On the Instability of Banks and other Financial Intermediaries

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Introduction

- Do sunspots matter?
  - Shell; Cass & Shell ...
- Are financial intermediaries particularly prone to self- fullfilling prophecies?
  - Diamond & Dybvig; Wallace; Green & Lin; Peck & Shell; Ennis & Keister ...
- A venerable view: Yes, these institutions are inherently unstable and excessively volatile.
  - Even Friedman advocated bank regulation.
- We study this in several models of banking/intermediation.

The many functions of banks

- Provide insurance against liquidity shocks.
- Act as middlemen between savers and borrowers.
- Issue relatively safe liabilities used as payment instruments.
- Make investments on behalf of depositors.
- Screen and monitor investment opportunities.
- Engage in maturity transformation.
- Maintain privacy about their customers or assets.

This paper

- As there is no all-encompassing model of these actvities, we consider distinct three setups:
  - A dynamic Diamond-Dybvig model using ideas in Gu et al
  - Rubinstein-Wolinsky middlemen in a Duffie et al OTC market
  - Bank liabilities as payment instruments as in He et al
- In each case we show financial intermediation engenders instability – it makes more likely:
  - multiple steady states
  - cyclic, chaotic and stochastic dynamics

Model 1: Banking and insurance

- Time is discrete and infinite. Each period has two subperiods.
- Agents:
  - A continuum of one-period-lived households born in each t
  - Some infinitely-lived candidate bankers
- Preferences:
  - Households: $u_1(c_1)$ with prob π, $u_2(c_2)$ with prob $1-\pi$.
  - Bankers: $v(c_2)$
- Endowment:
  - Households: endowed with 1 unit of consumption.
  - Bankers: nothing
- Technology: storage or $x \longrightarrow \begin{cases} x & \text{in subperiod 1} \\ Rx & \text{in subperiod 2} \end{cases}$

Friction – private information

- Preference types are unobservable.
- Incentive compatible contract among households:

$$\max_{c_1, c_2} \pi u_1(c_1) + (1-\pi) u_2(c_2)$$
$$\text{st} \ (1-\pi) c_2 = (1 - \pi c_1) R$$
$$c_2 \geq c_1$$

- Standard assumptions imply the efficient arrangement is incentive feasible with $1 < c_1^* < c_2^* < R$.

Friction – limited commitment

- Agents may fail to deliver the goods
  - Households: finite lives imply punishment as in Kehoe-Levine are unavailable
  - Bankers: infinite live implies reputation can sustain some creditability
- Households might delegate some investment to bankers (Gu et al; Huang).

Delegated investment

- Banker:
  - accepts deposits d
  - gets bR at the end of period
  - can abscond with d for opportunistic payoff λd
  - is monitored with probability μ
  - and punished to autarky if misbehavior is detected
- Banker incentive constraint:

$$v\left(b_t R\right) + \beta V_{t+1} \geq \lambda d_t + \beta\left(1-\mu\right) V_{t+1}$$
$$\Longrightarrow \lambda d_t - v\left(b_t R\right) \leq \beta\mu V_{t+1} \equiv \phi_t$$

where ϕ is (proportional to) bank's franchise value.

Bank contract problem

$$\max_{d,r_1,r_2,b} \pi u_1 \left(dr_1 + 1 - d \right) + \left(1 - \pi \right) u_2 \left(dr_2 + \left(1 - d \right) R \right)$$

$$\text{st} \;\; \left(1 - \pi \right) dr_2 = \left(d - b - \pi dr_1 \right) R$$

$$r_2 \geq r_1$$

$$\phi_t \geq \lambda d_t - v \left(b_t R \right)$$

$$r_1, r_2 \geq 0$$

$$0 \leq d \leq 1, \; b \geq 0$$

Solution: three cases

$\exists\ \hat{\phi} > 0$ and $\tilde{\phi} < \hat{\phi}$ such that

1. $\phi > \hat{\phi} \implies$ IC loose $\implies d = 1,\ b = 0$ is a solution

   there are other payoff equivalent contracts (Peck & Valipour).

