On the Instability of Banks and other Financial Intermediaries

Chao Gu
University of Missouri

Cyril Monnet
University of Berne

Ed Nosal
FRB Atlanta

Randall Wright
University of Wisconsin
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.
As there is no all-encompassing model of these activities, 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 $\pi$, $u_2(c_2)$ with prob $1 - \pi$.
  - Bankers: $v(c_2)$
- Endowment:
  - Households: endowed with 1 unit of consumption.
  - Bankers: nothing
- Technology: storage or $x \rightarrow \begin{cases} x & \text{in subperiod 1} \\ Rx & \text{in subperiod 2} \end{cases}$
Friction – private information

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

\[
\max_{c_1, c_2} \pi u_1 (c_1) + (1 - \pi) u_2 (c_2)
\]

s.t. \((1 - \pi) c_2 = (1 - \pi c_1) R\)

\[c_2 \geq c_1\]

- 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 $\lambda d$
  - is monitored with probability $\mu$
  - and punished to autarky if misbehavior is detected

- Banker incentive constraint:

$$v(b_t R) + \beta V_{t+1} \geq \lambda d_t + \beta (1 - \mu) V_{t+1}$$

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

where $\phi$ is (proportional to) bank’s franchise value.
Bank contract problem

\[
\begin{align*}
\max_{d,r_1,r_2,b} & \quad \pi u_1 (dr_1 + 1 - d) + (1 - \pi) u_2 (dr_2 + (1 - d) R) \\
\text{st} & \quad (1 - \pi) dr_2 = (d - b - \pi dr_1) R \\
& \quad r_2 \geq r_1 \\
& \quad \phi_t \geq \lambda d_t - \nu (b_t R) \\
& \quad r_1, r_2 \geq 0 \\
& \quad 0 \leq d \leq 1, \ b \geq 0
\end{align*}
\]
Solution: three cases

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

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

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

1. \( \tilde{\phi} \leq \phi < \hat{\phi} \implies \text{IC medium} \implies d < 1, b = 0. \)

2. \( \phi < \tilde{\phi} \implies \text{IC tight} \implies d < 1, b > 0. \)
Static partial equilibrium

Figure: \((d, r, b)\) vs \(\phi\)
Dynamic general equilibrium

- Banker’s value equation

\[ V_t = \nu (b_t R) + \beta V_{t+1} \]

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

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

**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:
  - $v(c) = A_0 c$
  - $u_1(c) = A_1 \frac{(c + \epsilon)^{1-\sigma_1} - \epsilon^{1-\sigma_1}}{1 - \sigma_1}$
  - $u_2(c) = A_2 \frac{(c + \epsilon)^{1-\sigma_2} - \epsilon^{1-\sigma_2}}{1 - \sigma_2}$

- Parameter values:
  - $A_0 = 0.95, A_1 = 1, A_2 = 0.1, \sigma_1 = \sigma_2 = 1.5, \epsilon = 0.01,$
  - $R = 2.1, \pi = 0.2, \lambda = 0.6, \beta = 0.7, \mu = 0.7.$

- Vary $\sigma$’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 $V_t = \nu (b_t R) + \beta V_{t+1}$, 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 $\pi$ 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:**
  
  \[
  V_{b,t} (\pi) = \frac{\alpha n_{s,t}}{N_t} \theta_{bs} \pi + \frac{\alpha n_t}{N_t} \tau (\pi, R_t) \theta_{bm} [\pi - (1 - \delta) \beta \Delta_{t+1}]
  \]

- **Seller:**
  
  \[
  V_{s,t} = \frac{\alpha n_b}{N_t} \theta_{sb} E \pi + \frac{\alpha (n_m - n_t)}{N_t} \theta_{sm} (1 - \delta) \beta \Delta_{t+1}
  \]

- **Middleman:**
  
  \[
  V_{0,t} = \frac{\alpha n_{s,t}}{N_t} \theta_{ms} R_t + \beta V_{0,t+1}
  \]

  \[
  V_{1,t} = \rho + \frac{\alpha n_b}{N_t} \theta_{mb} \int_{R_t}^{\infty} (\pi - R_t) dF (\pi) + (1 - \delta) \beta V_{1,t+1} + \delta \beta V_{0,t+1}.
  \]
Equilibrium

- The value functions reduce to

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

- 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 $\rho$
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
Figure: Time series for a two-period cycle with entry by $S$
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 $(x, \ell)$, 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
Let $A = (\phi + \rho)(a_1 + a_2)$.

$$W_t(A_t) = \max_{x_t, \ell_t, \hat{a}_t} \{U(x_t) - \ell_t + \beta V_t(\hat{a}_t)\}$$

$$\text{st } x_t = A_t + \ell_t - \phi_t (\hat{a}_{1,t} + \hat{a}_{2,t})$$

Standard results: $W_t(A_t)$ linear.

FOC for demand for $\hat{a}_{j,t+1}$:

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

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

\[
V_t(a_t) = (1 - \delta) \left\{ W_t(A_t) + \alpha \left[ u(q_t) - v(q_t) \right] \right\} \\
+ \delta W_{t+1} \left[ (\phi_t + \rho) \ a_1,t \right]
\]

- Euler equations:

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

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

Figure: Steady State Regimes
Suppose $\delta < \hat{\delta}$. The dynamic system is

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

where $\alpha \lambda \circ v^{-1} (\tilde{\phi}_0 + \rho) = \delta / (1 - \delta)$
Equilibrium without banking

Figure: Dynamic equilibrium
Asset can be deposited at a bank with return \( i = \rho \) and \( \delta = 0 \).

**Equilibrium:**

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

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