Bank Overleverage and Macroeconomic Fragility

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Motivation

- Was the 2007–2008 crisis an unavoidable, unfortunate accident or because of any market failure?
- A few suspects in the run-up to the crisis:
  1. Expansion of leverage in the (shadow) banking system
  2. Loopholes of the existing regulatory framework
  3. Erosion of discipline owing to the "Greenspan put," or expectations for bank bailouts.

Questions to be addressed

- We develop a dynamic GE model (OLG model) that explicitly includes banks with **maturity mismatch** (Diamond-Rajan, 2001, 2012)
  - A **liquidity shortage** precipitating a devastating crisis

1. Can a competitive banking sector prevent "inefficient" financial crises?
   -
2. Can the existing policy measures reduce the probabilities of financial crises?
   - Bank bailout
     -

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1. Can a competitive banking sector prevent "inefficient" financial crises?
   - No, due to pecuniary externalities and overleverage
2. Can the existing policy measures reduce the probabilities of financial crises?
   - Bank bailout
     - Highly unlikely

Main results: Illustration

- **At normal times:** capital accumulation with consumption smoothing

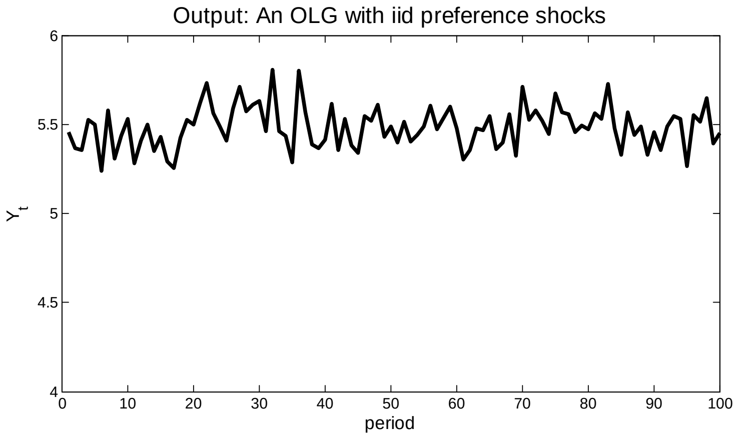
$$
\begin{aligned}
K_{t+1} &= I\left(R_t / q_{t+1}\right) + \underline{I} \\
R_t &= \frac{\theta_t}{1-\theta_t}\left(\frac{C_{1,t}}{C_{2,t+1}}\right)^{-1}
\end{aligned}
$$

where θ_t is the iid preference shock (mean=0.5) in HH utility,

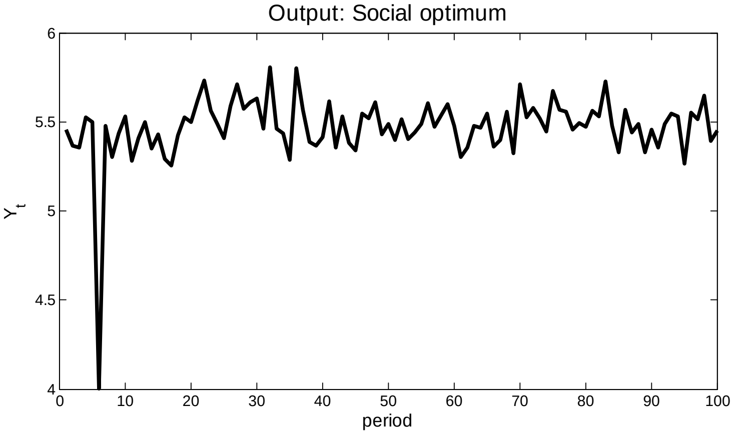
$$
U = \theta_t \log C_{1,t} + (1-\theta_t) \log C_{2,t+1}
$$

- **In a crisis**, no investment, no consumption-smoothing, owing to the lack of intertemporal substitution overview

