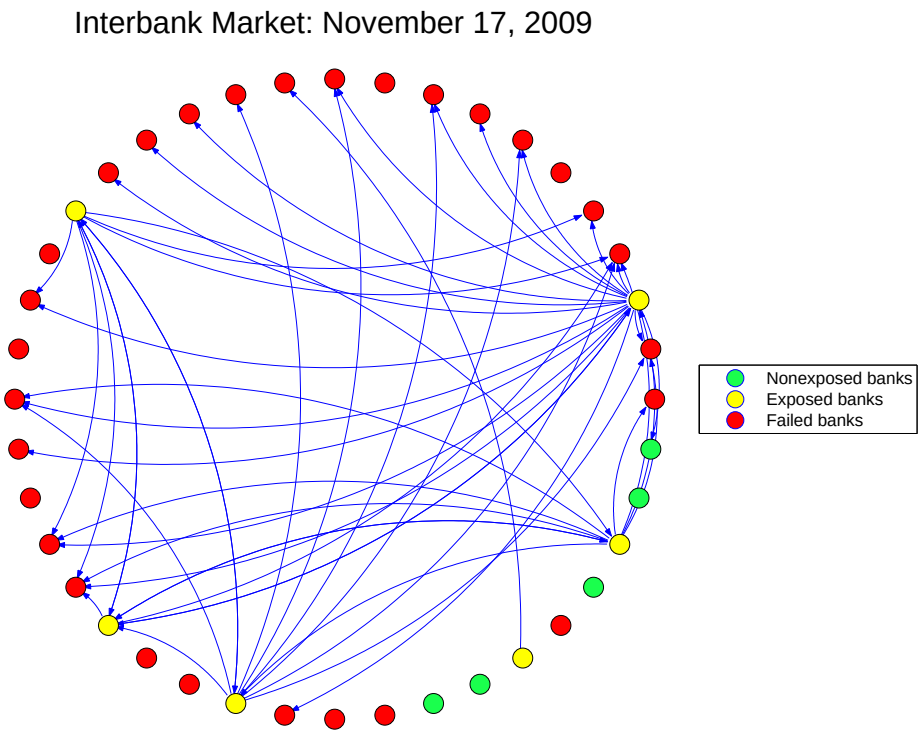
Interbank Market: November 17, 2009



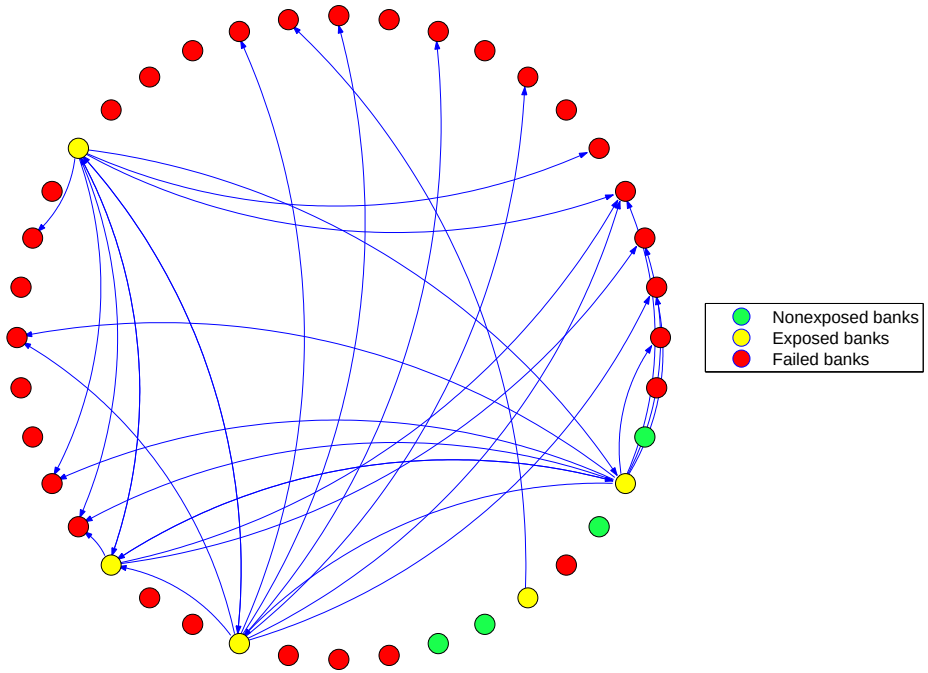
Contagion III.



Contagion IV.



Contagion V.


Interbank Market: November 17, 2009
Nonexposed banks
Exposed banks
Failed banks

Summary

- The literature adhered to the belief that the topology of the network was enough to characterize the systemic riskiness of a particular financial system.
- The relevance of the initial macroeconomic shock should not be disregarded.
- Finally, to concentrate on size and interconnectedness to determine the systemic importance of institutions could be misleading.

- Future work:
  - The issue here is how to deal with the implicit trade-off: a more accurate credit risk measurement requires a sacrifice in the market risk measurement accuracy and viceversa.
  - Using a distribution with heavier tails is an alternative worth exploring that wouldn't require a change of paradigm.

Thanks

Thank you!

Questions

Questions.