

Booms and Banking Crises

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- Better understand the dynamics of financial and real business cycles
- A few features are common to financial recessions (*i.e.* recessions concomitant with banking crises):
 - Fact #1: They are rare events
 - Fact #2: They are deeper and last longer
 - Fact #3: **Unlike other types of recessions, financial recessions follow credit booms**

Motivation/Objective

Financial recession statistics

| | Recessions | | | |
|---|------------|-------|----------|-------|
| | Financial | Other | Severe | Mild |
| Frequency (%) | 2.36 | 8.93 | 4.05 | 4.05 |
| Duration (years) | 2.32*** | 1.65 | 2.46*** | 1.25 |
| Magnitude (%) | -6.84*** | -3.75 | -9.28*** | -0.89 |
| Credit Boom | | | | |
| % credit growth 2 years before peak (a) | 4.56*** | 0.01 | 1.33 | 0.40 |
| Credit Crunch | | | | |
| % credit growth 2 years after peak (a) | -3.59* | -1.24 | -1.69 | -2.44 |

Source: Schularik et al. (2011), data for 14 OECD countries, 1870-2008. Crises defined as in Laeven and Valencia (2008); *, **, ***: the difference is statistically significant at 10%, 5%, 1%; (a) HP-filtered credit.

- In most DSGE models financial recessions are big negative shocks amplified
- Can explain Facts #1 & #2
- **Cannot explain Key Fact #3** ← crises are not random

- Textbook stochastic optimal growth model (RBC)
- Heterogenous banks with intermediation and storage technologies
- Interbank market subject to MH and AI
- A 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

- 1 Normal times feature productivity-driven business cycles with a small financial accelerator; a crisis every 42 years.

Main Results

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- 2 The **typical banking crisis follows an unusually long sequence of small, positive, transitory productivity shocks** — No need for a large negative financial shock

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- 3 High productivity generates a credit boom and a ballooning banking sector

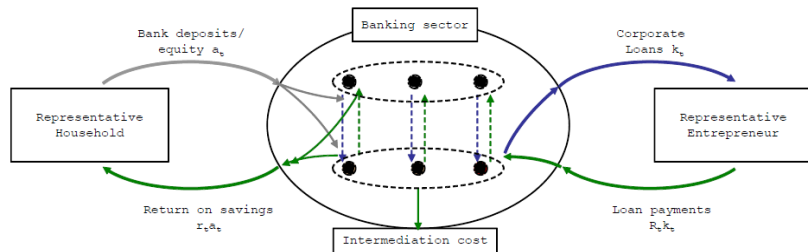
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- 5 The subsequent financial recession is deep and long because of a credit crunch; credit-to-GDP ratio predicts financial recessions

- Kiyotaki-Moore (1997), Bernanke-Gertler-Gilchrist (1999), Christiano-Motto-Rostagno (2013), Gertler-Kiyotaki (2009), Gertler-Karadi (2010):
 - ≠ Full equilibrium non-linearities, such as sudden bank runs
- Bianchi (2009), Bianchi-Mendoza (2010):
 - ≠ Endogenous interest rates play a key role
- Brunnermeier-Sannikov (2012), He-Krishnamurthy (2012):
 - ≠ Typical crisis follows a rare, long sequence of positive TFP shocks
 - ≠ Typical crisis identified as a bank run, not as a binding borrowing constraint
- Gertler-Kiyotaki (2012)
 - ≠ 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:

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

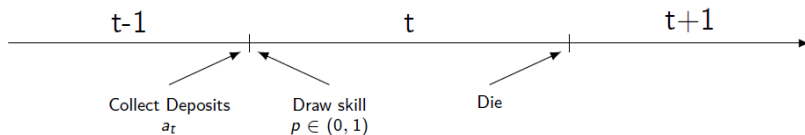
subject to budget constraint

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

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

The Banking Sector

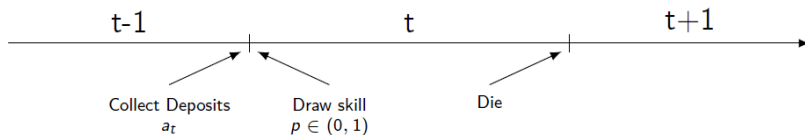
- Banks are atomistic, competitive, and price takers
- Continuum of heterogeneous 1-period banks p , with *cdf* $\mu(p)$ over $(0, 1)$



