Booms and Systemic Banking Crises

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Disclaimer

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Motivation/Objective

- Better understand the joint dynamics of regular business cycles and systemic banking crises (SBCs)
- A few features are common to SBCs (e.g. Reinhart and Rogoff 2009; Jordà et al., 2011; Claessens et al., 2011; Schularick and Taylor, 2012):
  - Fact #1: SBCs are **rare events**

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    - Fact #2: Recessions that follow SBCs are **deeper and last longer**

Stylized facts

SBCs are rare and bring about deep and long recessions

Frequency, magnitude, and duration of systemic banking crises

	Frequency (%)	Magnitude (%) from peak to trough	Duration (Years)
Systemic Banking Crises (SBC)	2.42		
Recessions with SBC (A)		6.74	2.59
Recessions w/o SBC (B)		4.27	1.61

Source: Schularik et al. (2011), data for 14 OECD countries, 1870-2008

Crises defined as in Laeven and Valencia (2008)

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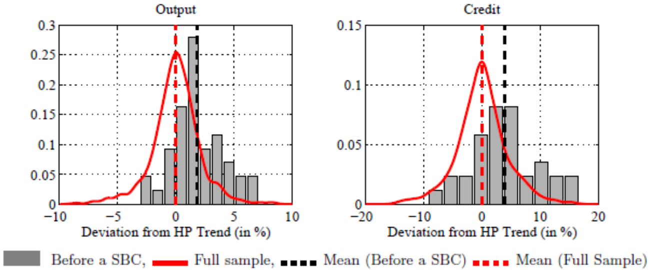
  - Fact #2: Recessions that follow SBCs are **deeper and last longer**
  - Fact #3: SBCs are "**credit booms gone wrong**"

Distribution of GDP and credit gaps on average (red line) and around SBCs (bars)



Motivation/Objective

- In most DSGE models with financial frictions banking crises are big negative shocks amplified
  - Can explain Facts #1 & #2
  - **Cannot explain Key Fact #3** $\leftarrow$ SBCs are not random
- To explain Fact #3 one needs to model the dynamics leading to SBCs

Our Framework

- Textbook stochastic optimal growth model (RBC)
- Heterogenous banks with intermediation and storage technologies
- Interbank market subject to MH and AI
- A Systemic Banking Crisis is an interbank market freeze
- Spill–over and feedback effects between the interbank market, the retail corporate loan market, and the real economy

Main Results

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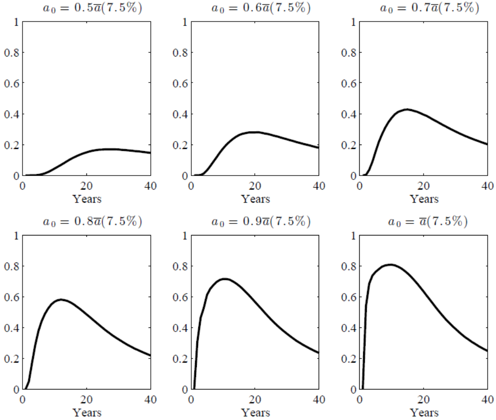
5. SBCs bring about deeper and longer lasting recessions because of a credit crunch

Crisis probability: Sensitivity to initial imbalances



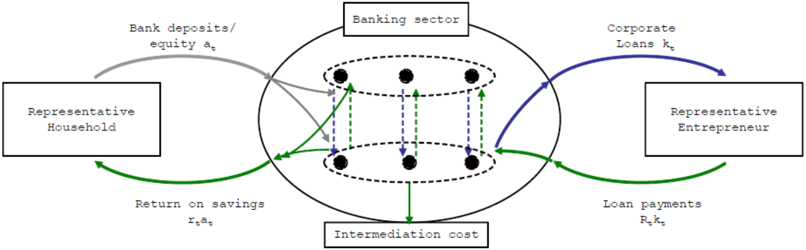
This figure reports the evolution of the frequency of SBCs during the transition toward the average steady state.