1. $\tilde{\phi} \leq \phi < \hat{\phi} \implies$ IC medium $\implies d < 1,\ b = 0.$
2. $\phi < \tilde{\phi} \implies$ IC tight $\implies d < 1,\ b > 0.$

Static partial equilibrium

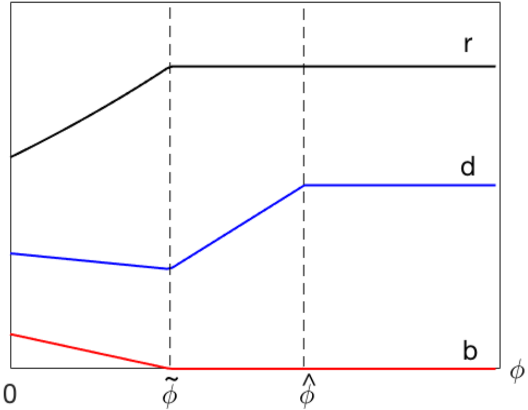


Figure: (d, r, b) vs ϕ

Dynamic general equilibrium

- Banker's value equation

$$V_t = v\left(b_t R\right) + \beta V_{t+1}$$

- Use $\phi_t \equiv \beta\mu V_{t+1}$ to get

$$\phi_{t-1} = f\left(\phi_t\right) \equiv \beta\mu v\left[b\left(\phi_t\right) R\right] + \beta\phi_t.$$

Proposition: $\exists!$ stationary equilibrium. If **C** (a parameter condition) holds there is banking and $\bar{\phi} \in (0, \tilde{\phi})$; if **C** fails there is no banking.

Proposition: For some parameters $\exists$ nonstationary equilibria.

Examples

- Utility functions:
  - $v(c) = A_0 c$
  - $u_1(c) = A_1 \frac{(c+\varepsilon)^{1-\sigma_1} - \varepsilon^{1-\sigma_1}}{1-\sigma_1}$

    $u_2(c) = A_2 \frac{(c+\varepsilon)^{1-\sigma_2} - \varepsilon^{1-\sigma_2}}{1-\sigma_2}$
- Parameter values:

  $A_0 = 0.95,\ A_1 = 1,\ A_2 = 0.1,\ \sigma_1 = \sigma_2 = 1.5,\ \varepsilon = 0.01,$

  $R = 2.1,\ \pi = 0.2,\ \lambda = 0.6,\ \beta = 0.7,\ \mu = 0.7.$
- Vary σ's for different examples.

Example with unique equilibrium

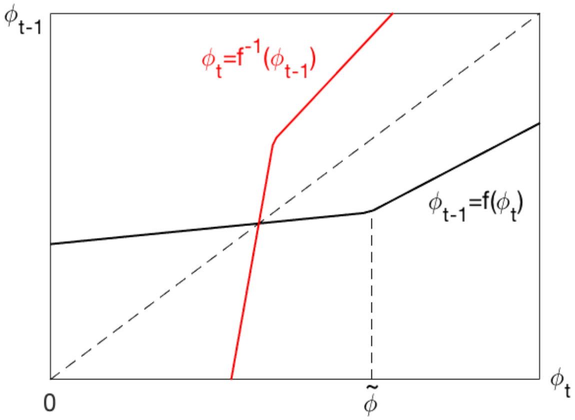


Figure: monotone f

Example with two-cycles and sunspot equil

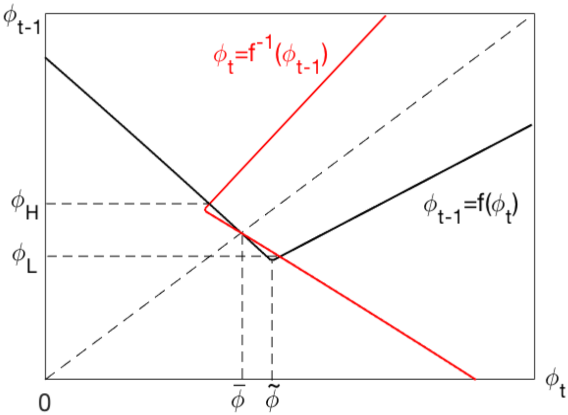
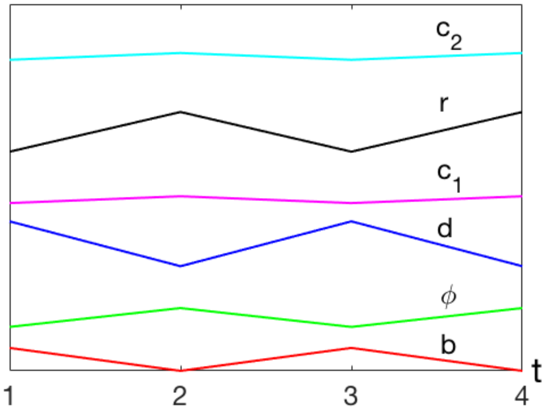