- 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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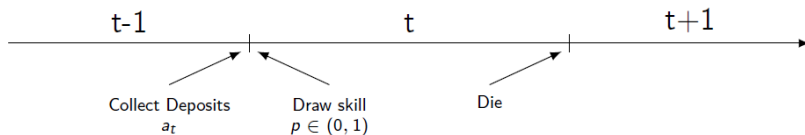
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- Bank p 's net return per unit of corporate loan is pR_t
- It is beneficial to relocate funds, but relocation is impaired due to:
 - **Asymmetric information:** p is private information
 - **Moral hazard:** bank p may borrow ϕ_t and walk away ("diversion")

- Bank p has 4 options:

1. Lend to other banks on the interbank market $\implies \rho_t$
2. Store goods $\implies \gamma$
3. Raise funds ϕ_t from interbank market and lend to firm
 $\implies pR_t(1 + \phi_t) - \rho_t\phi_t$
4. Raise funds ϕ_t from interbank market and walk away $\implies \gamma(1 + \theta\phi_t)$

- **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:

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

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

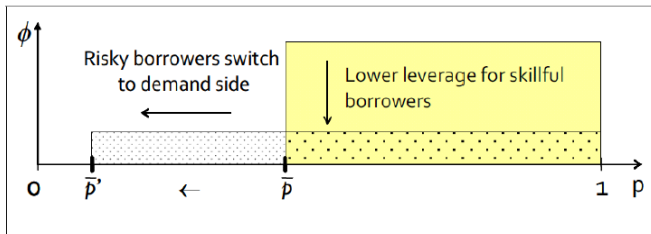
- Profits are fully distributed to household: $r_t \equiv \int_0^1 r_t(p) d\mu(p)$

Interbank Market Equilibrium

Interbank market clearing condition

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

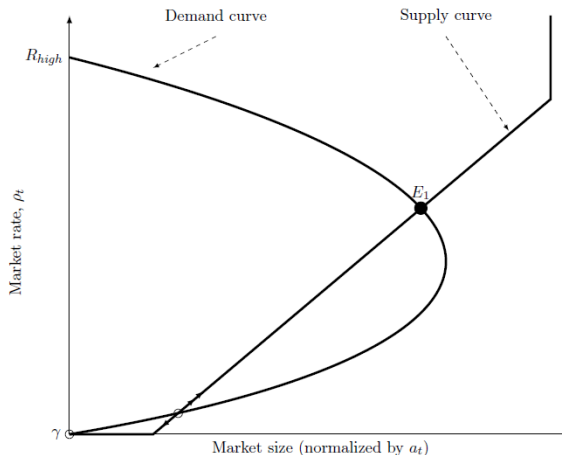
with $\bar{p}_t \equiv \rho_t / R_t$ and $\phi_t = (\rho_t - \gamma) / \theta \gamma$