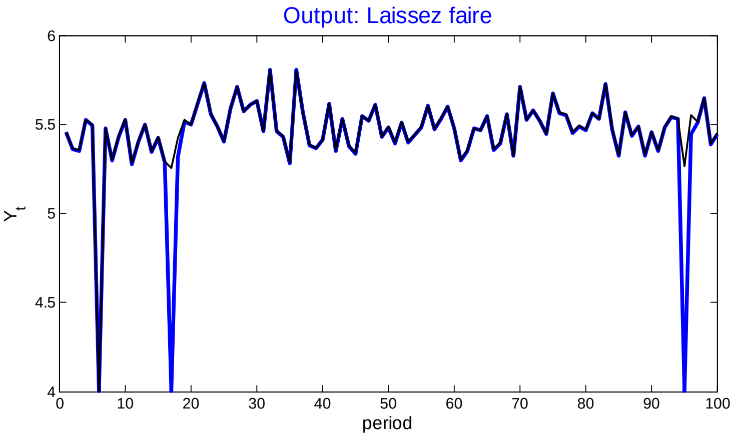
Plain-vanilla OLG (with iid preference shocks)



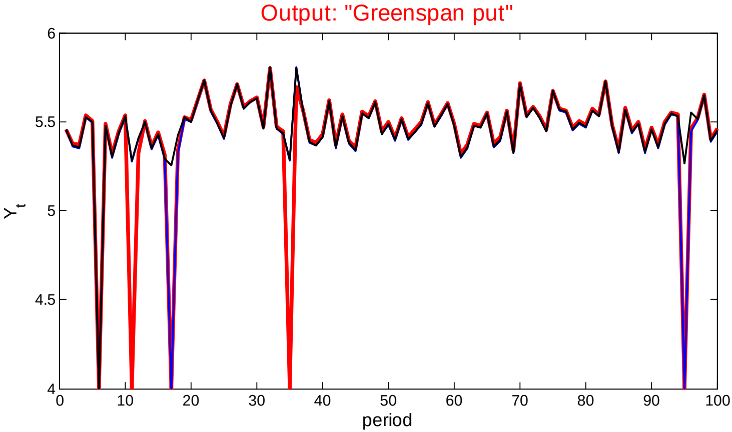
Social optimum: The optimal crises á la Allen and Gale (1998)



Laissez faire economy: Inefficient crises



With “Greenspan put”: Even more frequent crises



Related literature

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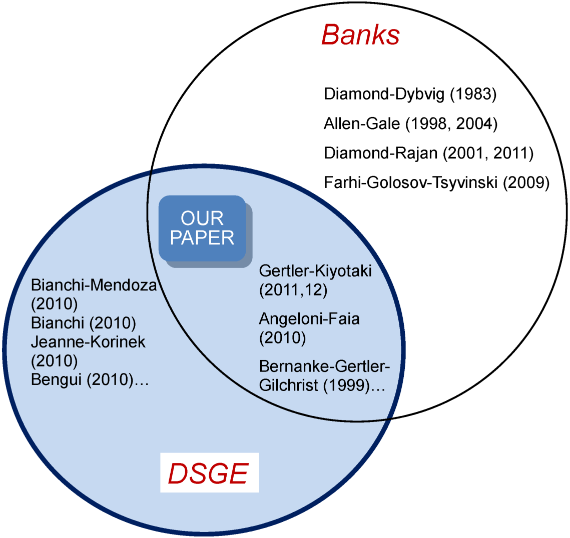
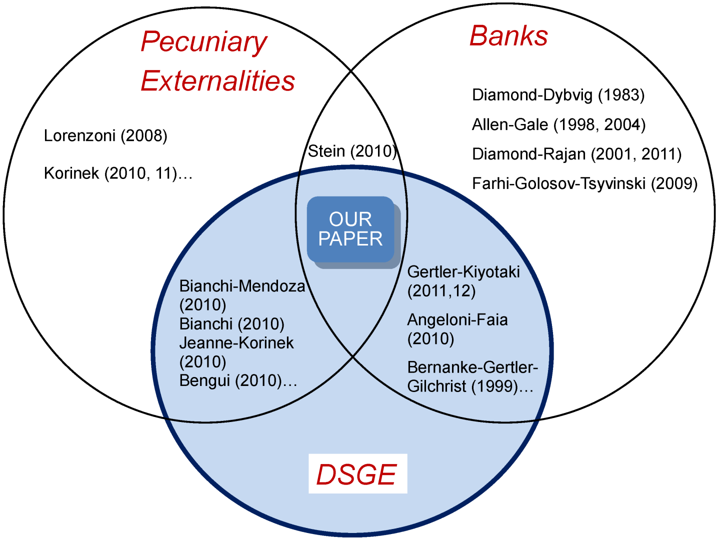