Related literature

- Kiyotaki-Moore (1997), Bernanke-Gertler-Gilchrist (1999), Christiano-Motto-Rostagno (2008), Gertler-Kiyotaki (2009), Gertler-Karadi (2010), Jermann-Quadrini (2012):
  - $\neq$ Full equilibrium non-linearities, such as sudden bank runs
- Bianchi (2009), Bianchi-Mendoza (2010):
  - $\neq$ Endogenous interest rates play a key role
- Brunnermeier-Sannikov (2012), He-Krishnamurthy (2012):
  - $\neq$ Typical crisis follows a rare, long sequence of positive TFP shocks
  - $\neq$ Typical crisis identified as a bank run, not as a binding borrowing constraint
- Gertler-Kiyotaki (2012)
  - $\neq$ Bank run is market based and rationally expected

Model setup

Overview



Representative Household and Firm

- Firm: $\max_{\{k_t,h_t\}} \pi_t = F(k_t, h_t; z_t) + (1-\delta)k_t - R_t k_t - w_t h_t$
- Household:

$$\max_{\{a_{t+\tau+1},c_{t+\tau},h_{t+\tau}\}_{\tau=0}^{\infty}} \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} u\left(c_{t+\tau}, h_{t+\tau}\right)$$

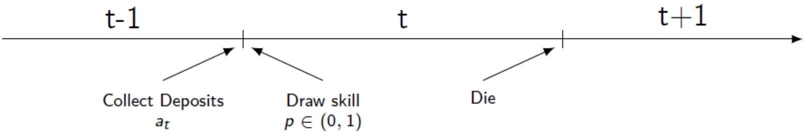
subject to budget constraint

$$c_t + a_{t+1} = r_t a_t + w_t h_t + \pi_t$$

- Notice that $r_t \leqslant R_t$ (spread) and $k_t \leqslant a_t$ (credit crunch)

The Banking Sector

- Banks are atomistic, competitive, and price takers
- Continuum of heterogeneous 1–period banks p, with *cdf* $\mu(p)$ over $(0,1)$



- Bank p's net return per unit of corporate loan is pR_t
- It is beneficial to relocate funds, but relocation is impaired due to:

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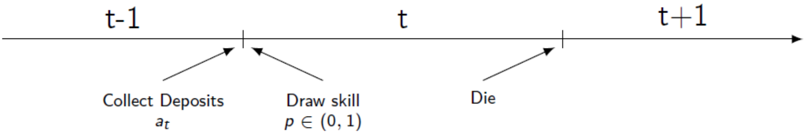

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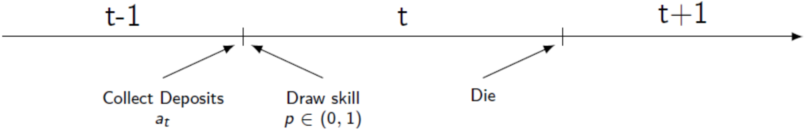

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- It is beneficial to relocate funds, but relocation is impaired due to:
  - **Asymmetric information:** p is private information
  - **Moral hazard**: bank p may borrow ϕ_t and walk away ("diversion")

The Banking Sector

- Bank p has 4 options:
  1. Lend to other banks on the interbank market $\Longrightarrow \rho_t$
  2. Store goods $\Longrightarrow \gamma$
  3. Raise funds ϕ_t from interbank market and lend to firm $\Longrightarrow pR_t\left(1+\phi_t\right)-\rho_t\phi_t$
  4. Raise funds ϕ_t from interbank market and walk away $\Longrightarrow \gamma\left(1+\theta\phi_t\right)$
- **Incentives to divert depend on the corporate loan rate:** the lower R_t, the higher these incentives, and the more counterparty fears on the interbank market

The Borrowing Bank's Problem

- Borrowing bank p solves:

$$\max_{\phi_t} r_t(p) \equiv pR_t(1+\phi_t) - \rho_t\phi_t$$

$$\begin{aligned} PC: &\quad pR_t(1+\phi_t) - \rho_t\phi_t \geqslant \rho_t &&\Rightarrow p \geqslant \overline{p}_t \equiv \rho_t / R_t \\ IC: &\quad \gamma(1+\theta\phi_t) \leqslant \rho_t &&\Rightarrow \phi_t = (\rho_t - \gamma)/\theta\gamma \end{aligned}$$

