An agent-based model for bank formation, bank runs and interbank networks

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IFT, August 31, 2011

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- However, the principles that govern individual prudence do not necessarily apply to systems as a whole.
- Financial innovation and integration leads to highly interconnected, complex and potentially fragile banking systems.
- Systemic crises are essentially stories of contagion, interdependence, interaction and trust - Kirman (2010).

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PHIMAC

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- The bulk of recent work on systemic risk focuses on the first aspect.

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- Systemic failure should also include cases where the network does not provide its social and economic function.

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where w is the proportion of early consumers (type 1).
- Sufficiently risk-averse consumers prefer the liquid asset.

Example: Diamond (2007)

- Let $A = (r_1 = 1, r_2 = 2)$ represent an illiquid asset and $B = (r_1 = 1.28, r_2 = 1.813)$ a liquid one.

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- Observe, however, that risk-neutral investors would prefer the illiquid asset, since:

$$E[A] = 1.75 > 1.68 = E[B]$$

Liquidity risk sharing

- Consider an economy with dates $T = 0, 1, 2$ and an illiquid asset $A = (1, R)$ and consumer preferences given by

$$U(c_1^j, c_2^j, \omega) = \begin{cases} u^j(c_1) & \text{if j is of type 1 in state } \omega \\ u^j(c_2) & \text{if j is of type 2 in state } \omega \end{cases} \quad (1)$$

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- Denoting by w the fraction of early consumers (type 1), the optimal risk sharing for *publicly* observed preferences is

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- However, liquidity preferences are private unverifiable information !

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- However, it is clear that $f = 1$ (run) is also an equilibrium leading to $V_1 \leq c_1^{1*}$ and $V_2 = 0 < c_2^{2*}$.

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- However, the forecast $\hat{f} = 1$ is another Nash equilibrium.

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- Each bank can invest in a liquid asset $(1, 1)$ and an illiquid asset $(r < 1, R > 1)$ and promises consumption (c_1, c_2).

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- For example, in state S_1, A and C have excess demand $(w_H - \gamma)c_1$ at $t = 1$, which equals the excess supply $(\gamma - w_L)c_1$ from B and D.

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- For example, in state S_1, A and C have excess demand $(w_H - \gamma)c_1$ at $t = 1$, which equals the excess supply $(\gamma - w_L)c_1$ from B and D.
- At $t = 2$ the flow is reversed, since the excess supply $(w_H - \gamma)c_2$ from A and C equals the excess demand $(\gamma - w_L)c_2$ from B and D.

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- At $t = 2$, the same bank satisfies

$$[(1 - w_H) + (w_H - \gamma)]c_2 = Rx,$$

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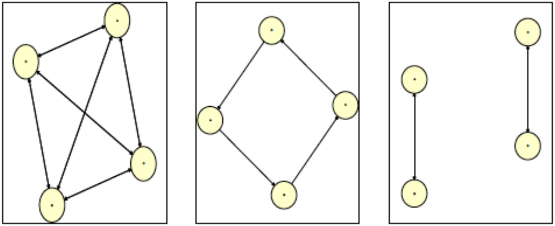
Shocks and stability

- Allen and Gale (2000) then analyze the effects of small shocks to interbank markets with networks of the form:



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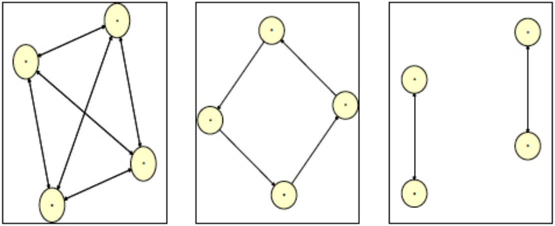

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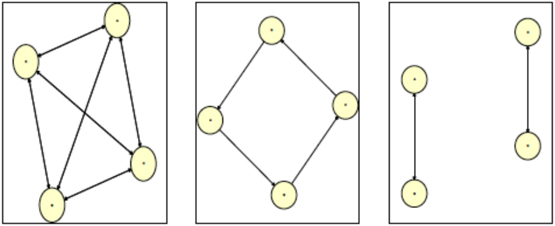

- They show that the complete network absorbs shocks better than the incomplete one.
- Their analytic model is difficult to generalize to arbitrary (asymmetric) networks.

Our model - the summarized story

- Society

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- Society
- Liquidity Preference

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- Because of anticipated shocks, individuals explore the society searching to partners to exchange investments.

