Banks and Liquidity Crises in Emerging Market Economies

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After financial liberalizations in the 1980s, crises have become more frequent and more costly events.

Emerging markets experienced a banking or currency crisis or both.

Examples:

Facts

1. Capital inflow increases the probability and size of a banking crisis.

2. Financial institutions take on significant amounts of short-term debt relative to liquid reserves.

3. A banking crisis is closely linked to an asset-price boom and burst.
**“Sudden Stops”**

Current Account Balance of ASEAN-5 (% of GDP)

- **Thailand**
- **Korea**
- **Indonesia**
- **Malaysia**
- **Philippines**
Too Much Short-Term Foreign Debt

- Short-Term Debt To International Reserves Ratio:

<table>
<thead>
<tr>
<th></th>
<th>Indonesia</th>
<th>Korea</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
<th>Asia-5</th>
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<tbody>
<tr>
<td>June 94</td>
<td>1.73</td>
<td>1.61</td>
<td>0.25</td>
<td>0.40</td>
<td>0.99</td>
<td>0.92</td>
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<td>June 97</td>
<td>1.70</td>
<td>2.06</td>
<td>0.61</td>
<td>0.85</td>
<td>1.45</td>
<td>1.43</td>
</tr>
</tbody>
</table>

source: Chang and Velasco (1998)
Collapse of Asset Prices

Stock market capitalization to GDP (%)

Years


0 50 100 150 200 250 300

Stock market capitalization to GDP (%)

Thailand
Korea
Indonesia
Malaysia
Philippines
The aim of this paper

- Develop a theory with **financial markets** and **financial institutions**
- Show
  - how these interactions cause economy-wide banking crises.
  - capital inflow increases the asset price volatility and the size of a crisis
- Ask: Can public policies stabilize the financial system?
  - liquidity regulation
  - public deposit insurance
Main Results

- The model generates two types of equilibria:
  - a no-default equilibrium
    - banks have enough liquidity to pay all depositors during bank runs
    - all banks remain solvent.
  - a mixed-equilibrium.
    - ex ante identical banks choose different strategies
    - some banks default with positive probability
    - the asset price is more volatile.
    - defaulting banks increase as capital inflow increases

- Liquidity regulation may stabilize the financial system, but public deposit insurance may not.
Related Literature

- **Multiple equilibria:**

- **Fundamental bank runs:**
  - Allen & Gale (2000a,b)

- **Financial frictions:**
The Model

- Three periods, $t = 0, 1, 2$.
- A $[0, 1]$ continuum of ex ante identical agents.
- Each agent has an endowment only in $t = 0$.
- Diamond-Dybvig preferences:
  - “early consumer” (consume at $t = 1$) with prob. $\lambda_\theta$
  - “late consumer” (consume at $t = 2$) with prob. $1 - \lambda_\theta$
- Aggregate uncertainty:
  \[
  \lambda_\theta = \begin{cases} 
  \lambda_L \quad \text{with prob. } \pi, \\
  \lambda_H \quad \text{with prob. } 1 - \pi,
  \end{cases}
  \]
  where $0 < \lambda_L < \lambda_H$ and $0 < \pi < 1$. 
Two types of assets:
- a short asset \((y)\) = less productive but liquid
- a long asset \((x)\) = productive but illiquid

Competitive (interbank) asset market at \(t = 1\).
- \(P_\theta\) = the price of the long asset
- **International capital market:**
  - international creditors are risk neutral.
  - the net interest rate is zero.

- **Assumptions:**
  - International creditors can not access to the domestic asset market.
  - Only banks can access to the international capital market.
  - Borrowing limit $f$
Banks offer \((c_1, c_{2L}, c_{2H})\) and collect funds at \(t = 0\).
- non-contingent (incomplete) deposit contract
- \(c_1\) is fixed at \(t = 0\).

Banks can access to the asset market at \(t = 1\)
- buy or sell the long asset
- agents are excluded

Banks can access to the international capital market at \(t = 0, 1, 2\)
- lend as much as possible
- borrow at most the amount \(f > 0\)
The timing of events

- **In period 0:**
  - agents deposit all their endowments
  - banks borrow funds in the international market
  - banks divide deposits between short and long assets.

- **In period 1:**
  - state and depositors’ types have been realized
  - the asset market opens.
  - some depositors receive payments \( c_1 \) from the banks.
  - banks repay short-term foreign debt \( b_{01} \) and borrow short term \( b_{1\theta} \).

