# Financial Contagion

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EPGE

Abril, 16, 2024

# Summary

# What is Financial Contagion

- Allen and Gale (2000) "Financial Contagion" .
- What is it? Equilibrium Phenomena where the spread of a negative shock on a bank goes through the sector.
- What drives this phenomena? Bank's assets and liabilities, the cross-claims.

# Trade-off banks face

- Cabrales, Gottardi, Vega-Redondo (2017) "Risk Sharing and Contagion in Networks".
- There is a trade-off between the risk expousure and the risk sharing among the network.
- How the shock propagates through the network and who is affected?

# References

- Upper(2007): Using counterfactual simulations to assess the danger of contagion in interbank markets . (Essential framework model).
- Nier(2008): Network models and financial stability.
- Gai(2010): Contagion in financial networks. (Simulation Methodology).
- Ugwu(2024): Contagion on Financial Network. (Usage of the Erdos-Rényi Model for simulation).

# Erdos–Rényi model

- Directed, independently and randomly assigned links.
- The network is directed, weighted and randomly generated. The incoming and outgoing links denote the realisation of the given probabilities.

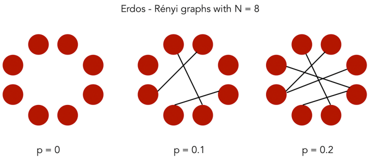


Figure: Erdos Graph

# Model

- There are three types of banks T={S,M,B}.
- Each type of company has an average probability of transmitting a shock to another firm given by $p_{t->t'}$.
- Therefore the average probabilities are given by the following matrix:

$$P = \begin{bmatrix} p_{S->S} & p_{S->M} & p_{S->B} \\ p_{M->S} & p_{M->M} & p_{M->B} \\ p_{B->S} & p_{B->M} & p_{B->B} \end{bmatrix}$$

# Model

- N is the total amount of banks.
- $\alpha_t$ gives the fraction of the banking population of type t.
- The probability that a bank of type t propagates the shock to a bank of type t' is given by a normal distribution $\pi \sim \mathcal{N}(p_{t->t'}, \sigma^2_{t->t'})$.
- Therefore, each row of the adjacency matrix is given by a Bernoulli Distribution with $p = max\{min\{\pi, 1\}, 0\}$.

# Numerical Exercises

- For $N = 100$, $\alpha_B = 2\%$, $\alpha_B = 28\%$ and $\alpha_S = 70\%$.
- We set the average probabilities and the standart deviations as follow:

$$P = \begin{bmatrix} \frac{1}{1000} & \frac{2.5}{10000} & \frac{1.25}{10000} \\ \frac{2}{100} & \frac{1.5}{100} & \frac{1}{100} \\ \frac{8}{100} & \frac{5}{100} & \frac{4}{100} \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} \frac{1}{1000} & \frac{1}{1000} & \frac{1}{1000} \\ \frac{1}{100} & \frac{1}{100} & \frac{1}{100} \\ \frac{1}{100} & \frac{1}{100} & \frac{1}{100} \end{bmatrix}$$

# Numerical Exercises

- With thoose values, we ran 1000 simulations and report the following metrics.

| Inicial Bank Size | Percentage of Contagion |
|---|---|
| Small | 40% |
| Medium | 55% |
| Big | 66% |

# Numerical Exercises

- For $N = 1000$,$\alpha_B = 20\%$, $\alpha_B = 30\%$ and $\alpha_S = 50\%$.
- We set the average probabilities and the standart deviations as follow from the following simulations:

$$P = \begin{bmatrix} \frac{7}{100000} & \frac{8}{100000} & \frac{9}{100000} \\ \frac{7}{10000} & \frac{8}{10000} & \frac{7}{10000} \\ \frac{9}{1000} & \frac{8}{1000} & \frac{7}{1000} \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} \frac{1}{10000} & \frac{1}{10000} & \frac{1}{10000} \\ \frac{1}{10000} & \frac{1}{10000} & \frac{1}{10000} \\ \frac{1}{10000} & \frac{1}{10000} & \frac{1}{10000} \end{bmatrix}$$