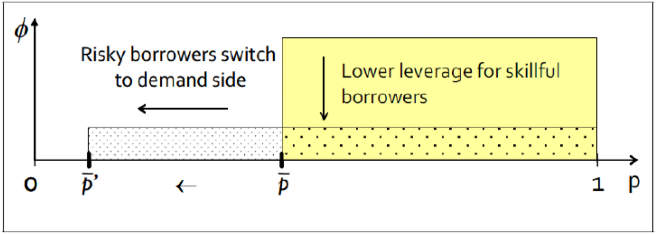
- Profits are fully distributed to household: $r_t \equiv \int_0^1 r_t(p)\,\mathrm{d}\mu(p)$

Interbank Market Equilibrium

Interbank market clearing condition

$$\overbrace{\mu\left(\overline{p}_t\right)}^{\text{Supply }(+)} = \overbrace{\underbrace{\left(1-\mu\left(\overline{p}_t\right)\right)}_{\text{"extensive margin" }(-)} \times \underbrace{\phi_t}_{\text{"intensive margin" }(+)}}^{\text{Demand bends backward }(+\text{ or }-)}$$

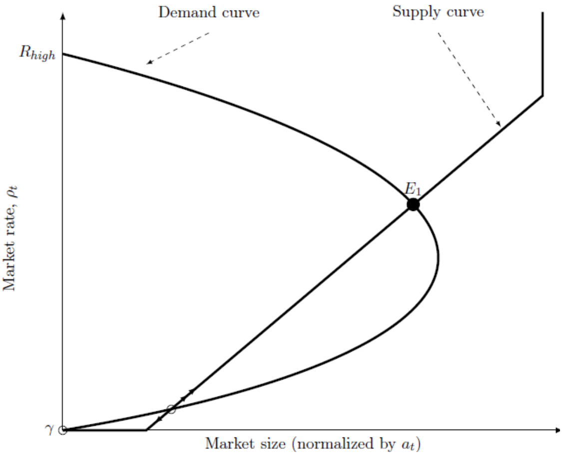
$$\text{with } \overline{p}_t \equiv \rho_t / R_t \text{ and } \phi_t = (\rho_t - \gamma)/\theta\gamma$$



Two opposite effects on aggregate demand of a decrease in ρ_t

Interbank Market Equilibrium

The interbank market freezes when the retail corporate loan rate is below a threshold



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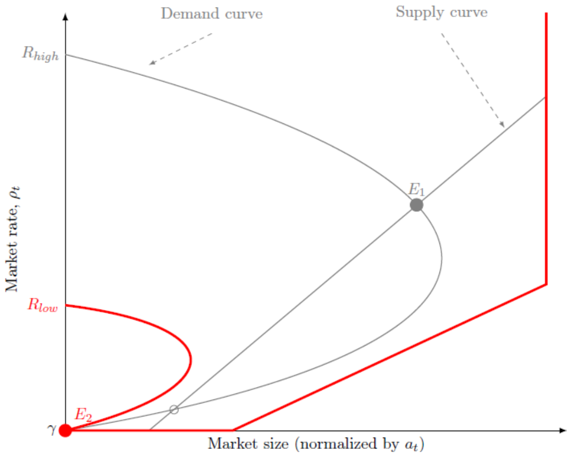

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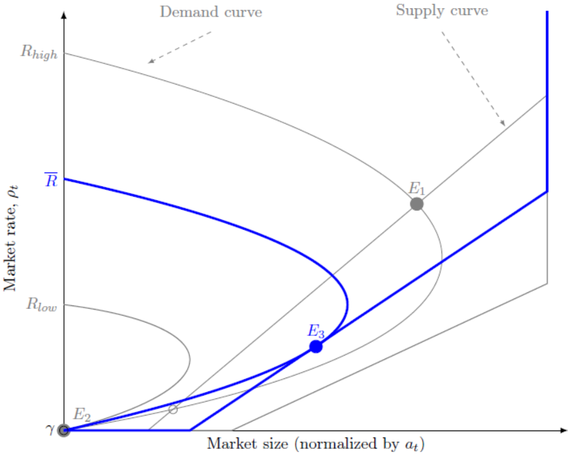


Return on Deposits and Corporate Loan Supply

- Return on deposits:

$$r_t = \begin{cases} R_t \int_{\overline{p}_t}^{1} p \frac{\mathrm{d}\mu(p)}{1-\mu(\overline{p}_t)} & \text{, if an equilibrium with trade exists} \\ R_t \left(\frac{\gamma}{R_t} \mu\left(\frac{\gamma}{R_t}\right) + \int_{\frac{\gamma}{R_t}}^{1} p \, \mathrm{d}\mu\left(p\right) \right) & \text{, otherwise.} \end{cases}$$