Related literature



Overview of the model

- Each generation has 3 agents who live for 2 periods
  1. Households
     - are endowed with a unit consumption good $\Longrightarrow$ deposit in banks
     - supply fixed labor and receive w_t and w_{t+1}
     - are subject to liquidity (preference) shock θ_t
     - choose consumption after the realization of θ_t
  2. Entrepreneurs
     - launch long-term projects to produce capital goods
     - sell the capital goods, if completed, for q_{t+1} (one-period gestation)
  3. Bankers (à la Diamond and Rajan 2001, 2011)
     - pre-commit to the debt face value D_t before observing θ_t
     - raise funds via short-term debt (demand deposit) and lend them to entrepreneurs (=maturity transformation)
- Consumption goods producing tech., $Y_t = K_t^{\alpha} H_t^{1-\alpha}$

Banks commit to their debt, D_t.

------------ Markets open ------------

Liquidity preference (θ_t) realizes.

Price of liquidity (R_t/q_{t+1}) determined in liquidity market

All banks are solvent

Banking system crisis

---------- Markets close ----------

Normal dynamics

No capital accumulation

return

Households

- Liquidity preference θ_t is the only random variable in the model.
- HHs make their decisions **after** observing θ_t.
- Given the deposit face value D_t and interest rate R_t, households maximize

$$
\begin{aligned}
U\left(C_{1,t}, C_{2,t+1}\right) &= \theta_t \log C_{1,t} + (1-\theta_t) \log C_{2,t+1} \\
\text{s.t. } C_{1,t} &= \begin{cases} w_t + g_t & \text{at normal times} \\ w_t + X & \text{in a crisis} \end{cases} \\
C_{2,t+1} &= \begin{cases} w_{t+1} + R_t\left(D_t - g_t\right) & \text{at normal times} \\ w_{t+1} & \text{in a crisis,} \end{cases}
\end{aligned}
$$

N.B.: HHs can make their decisions without uncertainty, while the probability of a financial crisis varies endogenously. ▸ FOC

Entrepreneurs and banks

- Entrepreneurs' project
  - yields $\omega \in [\omega_L, \omega_H]$ at $t+1$, but may be liquidated at t
  - leaves only X, if liquidated ($X < 1$ is the liquidation value)
  - can be sold for $q_{t+1}\omega$, if completed
  - if completed, fraction $1-\gamma$ of output accrues to entrepreneurs
- Banks' liquidation decision
  - Banks are relationship lenders that can collect γ of the output
  - Banks liquidate projects if MRT < gross interest rate R_t,

$$\gamma q_{t+1}\omega < R_t X \iff \frac{\gamma q_{t+1}\omega}{X} = MRT_t < R_t$$

  - Equivalently, the cut-off level for liquidation,

$$\omega < \tilde{\omega}_{t+1} \equiv \frac{X R_t}{\gamma q_{t+1}}$$

Bank assets

- With $\tilde{\omega}_{t+1} = XR_t/\gamma q_{t+1}$, the bank's asset $A\left(R_t/q_{t+1}\right)$ is

$$A\left(\frac{R_t}{q_{t+1}}\right) = \underbrace{\int_{\omega_L}^{\tilde{\omega}_{t+1}} Xh\left(\omega\right) d\omega}_{\text{liquidation}} + \underbrace{\frac{\gamma q_{t+1}}{R_t}\int_{\tilde{\omega}_{t+1}}^{\omega_H} \omega h\left(\omega\right) d\omega}_{\text{bank's share of projects}}$$

$$= L\left(\frac{R_t}{q_{t+1}}\right) + \frac{\gamma q_{t+1}}{R_t} I\left(\frac{R_t}{q_{t+1}}\right)$$

where $h\left(\omega\right)$ is pdf for ω and $L\left(R_t/q_{t+1}\right)$ is the liquidity supply.