Two opposite effects on aggregate demand of a decrease in ρ_t

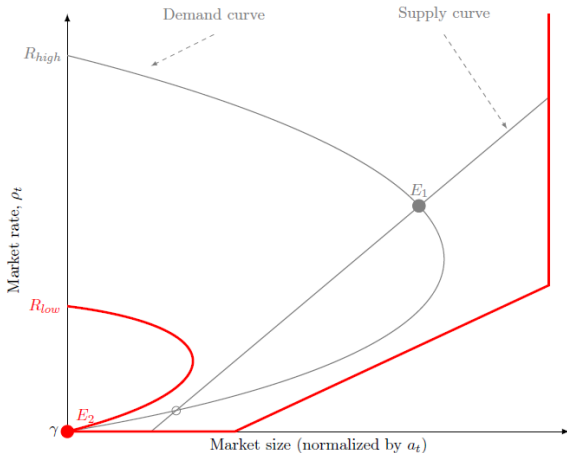
Interbank Market Equilibrium

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



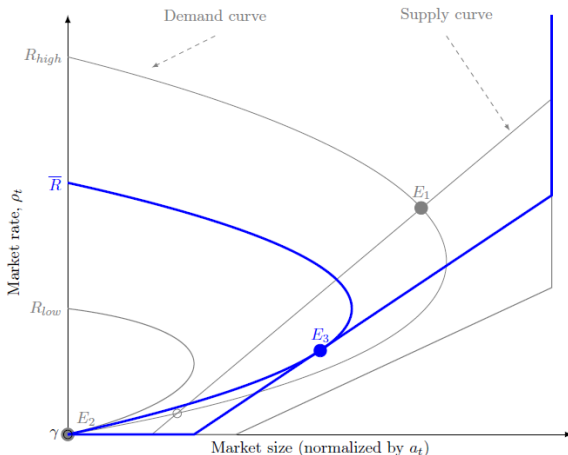
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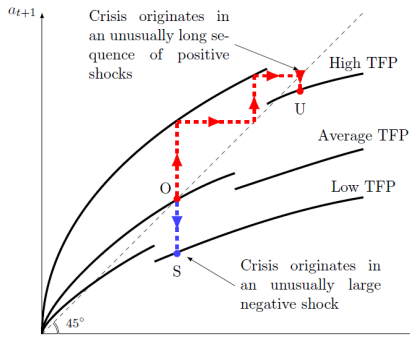


- **Proposition (Interbank loan market freeze):** *The interbank loan market is at work if and only if $a_t \leq \bar{a}_t \equiv f_k^{-1}(\bar{R} + \delta - 1; z_t)$, and freezes otherwise.*
- The interbank market improves efficiency but freezes when $R_t < \bar{R}$
- In general equilibrium, R_t is driven by savings (a_t) and technology (z_t). Hence the interbank market freezes when $a_t > \bar{a}(z_t)$
- **Threshold $\bar{a}(z_t)$ is the banking sector's "absorption capacity"**

- Calibration of the real side is standard
- Financial sector $(\gamma, \theta, \mu(.))$ is calibrated so that:
 - Crisis probability is 2.3%
 - Average interest rate spread is 1.7%
 - Average corporate loan rate of 4.4%
- The model is solved numerically by a collocation method

Quantitative Analysis

Optimal savings rule: exogenous versus endogenous crises

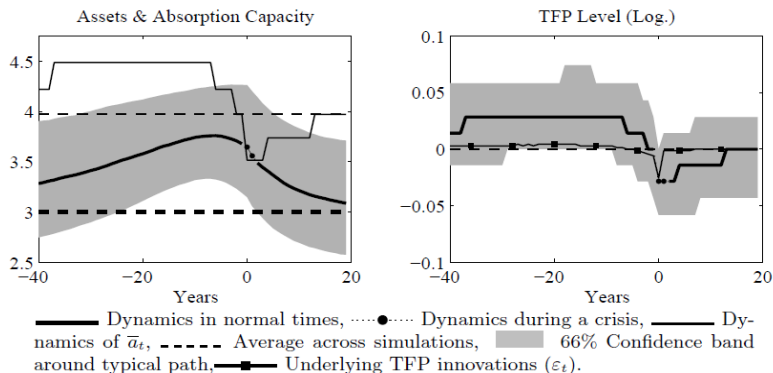


Note: Dashed line: 45° line where $a_{t+1} = a_t$.