- Corporate loan supply

$$k_t^s = \begin{cases} a_t & \text{, if an equilibrium with trade exists} \\ \left(1 - \mu\left(\frac{\gamma}{R_t}\right)\right) a_t & \text{, otherwise} \end{cases}$$

Absorption Capacity and Financial Imbalances

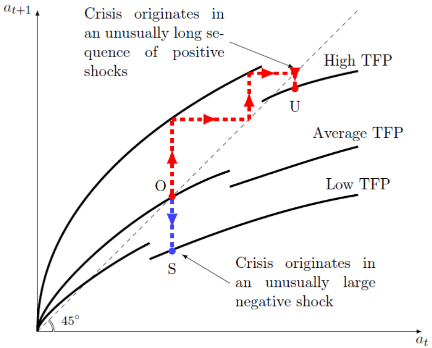
- **Proposition 2 (Interbank loan market freeze):** *The interbank loan market is at work if and only if* $a_t \leqslant \overline{a}_t \equiv f_k^{-1}(\overline{R} + \delta - 1; z_t)$, *and freezes otherwise.*

- The interbank market improves efficiency but freezes when $R_t < \overline{R}$
- In general equilibrium, R_t is driven by savings (a_t) and technology (z_t). Hence the interbank market freezes when $a_t > \overline{a}(z_t)$
- **Threshold $\overline{a}(\mathbf{z}_t)$ is the banking sector's "absorption capacity"**
- A measure of financial imbalances is $\overline{a}_t\,(z_t) - a_t$

- Calibration of the real side is most standard
- Financial sector $(\gamma,\, \theta,\, \mu(.))$ is calibrated so that:
  - Crisis probability is 2.5%
  - Average interest rate spread is 1.71%
  - Average corporate loan rate of 4.35%
- The model is solved numerically by a collocation method

Quantitative Analysis

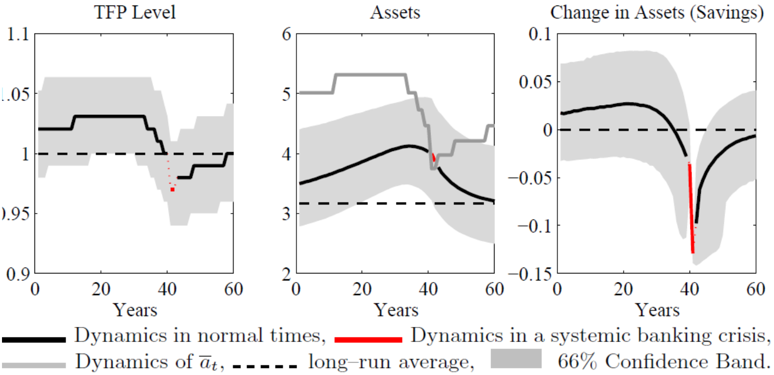
Optimal savings rule: exogenous versus endogenous crises



Note: Dashed line: 45^o line where $a_{t+1} = a_t$.

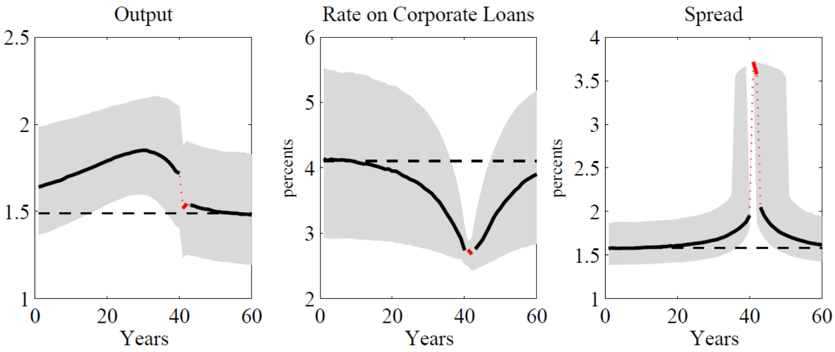
- Variety of SBCs: shock–driven (S) and credit boom–driven (U)
- History suggests that credit–boom driven crises prevail