  - $A' < 0$ and $I' < 0$ (investment) $\Rightarrow K_{t+1} = I\left(R_t/q_{t+1}\right) + \underline{I}$
  - $L' > 0$ (liquidity supply)

Optimal bank leverage

- Banks choose D_t (face value of deposits) before observing θ_t
    - Deposits are non state-contingent debt
    - D_t has a one-to-one relationship with bank leverage $A_t/(A_t - D_t)$
        - Choice of leverage (size of liabilities) = choice of D_t

- Banks compete to raise funds from HHs
    - Competition forces banks to maximize the HH expected utility
    - Banks internalize the liquidity mrkt clearing condition

- Liquidity market clearing condition at normal times:

$$\underbrace{L\left(\frac{R_t}{q_{t+1}}\right)}_{\text{supply}} = \underbrace{\theta_t\left(\frac{w_{t+1}}{R_t} + D_t\right) - (1-\theta_t)\, w_t}_{\text{demand}} = g_t$$

Optimal bank leverage (2)

- A high D_t raises both (i) return for HH and (ii) crisis probability
  - Banks need to strike the right balance b/w risk and return
  - To make the right decision, banks assess their own solvency

$$D_t = A\left(R_t^* / q_{t+1}^*\right)$$

- θ_t^* is defined as the maximum level of the preference shock in which banks can remain solvent with $R_t^* / q_{t+1}^* = A^{-1}(D_t)$.

$$\begin{aligned} L\left(\frac{R_t^*}{q_{t+1}^*}\right) &= \theta_t\left(\frac{w_{t+1}^*}{R_t^*} + D_t\right) - (1-\theta_t)\, w_t \\ &\Longleftrightarrow \\ \theta_t^* &= \frac{L\left(R_t^* / q_{t+1}^*\right) + w_t}{w_t + D_t + w_{t+1}^* / R_t^*}. \end{aligned}$$

Problem LF

- In a laissez-faire economy, banks maximize HH expected utility

$$\max_{D_t} \int_0^{\theta_t^*} \left[\theta_t \log\left(w_t + L_t\right) + \left(1-\theta_t\right) \log\left(w_{t+1} + R_t\left(D_t - L_t\right)\right)\right] f\left(\theta_t\right) d\theta_t$$
$$+ \int_{\theta_t^*}^{1} \left[\theta_t \log\left(w_t + X\right) + \left(1-\theta_t\right) \log\left(\underline{w}\right)\right] f\left(\theta_t\right) d\theta_t$$

$$\text{s.t.} \quad D_t = A\left(R_t^* / q_t^*\right)$$
$$L_t = \theta_t \left(\frac{w_{t+1}}{R_t} + D_t\right) - \left(1-\theta_t\right) w_t$$
$$\theta_t^* = \frac{L\left(R_t^* / q_{t+1}^*\right) + w_t}{w_t + D_t + w_{t+1}^* / R_t^*}$$

where w_t and $\underline{w}$: wages at normal times and in a crisis SP FOC

Social planning banks

- Motivation
  - Can a LF banking sector achieve the best outcome in the absence of Arrow securities?
  - Assume that social planning banks can internalize all the price effects,
    - but they need to choose D_t before observing θ_t,
    - HHs can make their decisions after observing θ_t
  - Focus on the constrained optimum where banks can only use non state-contingent debt.

Problem SP

- The social planning banks maximize HH expected utility

$$\max_{D_t} \int_0^{\theta_t^*} \left\{\theta_t \ln\left(F_{H,t} + L_t\right) + \left(1-\theta_t\right) \ln\left[F_{H,t+1} + R_t\left(D_t - L_t\right)\right]\right\} f\left(\theta_t\right) d\theta_t$$

$$+ \int_{\theta_t^*}^1 \left[\theta_t \ln\left(F_{H,t} + X\right) + \left(1-\theta_t\right) \ln \underline{F}_H\right] f\left(\theta_t\right) d\theta_t$$

$$\text{s.t.} \qquad D_t = A\left(R_t^* / F_{K,t+1}^*\right)$$

$$L_t = \theta_t \left(\frac{F_{H,t+1}}{R_t} + D_t\right) - \left(1-\theta_t\right) F_{H,t}$$

$$\theta_t^* = \frac{L\left(R_t^* / F_{K,t+1}^*\right) + F_{H,t}}{F_{H,t} + D_t + F_{K,t+1}^* / R_t^*}$$

q_{t+1} and w_{t+1} in LF are replaced with $F_{K,t+1}$ and $F_{H,t+1}$ here. LF

Main result 1: Overleverage

Proposition

LF banking sector tends to be overleveraged.