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

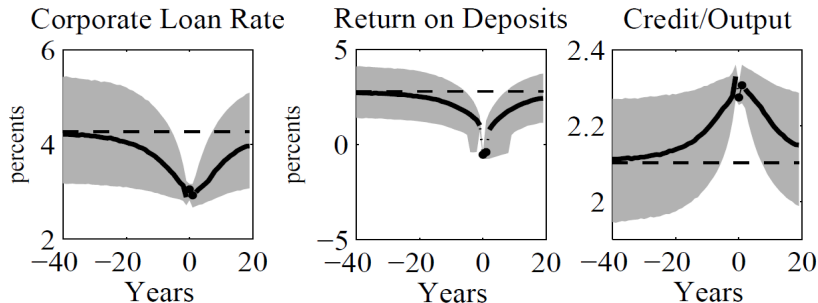
Quantitative Analysis

Typical path to crisis



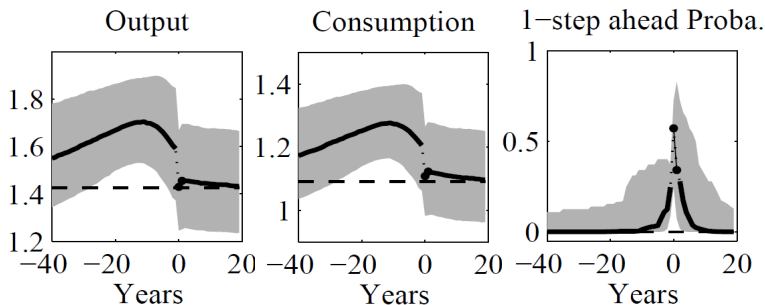
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Quantitative Analysis

Intuition

- 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**
- 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; interest rates go down
- ③ As the probability of a crisis increases, the household maintains savings to hedge against a more likely loss of revenue, which works to reduce interest rates and to raise the likelihood of a crisis even further — **saving glut externality**
- ④ A crisis breaks out as the corporate loan R_t rate crosses threshold \bar{R}

Quantitative Assessment

Financial recession statistics

| | Recessions | | | |
|---|------------|-------|--------|-------|
| | Financial | Other | Severe | Mild |
| Frequency (%) | 2.35 | 8.94 | 3.76 | 3.76 |
| Duration (years) | 2.08 | 1.39 | 2.22 | 1.04 |
| Magnitude (%) | -12.60 | -4.98 | -11.32 | -3.28 |
| Credit Boom | | | | |
| % credit growth 2 years before peak (a) | 3.81 | 0.11 | 2.33 | 0.06 |
| Credit Crunch | | | | |
| % credit growth 2 years after peak (a) | -5.09 | 0.09 | -2.97 | 0.02 |

(a) HP-filtered credit.

Welfare

%-Loss in permanent consumption

| Financial frictions | Deficient institutions | Externalities | Fin. under-development |
|---------------------|------------------------|---------------|------------------------|
| FBA – DEA | FBA – CEA | CEA – DEA | DEA – NIM |
| 2.20 | 1.53 | 0.61 | 4.61 |

FBA: First Best Allocation; DEA: Decentralized Equilibrium Allocation

CEA: Constrained Efficient Allocation; NIM: No Interbank Market

Concluding Remarks

- Develop a simple quantitative macro-model with banking crises, where crises are not caused by large, negative, financial shocks but rather by long sequences of small, positive, productivity shocks
- Credit booms are conducive to crises
- Highlight the role of consumption smoothing and saving glut externalities
- From a policy making perspective:
 - Framework for both crisis management and crisis prevention
 - DSGE-based probability of a crisis

THANK YOU

Return on Deposits and Corporate Loan Supply

- Return on deposits:

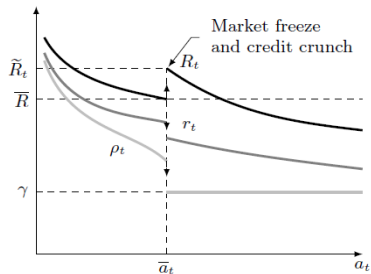
$$r_t = \begin{cases} R_t \int_{\bar{p}_t}^1 p \frac{d\mu(p)}{1-\mu(\bar{p}_t)} , & \text{if an equilibrium with trade exists} \\ R_t \left(\frac{\gamma}{R_t} \mu \left(\frac{\gamma}{R_t} \right) + \int_{\frac{\gamma}{R_t}}^1 p d\mu(p) \right) , & \text{otherwise.} \end{cases}$$