Typical path



1. At the beginning, a positive shock brings TFP above its mean
   - Credit demand rises. Return on savings goes up. The household accumulates assets for *consumption smoothing*
   - The **credit boom is initially demand–driven**
2. TFP goes down back to mean but remains above it for a long time
   - Credit demand decreases, while the household keeps on accumulating savings
   - The **credit boom becomes supply–driven,** interest rates go down
3. As the probability of a crisis increases, the household accumulates assets for *precautionary motives*, which works to reduce interest rates and to raise the likelihood of a crisis even further
4. A SBC breaks out as the corporate loan R_t rate crosses threshold $\overline{R}$

Selected dynamics along the typical path



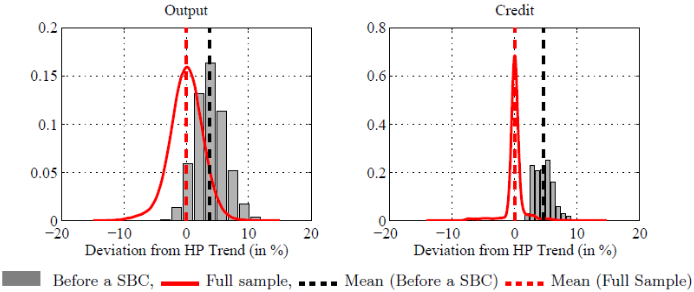
Quantitative Assessment

SBCs are rare and bring about deep and long recessions

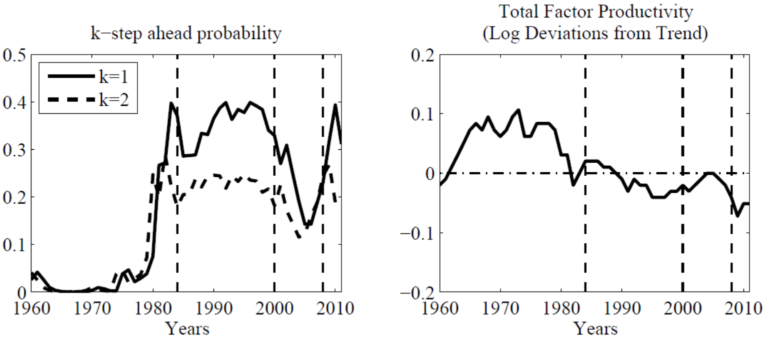
Frequency, magnitude, and duration of systemic banking crises

	Frequency (%)	Magnitude (%) from peak to trough	Duration (Years) from peak to trough
Systemic Banking Crises (SBC)	2.69		
Recessions with SBC (A)		17.87	2.62
Recessions w/o SBC (B)		10.04	1.90

Distribution of GDP and Credit gaps on average (red line) and around SBCs (bars)



Crisis probabilities for the US



Note: The vertical thin dashed lines correspond to the 1984 Savings & Loans, the 2000 dotcom and 2008 crises.

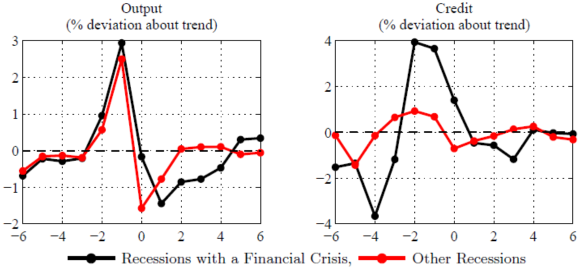
Concluding Remarks

- Develop a simple DSGE model with SBCs, where SBCs are not caused by large, negative, financial shocks but rather by long sequences of small, positive, productivity shocks
- Credit booms are conducive to crises when they turn supply–driven
- Highlight the role of consumption smoothing and precautionary savings in the build-up of financial imbalances
- From a policy making perspective:
  - Framework for both crisis management and crisis prevention
  - DSGE-based probability of a crisis