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- We use a combination of Von Neumann and Moore neighborhood:

5	1	6
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PHIMAC

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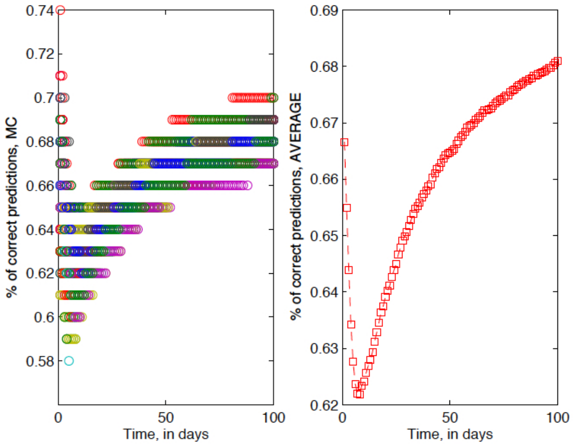
- Depending on the realized outcome, a predictor's strength gets updated by

$$\Delta S = \begin{cases} +1 & \text{if the forecast is correct} \\ -1 & \text{if the forecast is incorrect} \end{cases}$$

Learning simulation

We use 400 persons over a time span of 100 periods in a simulation with 100 realizations:



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- Individuals become aware of bank existence only if the bank lies in their neighbourhood
- In addition we give the bank the reach of its new members

To join or not to join a bank

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	forecast	strength	payoff (join)	payoff (not join)
1	N	-2	c_2	R
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- The decision is based on the weighted sum of payoffs.

Experiment: bank formation

Experiment (continued): established banks

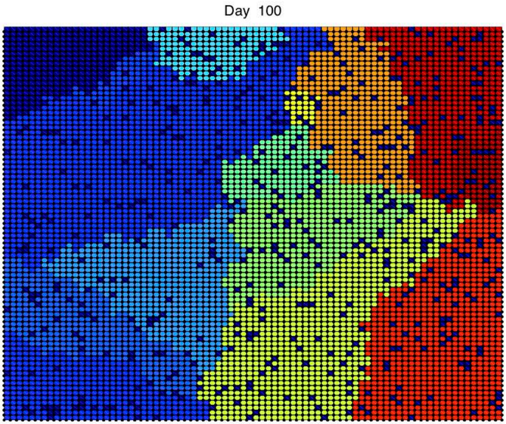
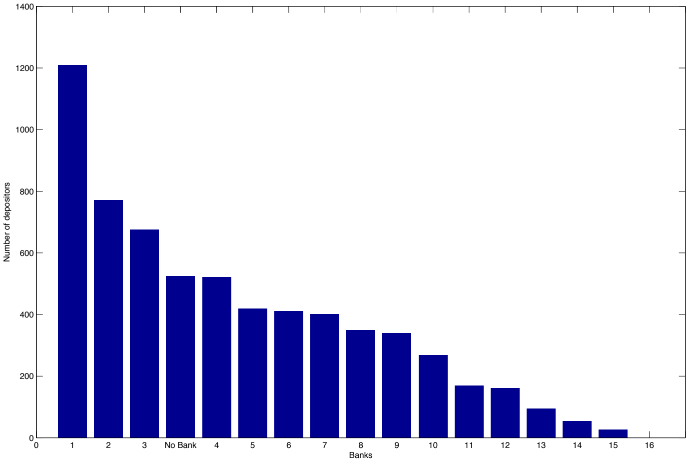


Figure: Banks at T=100 with $c_1 = 1.1$, $c_2 = 1.5$ and $R = 2$

Experiment (continued): number of depositors



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$$C_t^i = [y_t^i - c_1 \overline{W}_t^i] + [R x_t^i - c_2(1 - \overline{W}_t^i)].$$

Dynamic allocation

An agent-based model for bank formation, bank runs and interbank networks

Matheus R. Grasselli

Introduction

Theoretical underpinnings

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Bank runs

Interbank networks

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- Banks update their estimate of early consumers through

$$W_{t+1}^i = \max\left\{ W_t^i + \alpha(\overline{W}_t^i - W_t^i), \frac{1 - c_2/R}{c_1 - c_2/R} \right\}, \qquad (4)$$

reflecting both adaptation through a parameter $\alpha \in (0,1)$ and the budget constraint $x_{t+1}^i + y_{t+1}^i \leq 1$ where

$$y_{t+1}^i = c_1 W_{t+1}^i, \quad R x_{t+1}^i = c_2(1 - W_{t+1}^i).$$

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$$(\overline{W}_t^i - W_t^i)c_1 > \left[\frac{(1-W_t^i)c_2}{R} - \frac{(1-\overline{W}_t^i)c_1}{R}\right] r + C_t^i$$

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- The banks uses reserves to bring this as close as possible

Experiment: bank formation and runs

Experiment: established banks (with possible runs)