Figure: nonmonotone f

Banking activity over the cycle



Example with three-cycles and chaos

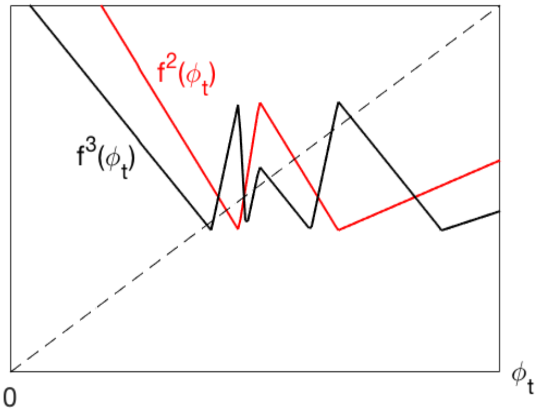


Figure: cycles

Summary

Message:

- Banking is essential: if eliminated, payoffs go down.
- But it does engender instability: the equil set with (without) banking does (does not) admit cycles, chaos and sunspots.

Intuition:

- If bank franchise value V_{t+1} is high his current salary b_t can be low and still satisfy IC thus making current value V_t low.
- This can dominate the linear term in $V_t = v\left(b_t R\right) + \beta V_{t+1}$, leading to nonmonotone dynamics.

Model 2: Asset Market Intermediation

- Time is discrete and infinite.
- Agents
  - Buyers and sellers: one-period lived, replaced by "clones"
  - Middlemen: infinitely lived
- Sellers endowed with 1 unit of capital.
- Buyers can transform capital into π units of cons good, random with cdf $F(\pi)$.
- Preferences: linear utility of cons; TU for payments.
- Agents meet bilaterally.
- Entry by sellers or buyers or middlemen.

Agent's problem

Let $\Delta_t \equiv V_{1,t} - V_{0,t}$ and $R_t \equiv (1-\delta)\,\beta\Delta_{t+1}$

- Buyer:

$$V_{b,t}(\pi) = \frac{\alpha n_{s,t}}{N_t}\theta_{bs}\pi + \frac{\alpha n_t}{N_t}\tau(\pi, R_t)\,\theta_{bm}\left[\pi - (1-\delta)\,\beta\Delta_{t+1}\right]$$

- Seller:

$$V_{s,t} = \frac{\alpha n_b}{N_t}\theta_{sb}\mathbb{E}\pi + \frac{\alpha(n_m - n_t)}{N_t}\theta_{sm}\,(1-\delta)\,\beta\Delta_{t+1}$$

- Middleman:

$$\begin{aligned} V_{0,t} &= \frac{\alpha n_{s,t}}{N_t}\theta_{ms}R_t + \beta V_{0,t+1} \\ V_{1,t} &= \rho + \frac{\alpha n_b}{N_t}\theta_{mb}\int_{R_t}^{\infty}(\pi - R_t)\,dF(\pi) \\ &\quad +(1-\delta)\beta V_{1,t+1} + \delta\beta V_{0,t+1}. \end{aligned}$$

Equilibrium

- The value functions reduce to

$$R_{t-1} = (1-\delta)\,\beta\left\{\rho + R_t + \frac{\alpha n_b \theta_{mb}}{N_t}\int_{R_t}^{\infty}\left[1 - F(\pi)\right] d\pi - \frac{\alpha n_{s,t}\theta_{ms}}{N_t} R_t\right\}$$