THANK YOU

Stylized facts

SBCs follow credit booms; they last longer



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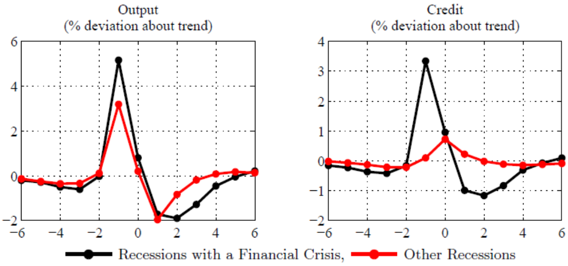
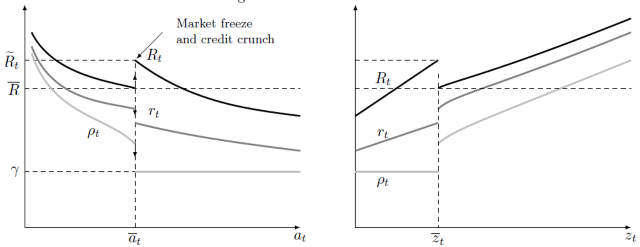


- **Proposition 3 (Credit crunch):** *An interbank market freeze is accompanied with a sudden fall in the supply of corporate loans k_t^s (i.e. given z_t, $\lim_{a_t \searrow \overline{a}_t} k_t^s < \lim_{a_t \nearrow \overline{a}_t} k_t^s$), as well as by a sudden increase in the interest rate spread R_t / r_t (i.e. given z_t, $\lim_{a_t \searrow \overline{a}_t} R_t / r_t > \lim_{a_t \nearrow \overline{a}_t} R_t / r_t$).*

Figure 4: Interest Rates



(a) Interest Rates vs Assets (b) Interest Rates vs Technology Shock

The Banking Sector

Two-way relationship between the retail and the wholesale loan markets

- Whether the interbank market is functioning depends on the corporate loan market equilibrium rate R_t^*
- R_t^* depends on whether the interbank market is functioning
- The model is solved taking these interactions into account

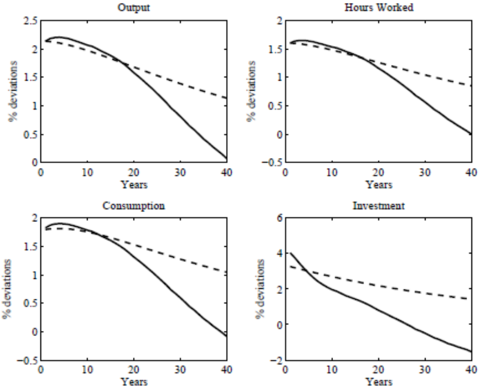
- Production function: $F(k_t, h_t; z_t) \equiv z_t k_t^{\alpha} h_t^{1-\alpha}$ with $\alpha \in (0, 1)$
- Utility function: $u(c_t, h_t) = \frac{1}{1-\sigma}\left(c_t - \vartheta \frac{h_t^{1+\upsilon}}{1+\upsilon}\right)^{1-\sigma}$
- Cdf of bank skills: $\mu(p) = p^{\lambda}$
- Real economy: standard calibration on US (annual) post–WWII data
- Financial sector $(\gamma,\, \theta,\, \lambda)$ is calibrated so that:
    - Crisis probability is 2.5%
    - Average interest rate spread is 1.71%
    - Average corporate loan rate of 4.35%

Parameters of the model

Parameter		Values
Discount factor	β	$1/1.03$
Risk aversion	σ	4.500
Frish elasticity	υ	$1/3$
Labor dis–utility	ϑ	0.944
Capital elasticity	α	0.300
Capital depreciation rate	δ	0.100
Standard dev. productivity shock	σ_z	0.018
Persistence of productivity shock	ρ_z	0.900
Bank distribution; $\mu(p) = p^{\lambda}$	λ	24
Diversion cost	θ	0.1
Storage technology	γ	0.936

- The model is solved numerically by a collocation method
- Discretize the TFP level (Tauchen and Hussey, 1991)
- Decision rule for a_{t+1} is approximated by a function of Chebychev polynomials
- The optimal decision rule is obtained as the fixed point solution to the Euler equation