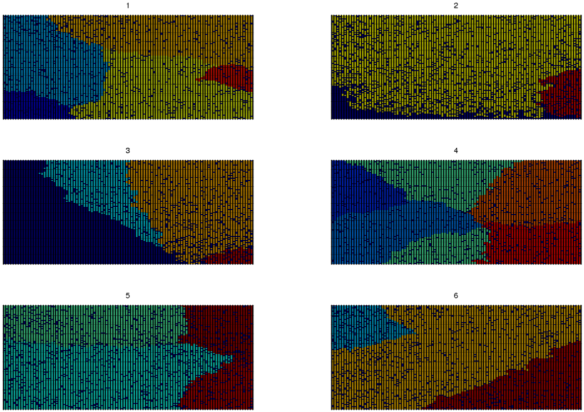

Figure: Banks at T=100 with $c_1 = 1.1$, $c_2 = 1.5$ and $R = 2$

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- They use the same set of predictors as clients to forecast the adequacy of their estimates as being ‘adequate’, ‘inadequate’ or ‘undetermined’.
- Banks with inadequate or undetermined estimates have an incentive to exchange deposits with other banks and try to protect their reserves.

Experiment: adequacy of estimates through time

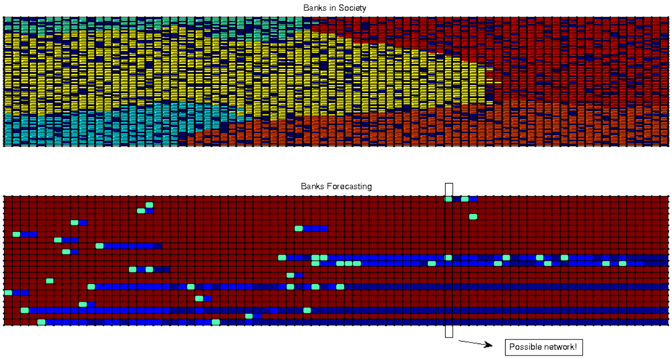

Figure: Banks at T=100 with $c_1 = 1.1$, $c_2 = 1.5$ and $R = 2$ and adequacy of estimates over time.

Experiment: possible network

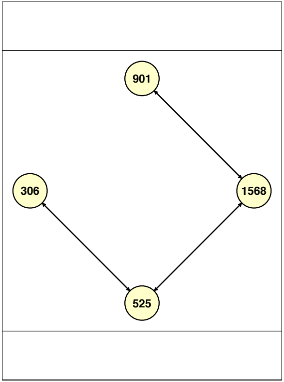

Figure: Snapshot of possible interbank loans

Correlated liquidity shocks

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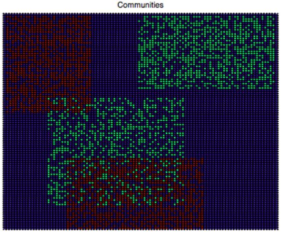
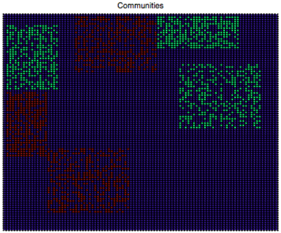
  4. Alter half of the communities to early preferences (i.e $\widetilde{U}_i = 0.2$) and half of the communities to late preferences (i.e $\widetilde{U}_i = 0.8$).

Examples of correlated liquidity shocks





Experiment: bank formation and runs with correlated shocks

Experiment: adequacy of estimates through time (with correlated shocks)

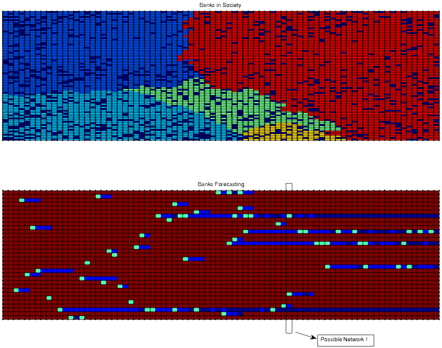


Figure: Banks at T=100 with $c_1 = 1.1$, $c_2 = 1.5$ and $R = 2$ and adequacy of estimates over time.

Experiment: another possible network

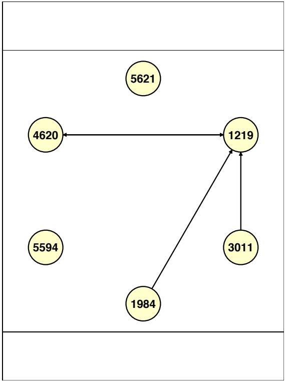


Figure: Snapshot of possible interbank loans with correlated liquidity shocks

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- Thank you.