- Law of motion of middlemen with inventory:

$$n_{t+1} = g(n_t, N_t, R_t)$$

- Free entry

$$n_{s,t} = h(n_t, R_t)$$

- Equilibrium is a two-dimensional dynamical system,

$$\begin{bmatrix} n_{t+1} \\ R_{t-1} \end{bmatrix} = \begin{bmatrix} f(n_t, R_t) \\ g(n_t, R_t) \end{bmatrix}$$

Steady states for a degenerate dist'n

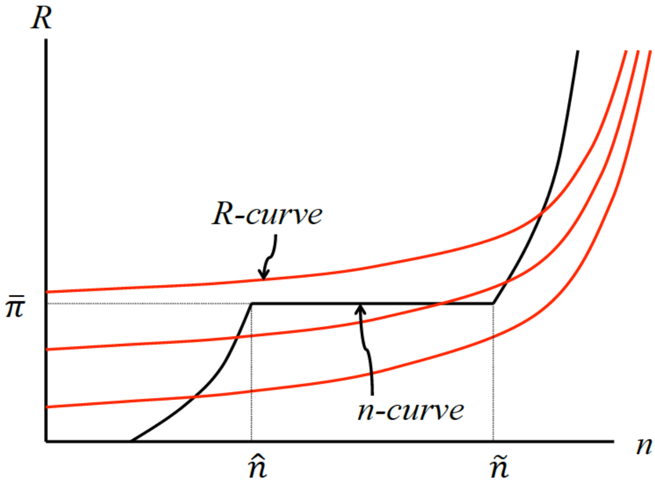


Figure: The n-curve and R-curve for different ρ

Steady state

Proposition: Consider entry by type S and $\pi = \bar{\pi}$. There exist $\tilde{\rho} > 0$ and $\hat{\rho} > \tilde{\rho}$ such that:

1. $\rho \in [0, \tilde{\rho})$ implies there is a unique steady state and it entails $R < \bar{\pi}$;
2. $\rho \in (\hat{\rho}, \infty)$ there is a unique steady state and it entails $R > \bar{\pi}$; and
3. $\rho \in (\tilde{\rho}, \hat{\rho})$ implies there are three steady states, one with $R < \bar{\pi}$, one with $R > \bar{\pi}$, and one with $R = \bar{\pi}$.