- Intuition: Focus on "solvency constraint"
  - LF banks take capital prices as given when assessing solvency

$$D_t = A\left(R_t^* / q_{t+1}^*\right)$$

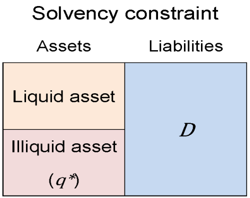
  - SP banks internalize all the price change effects

$$D_t = A\left(R_t^* / F_{K,t+1}^*\right)$$

  - Changes in q_{t+1}^* distort the LF banks' assessment of their solvency
  - Crisis probability is likely to be higher in the LF than in the SP economy
  - **Pecuniary externalities** welfare

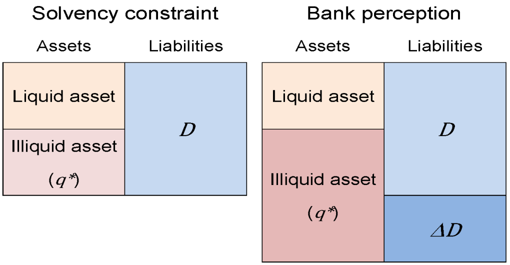
Intuition behind excessive risks

- To determine D_t, banks need to calculate balance sheet on the brink of a crisis: $D_t = A\left(R_t^* / q_{t+1}^*\right)$
- Banks' assets depends on the price of illiquid assets q^*



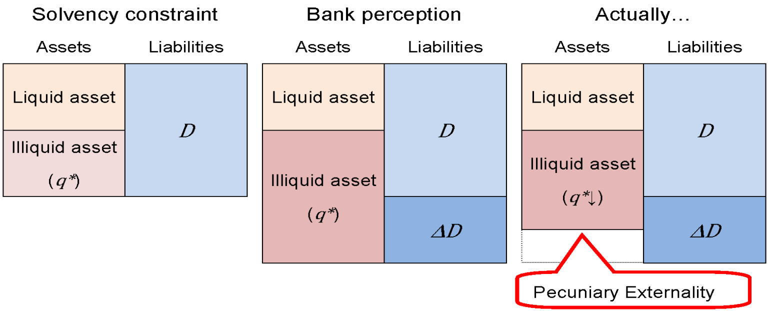
Intuition behind excessive risks

- When a single bank increases D_t, it increases illiquid assets to be solvent
- Each bank takes price of illiquid assets as given



Intuition behind excessive risks

- However, the increased illiquid assets decrease the prices q^*
- Banks over-estimate the value of their own assets



Bank bailouts: Interpretation

- Government/the central bank (GC hereafter) commits to emergency liquidity provision.
- Anatomy of a crisis in the model:
  - A high $\theta_t \Longrightarrow$ liquidity shortage $\Longrightarrow$ high interest rate (price of liquidity) $\Longrightarrow$ bank insolvency
  - Emergency liquidity provision to rein in the interest rate
- **Bank bailout $\rightarrow$Commitment to a low interest rate policy**
- Can this intervention reduce crisis probabilities? **Highly unlikely.**

Bank bailouts: Implementation

- Need financing: Bank levy (e.g., U.K. practice)

$$(1+\tau)\, D = A\left(R_t^* / q_{t+1}^*\right)$$

leaves τD_t of funds. Now, what can be done with the funds?

Option BL: Waste them
Option BB: Use them for bank bailouts:

$$\begin{aligned} \text{Liquidity supply} &= L\left(\frac{R_t}{q_{t+1}}\right) + M_t, \\ M_t &\leq \tau D_t. \end{aligned}$$

M_t : emergency liquidity provision to rein in R_t which continues until the budgetary resource is depleted. operation

- **BB** implies that GC commits to keep $R_t \leq R_t^*$ by injecting liquidity.

Main result 2: The intervention and crisis risks

- The commitment to a low interest policy would **raise**, rather than reduce, the crisis risks

	Option BL	Option BB
Leverage and probabilities		
D_t	1.03	1.04
Prob. of crisis (%)	6.84	7.06
Bank capital and GDP		
Bank capital (%)	13.94	13.35
Y_{t+1}	5.46	5.46

Notes: $\tau = 0.03$.