- Corporate loan supply

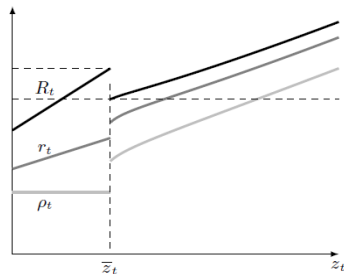
$$k_t^s = \begin{cases} a_t , & \text{if an equilibrium with trade exists} \\ \left(1 - \mu \left(\frac{\gamma}{R_t} \right) \right) a_t , & \text{otherwise} \end{cases}$$

Interest Rates

Endogenous and exogenous sources of instability

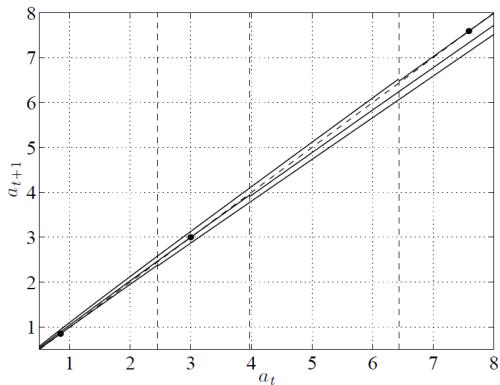


(a) Assets (a_t) as endogenous source of crisis



(b) Productivity (z_t) as exogenous source of crisis

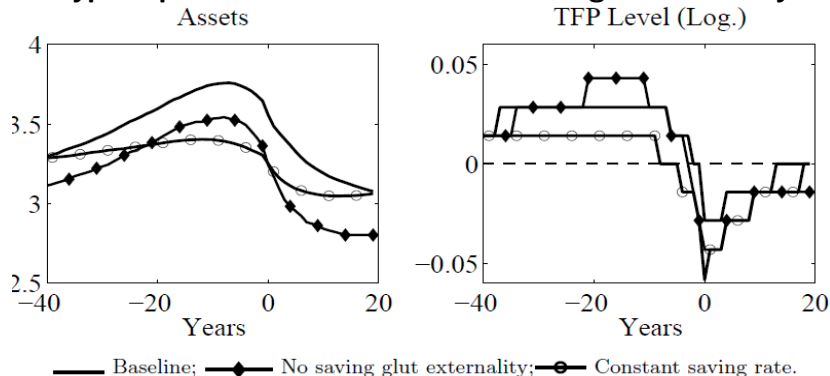
Optimal Decision Rules



Quantitative Analysis

Two counter-factual experiments

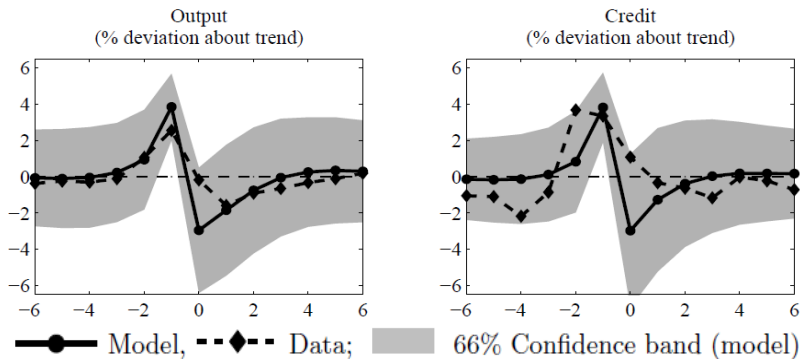
Typical paths to crisis without smoothing or externality