# Numerical Exercises

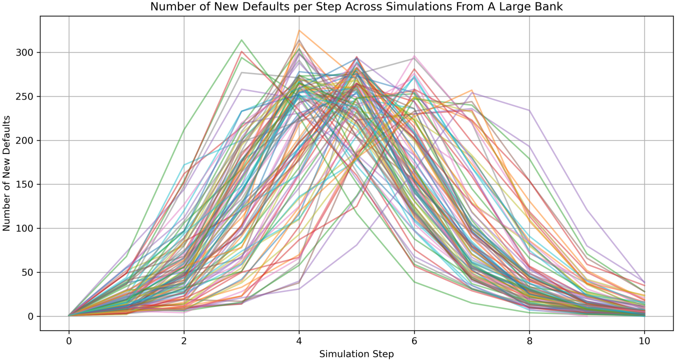


Figure: Large Bank Simulation

# Numerical Exercises

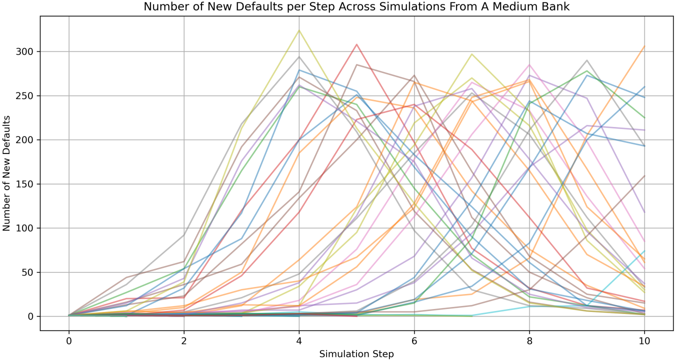


Figure: Medium Bank Simulation

# Numerical Exercises

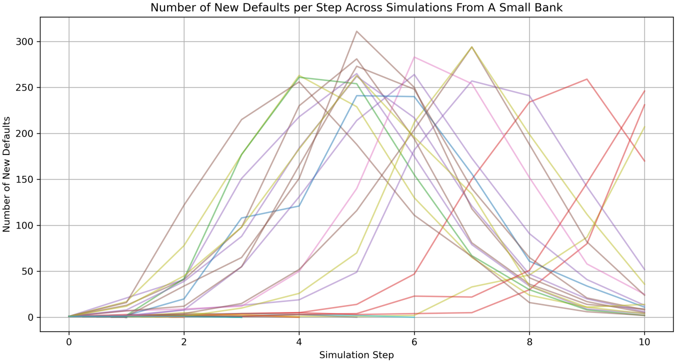


Figure: Small Bank Simulation

# Empirical Strategy

Upper(2008) Model:

- A bank $i$ fails by assumption.
- Any bank $j$ fails if its exposure versus $i$, $x_{ji}$, multiplied by an exogenously given parameter for loss-given-default (LGD), exceeds its capital $c_j$.
- A second round of contagion occurs if there is a bank $k$ for whom $LGD(x_{ki} + x_{kj}) > c_k$. Contagion stops if no additional banks go bankrupt. Otherwise a third round of contagion takes place.

# Major Problem

- Lack of publicly available data at individual bank level.
- Brazilian Central Bank has it available at the credit registry.
- Solution: OFR Contagion Index.

# Solution

- Using real data from Bank Systemic Risk Monitor.
- Utilises International Banks and gives their systemic risk on 2023
- Metrics:
  - G-SIBs: size, interconnectedness, substitutability, complexity, and cross-jurisdictional activity
  - OFR Contagion Index: Connectivity X Net Worth X Outside Leverage
- We use OFR to build our probability matrix as $P_{ij} = \frac{OFR_i}{\sum_{j=1}^{35}(OFR_j)}$
- Probability is a measure strictly increasing in the index.
- A more realistic approach would be $P_{ij} = F(OFR)$, i.e., a more complex construct not just the relative OFR Index

# Solution

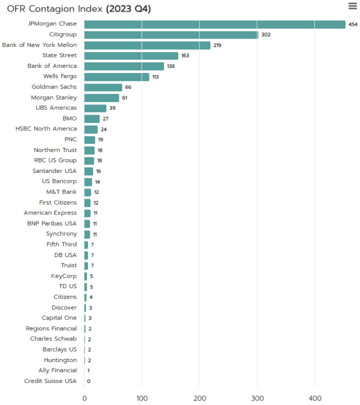


Figure: OFR Contagion Index

# Solution

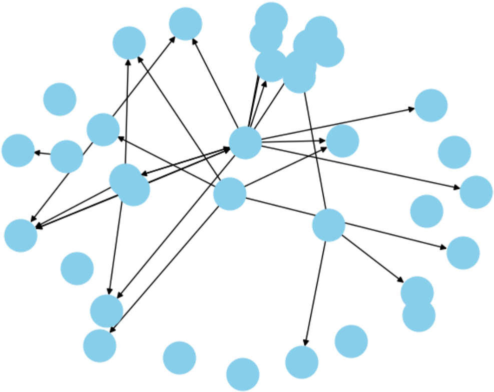

Figure: Possible Spread from the Empirical Network

# Solution

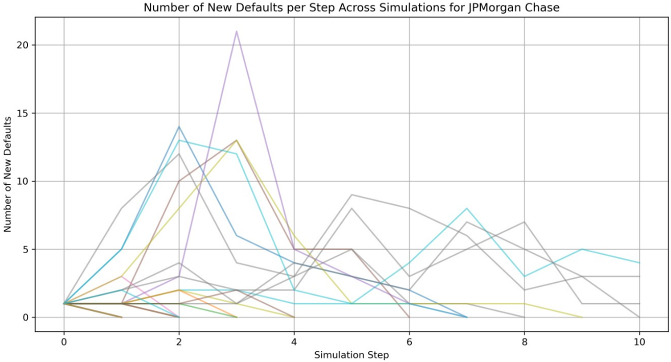


Figure: Simulation for JPMorgan Chase

# Solution

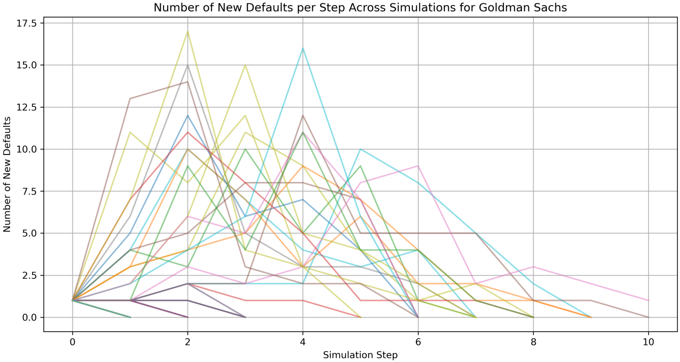


Figure: Simulation for Goldman Sachs

# Conclusion

- Model has the capability to replicate empirical data.
- The available data shows the expected patterns of contagion.
- There is high heterogeneity depending on where the shock starts.

# Extension

- Use the credit registry data to properly build a Network.
- Utilise stock data to observe the propagation of shocks through publicly available data.
- Central Bank best response at each step of the contagion.
- What kind of signals does the decision of the Central Bank send when facing a Bailout Policy? Does this increase or decrease the the attitude towards risk? Can this benefit the contagious or not?