Steady state

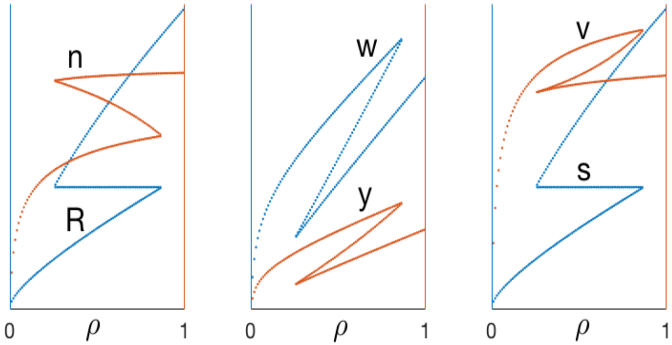


Figure: The equilibrium correspondence

Cycles

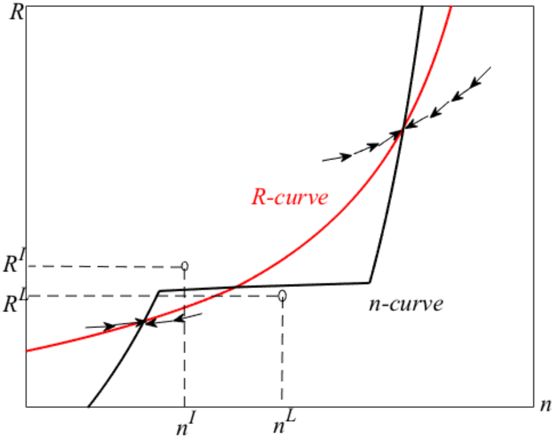


Figure: Phase plane with entry by S, including a two-cycle

Cycles

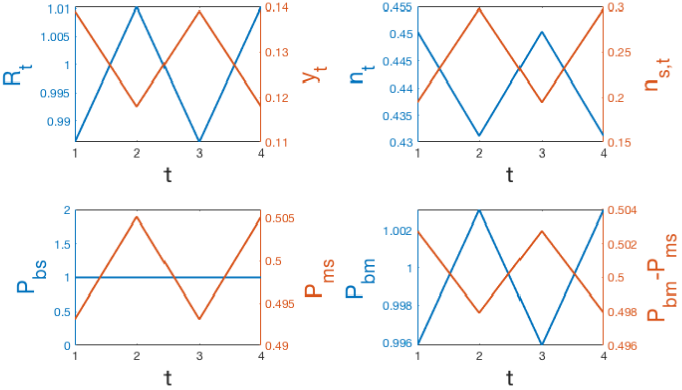


Figure: Time series for a two-period cycle with entry by S

Summary

Message:

- Asset market intermediation can be essential.
- But does engender instability: the equil set with (without) banking does (does not) admit multiple steady states, cycles, chaos and sunspots.

Intuition:

- Strategic complementarity between M and S.
- Trading by M leads to entry by S leads to trading by M.

Model 3: Safety and Liquidity

- Continuum of infinitely-lived buyers b and sellers s.
- Each period has two markets convene:
  - DM: s agents sell q and b agents buy q
  - CM: all trade (x, ℓ), adjust portfolios, settle debts
- Utility: $U(x) - \ell + u(q)$ & $U(x) - \ell - c(q)$
- An asset in fixed supply (tree) can be held in two ways:
  - a_1 : safe but illiquid,
  - a_2 : less safe but liquid

CM problem

- Let $A = (\phi + \rho)(a_1 + a_2)$.

$$
\begin{aligned}
W_t(A_t) &= \max_{x_t, \ell_t, \hat{\mathbf{a}}_t} \left\{ U(x_t) - \ell_t + \beta V_t(\hat{\mathbf{a}}_t) \right\} \\
\text{st } x_t &= A_t + \ell_t - \phi_t (\hat{a}_{1,t} + \hat{a}_{2,t})
\end{aligned}
$$

- Standard results: $W_t(A_t)$ linear.
- FOC for demand for $\hat{a}_{j,t+1}$:

$$
\hat{a}_{j,t+1} \left[-\phi_t + \beta \frac{\partial V_{t+1}(\hat{\mathbf{a}}_{t+1})}{\partial \hat{a}_{j,t+1}} \right] = 0
$$

DM problem

- A general trading mechanism $p = v(q)$, where $p \leq (\phi + \rho)\, a_2$

$$\begin{aligned} V_t(\hat{\mathbf{a}}_t) &= (1-\delta)\left\{W_t(A_t) + \alpha\left[u(q_t) - v(q_t)\right]\right\} \\ &\quad + \delta W_{t+1}\left[(\phi_t + \rho)\, \hat{a}_{1,t}\right] \end{aligned}$$

- Euler equations:

$$\begin{aligned} 0 &= \hat{a}_{1,t}\left[\beta\left(\phi_{t+1} + \rho\right) - \phi_t\right] \\ 0 &= \hat{a}_{2,t}\left\{\beta\left(\phi_{t+1} + \rho\right)(1-\delta)\left[1 + \alpha\lambda(q_{t+1})\right] - \phi_t\right\} \end{aligned}$$

where $\lambda(q) = u'(q)/v'(q) - 1$.