Quantitative Assessment

Dynamics of output and credit gaps around recessions

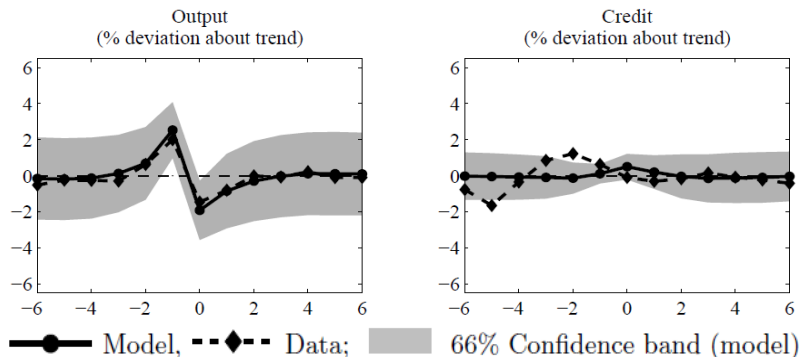
(a) Financial Recessions



Quantitative Assessment

Dynamics of output and credit gaps around recessions

(b) Normal Recessions



Crisis Prediction

Type-I and Type-II errors

| | Model Probability (benchmark) | Probability regressions | | | | Logit |
|--------------------|-------------------------------------|-------------------------|------------|-----------------|--------------|--------------|
| | | (1) z | (2) a | (3) (a, z) | (4) K/Y | (5) K/Y |
| R^2 | — | 0.03 | 0.55 | 0.69 | 0.72 | 0.38 |
| F-Test | — | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Type-I errors (%) | 31.43 | 100.00 | 72.50 | 56.87 | 36.79 | 35.97 |
| Type-II errors (%) | 4.85 | 0.00 | 4.11 | 5.55 | 4.92 | 5.16 |
| N. warnings | 30,215 | 0 | 22,020 | 30,439 | 29,911 | 31,089 |
| N. crises | 11,739 | 11,739 | 11,739 | 11,739 | 11,739 | 11,739 |
| N. obs (simul.) | 468,769 | 468,769 | 468,769 | 468,769 | 468,769 | 468,769 |

Sensitivity Analysis

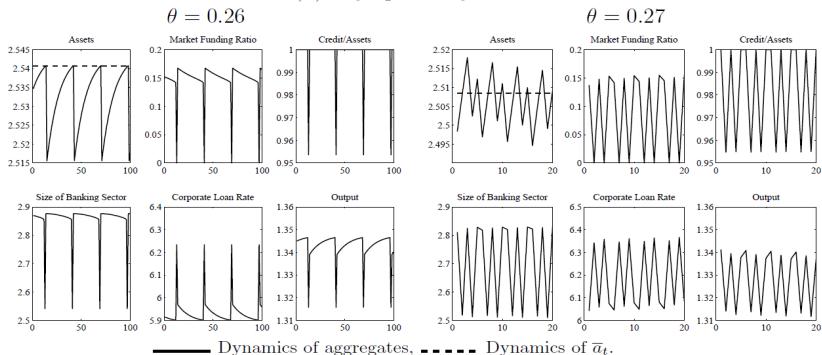
Financial recession statistics

| | Baseline | σ | ν | θ | λ | σ_z | ρ_z | Altern. |
|------------------|----------|----------|--------|----------|-----------|------------|----------|---------|
| | | 10 | 0.25 | 0.15 | 20 | 0.025 | 0.70 | TFP |
| Frequency (%) | 2.35 | 4.74 | 3.45 | 5.87 | 5.73 | 4.56 | 4.34 | 2.32 |
| Duration (years) | 2.08 | 1.75 | 2.31 | 1.72 | 1.84 | 2.09 | 2.22 | 1.99 |
| Magnitude (%) | -12.60 | -10.61 | -16.33 | -9.29 | -12.05 | -15.40 | -17.82 | -10.86 |

Endogenous Cycles

Two deterministic versions of the model (constant TFP)

(b) Asymptotic dynamics



Model With Both TFP and Financial Shocks

Typical path to crisis