- Implications:
  - Policy measures should aim at ex-ante de-leveraging of banks
  - Conversely, the "Greenspan put" may have fueled risk-taking

Conclusion

- We develop the dynamic GE model that explicitly includes a banking sector with maturity mismatch

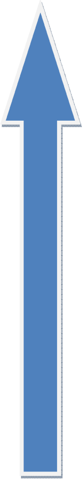
1. The Laissez-faire banking sector take on excessive risks systemically
    - Precipitating crises more frequently
    - The general equilibrium creates pecuniary externalities because of the lack of state-contingent debt
    - Pecuniary externalities distort the MC of increasing the debt
2. Policy implication
    - Expectations of bank bailout may have fueled risk-taking of the banking sector

The way forward

1. Create richer dynamics with boom-bust cycles, by including bubbles or “news shocks”
2. Further exploration of policy options
   - Capital adequacy requirement with prompt corrective action
   - G-SIFI surcharge, counter-cyclical capital requirement and other macro-prudential tools
   - Optimal policy designs

Banks and economic welfare

Welfare



◄ Arrow security: The first-best allocation

- □ Complete markets
- □ No default, no crisis

◄ Banks: The second-best allocation

- □ Incomplete markets
- □ Bank's solvency constraint
- □ Non-zero probability of default and crisis

◄ Autarky: No financial transaction

return

HH's decision and liquidity demand

- Normal times: consumption Euler eq. and budget constraint

$$R_t = \frac{\theta_t}{1-\theta_t}\left(\frac{C_{1,t}}{C_{2,t+1}}\right)^{-1}$$

$$C_{1,t} + \frac{C_{2,t+1}}{R_t} \leq D_t + w_t + \frac{w_{t+1}}{R_t}$$

HH's liquidity demand = withdrawal of deposit

$$g_t = C_{1,t} - w_t = \theta_t\left(\frac{w_{t+1}}{R_t} + D_t\right) - (1-\theta_t)\, w_t$$

- Crisis: No financial intermediation

$$C_{1,t} = w_t + X,\ C_{2,t+1} = w_{t+1}$$

return

First order condition

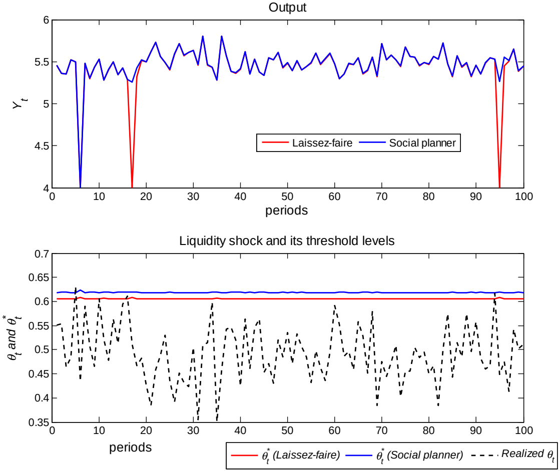
$$\underbrace{\left[\theta_t^* \log\left(\frac{w_t + L_t^*}{w_t + X}\right) + (1-\theta_t^*)\log\left(\frac{w_{t+1}^* + R_t^*(D_t - L_t^*)}{\underline{w}}\right)\right]}_{\text{Loss at a crisis}} \underbrace{\frac{d\pi_t}{d\theta_t^*}\theta_{LF,t}^{*\prime}}_{\text{Mrg.change in } \pi_t}$$

$$= \underbrace{\int_0^{\theta_t^*}\left[\frac{1}{m_t}\left(1 - \frac{w_{t+1}}{R_t^2}R'_{LF,t}\right) + (1-\theta_t)\frac{1}{R_t}R'_{LF,t}\right]f(\theta_t)\,d\theta_t}_{\text{MB of increasing } D_t}$$

- Marginal cost (MC) of D_t
  - Loss at a crisis (decline in utility in a crisis) times (marginal) change in $\pi_t = \int_{\theta_t^*}^1 f(\theta_t)\,d\theta_t$: how frequently do crises take place?
- Marginal benefit (MB) of D_t = Expected (marginal) return from banks

return

Numerical results: Dynamics



- The threshold θ_t precipitating a crisis is lower in LF than in SP
- The 2nd and 3rd crises should be prevented, but the 1st should not