Steady states

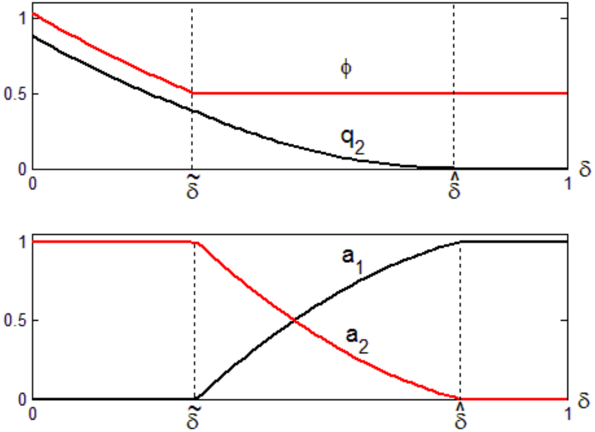


Figure: Steady State Regimes

Equilibrium without banking

Suppose $\delta < \hat{\delta}$. The dynamic system is

$$\phi_{t-1} = \begin{cases} \beta\left(\phi_t + \rho\right)\left(1-\delta\right)\left[1 + \alpha\lambda \circ v^{-1}\left(\phi_t + \rho\right)\right] & \text{if } \phi_t < \tilde{\phi}_0 \\ \beta\left(\phi_t + \rho\right) & \text{if } \phi_t \geq \tilde{\phi}_0 \end{cases}$$

where $\alpha\lambda \circ v^{-1}\left(\bar{\phi}_0 + \rho\right) = \delta / \left(1-\delta\right)$

Equilibrium without banking

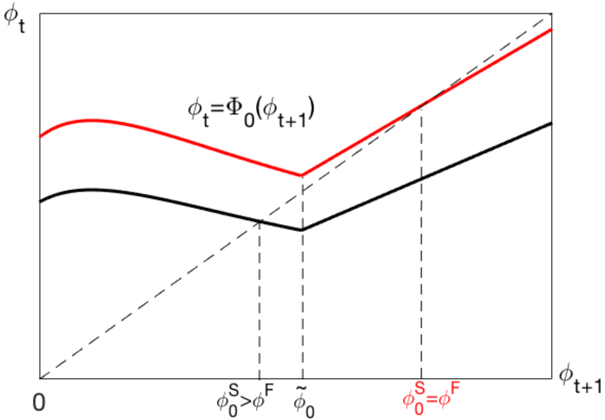


Figure: Dynamic equilibrium

Banking

- Asset can be deposited at a bank with return $\iota = \rho$ and $\delta = 0$.
- Equilibrium:

$$\phi_{t-1} = \begin{cases} \beta(\phi_t + \rho)\left[1 + \alpha\lambda \circ v^{-1}(\phi_t + \rho)\right] & \text{if } \phi_t < \bar{\phi}_1 \\ \beta(\phi_t + \rho) & \text{if } \phi_t \geq \bar{\phi}_1 \end{cases}$$

where $\lambda \circ v^{-1}(\bar{\phi}_1 + \rho) = 0$

Equilibrium with banking

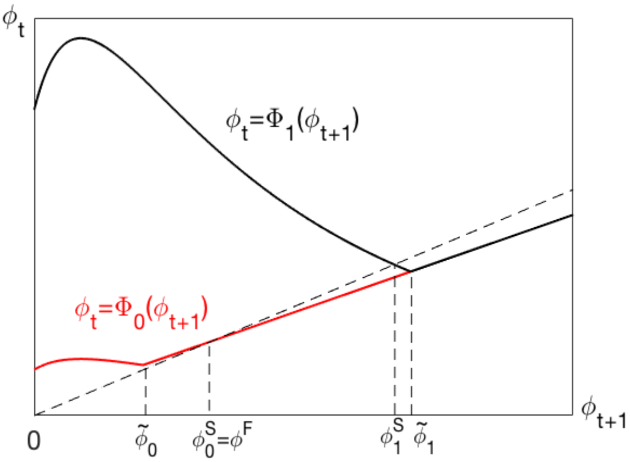


Figure: Equilibrium with banking

Summary

Message:

- Banking is essential.
- But does engender instability: the equilibrium set includes cycles, chaos and sunspots for more parameters if there is banking.

Intuition:

- The liquidity premium is decreasing an asset's value, and may dominate the linear term in the asset-pricing eqn.
- The liquidity premium is amplified when the asset is safer.

Conclusion

- "Banks, as several banking crisis throughout history have demonstrated, are fragile institutions. This is to a large extent unavoidable and is the direct result of the core functions they perform in the economy." *Finance Market Watch.*
- We study this idea by building three models of financial intermediation that are explicit about their core functions – models *of* these institutions, not just models *with* these institutions.
- Finding: these are socially useful institutions but are indeed prone to excess volatility or multiplicity.