IRF to a one-standard deviation TFP shock

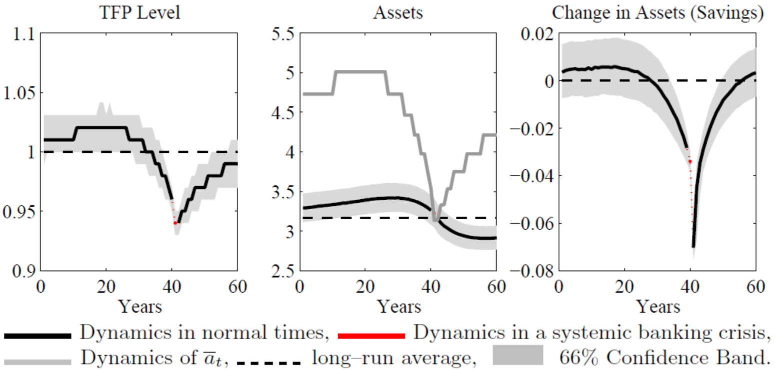


Note: Plain line : Average impulse response function across 100,000 simulations in the model, Dashed line: Average Impulse Response across simulations in the frictionless economy.

Quantitative Analysis

The role of savings behavior

Typical path to crisis with a constant savings rate (Solow)



Changes in standard parameters

Table 4: Sensitivity Analysis

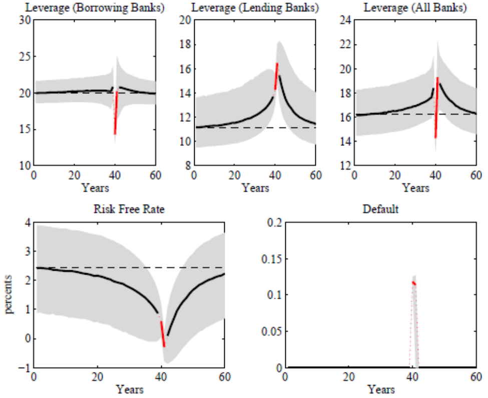
	Benchmark	σ		ν		θ	λ	σ_z	ρ_z
		2	10	0.25	1	0.20	35	0.02	0.95
Returns:									
Interbank (ρ)	0.86	1.04	0.23	0.84	0.83	0.40	1.34	0.89	0.72
Corporate (R)	4.35	4.55	3.70	4.28	4.41	5.50	3.70	4.32	4.29
deposit/equity (r)	2.64	2.96	1.61	2.52	2.80	2.61	2.67	2.55	2.59
Spread ($R-r$)	1.71	1.59	2.09	1.77	1.60	7 2.89	1.03	1.77	1.70
$\overline{R}$	2.43	2.43	2.43	2.43	2.43	4.83	0.41	2.43	2.43
Crises:									
Probability	2.69	1.20	5.43	3.31	0.99	7.34	0.16	3.35	1.90
Duration	2.62	1.89	4.08	2.90	1.97	5.06	1.87	2.82	2.92
Amplitude	17.87	17.30	19.00	19.94	11.96	16.90	15.80	19.36	16.08

Note: All numbers are averages over a long simulation of 500,000 periods and, except for durations, are expressed in percents. In the case where the persistence of the technology shock is raised to $\rho_z = 0.95$, the standard deviation of the innovation was rescaled so as to maintain constant the volatility of TFP.

Bank Leverage, Bank Defaults

- Absent frictions between banks and household, bank leverage is undetermined and bank default is not defined
- Two more assumptions to pin down leverage:
  - Bank deposits are safe assets (non state contingent return)
  - Bank managers are risk neutral (unlike household)
- One more assumption to introduce defaults:
  - Household (bank shareholder) has partial liability

Leverage and bank default dynamics along typical path



Dynamics in normal times, Dynamics in a systemic banking crisis, long–run average.

Bank balance sheets

Normal times	*Crisis times*
$\begin{array}{c\|c} A & L \\ \hline (1+\phi_t)\,a_t & a_t \\ & \phi_t a_t \end{array}$ $\quad p \geqslant \overline{p}_t$ $\longleftarrow$ $\begin{array}{c\|c} A & L \\ \hline & a_t \\ a_t & \end{array}$ $\quad p < \overline{p}_t$	$\begin{array}{c\|c} A & L \\ \hline a_t & a_t \\ & \end{array}$ $\quad p \geqslant \frac{\gamma}{R_t}$ $\begin{array}{c\|c} A & L \\ \hline & a_t \\ a_t & \end{array}$ $\quad p < \frac{\gamma}{R_t}$
Size is $a_t + (1-\mu(\overline{p}_t))\,\phi_t a_t$	Size is a_t