- **In period 2:**
  - remaining depositors withdraw their deposits from the banks
  - they consume \( c_2 \).
  - banks repay short-term \( b_{1\theta} \) and long-term foreign debt \( b_{02} \).
The Model

Constrained Efficient Allocation

The planner’s problem

\[
\max E_\theta[\lambda u(c_1) + (1 - \lambda) u(c_{2\theta})],
\]

subject to

\[
\begin{align*}
x + y & \leq 1 + b_{01} + b_{02}, \\
\lambda c_1 + b_{01} & \leq y + b_{1\theta}, \\
(1 - \lambda)c_{2\theta} + b_{1\theta} + b_{02} & \leq R x + (y + b_{1\theta} - b_{01} - \lambda c_1), \\
b_{01} + b_{02} & \leq f, \\
b_{1\theta} + b_{02} & \leq f, \\
c_1 & \leq c_{2\theta}.
\end{align*}
\]
The Model

Constrained Efficient Allocation

Since $R > 1$, the international borrowing constraints are binding

\[ b_{01} + b_{02} = f, \]
\[ b_{1H} + b_{02} = f. \]

At the optimum,

\[ \lambda_H c_1 = y + b_{1H} - b_{01} = y. \]

Then,

\[ (1 - \lambda_H)c_{2H} = Rx - f. \]
Constrained Efficient Allocation

- FOC:
  \[
  \frac{\pi \lambda_L + (1 - \pi)\lambda_H}{\lambda_H} u' \left( \frac{y}{\lambda_H} \right) - \pi \left( R - 1 + \frac{\lambda_L}{\lambda_H} \right) u' \left( \frac{R(1 + f) - f - (R - 1 + \frac{\lambda_L}{\lambda_H})y}{1 - \lambda_L} \right) - R(1 - \pi) u' \left( \frac{R(1 + f - y) - f}{1 - \lambda_H} \right) = 0. \tag{1}
  \]

- Optimal levels of consumption:
  \[
  c_1^* = \frac{y^*}{\lambda_H}, \quad c_{2H}^* = \frac{R(1 + f - y^*) - f}{1 - \lambda_H}, \quad c_{2L}^* = \frac{R(1 + f) - f - (R - 1 + \frac{\lambda_L}{\lambda_H})y^*}{1 - \lambda_L}.
  \]

- Optimal foreign debt structure \((b_{01}, \{b_{1\theta}\}_{\theta=L,H}, b_{02})\) is indeterminate.
Decentralized Banking Economy

Two types of equilibria:
- a no-default equilibrium
  - all banks are symmetric and take a safe portfolio.
  - all banks remain solvent.
- a mixed-equilibrium.
  - ex ante identical banks choose different strategies
  - some banks default with positive probability
Consider first an equilibrium in which all banks offer a \textit{run-preventing contract}.

The problem of banks:

\[
\begin{align*}
\max & \quad E_\theta [\lambda_\theta u(c_1) + (1 - \lambda_\theta) u(c_{2\theta})], \\
\text{s.t.} & \quad x + y \leq 1 + b_{01} + b_{02}, \\
& \quad \lambda_\theta c_1 + b_{01} \leq y + b_{1\theta}, \quad \forall \theta, \\
& \quad (1 - \lambda_\theta) c_{2\theta} + b_{1\theta} + b_{02} \leq R \left( x + \frac{y + b_{1\theta} - b_{01} - \lambda_\theta c_1}{P_\theta} \right), \quad \forall \theta, \\
& \quad b_{01} + b_{02} \leq f, \\
& \quad b_{1\theta} + b_{02} \leq f, \quad \forall \theta, \\
& \quad c_1 \leq c_{2\theta}, \quad \forall \theta.
\end{align*}
\]
The no default equilibrium (2)

- **FOCs:**

\[ \left[ \pi \lambda_L + (1 - \pi) \lambda_H \right] u'(c_1) = \pi \lambda_L \frac{R}{P_L} u'(c_{2L}) + (1 - \pi) \lambda_H \frac{R}{P_H} u'(c_{2H}), \tag{2} \]
\[ \pi \left(1 - \frac{1}{P_L}\right) u'(c_{2L}) \leq (1 - \pi) \left(\frac{1}{P_H} - 1\right) u'(c_{2H}), \tag{3} \]

with equality if \( y < 1 + f \)

- The asset market at period 1 clears if

\[ \lambda_L c_1 < \lambda_H c_1 = y. \tag{4} \]

- Since \( \lambda_L c_1 < y \), excess liquidity at period 1 in state \( L \):

\[ P_L = R. \tag{5} \]
The no default equilibrium (3)

- Combining (2)–(4) yields

\[
\pi \lambda_L + (1 - \pi) \lambda_H \frac{u'(y)}{\lambda_H} = \pi \left[ \lambda_H (R - 1) + \lambda_L \right] u' \left( \frac{R(1 + f) - f - (R - 1 + \frac{\lambda_L}{\lambda_H})y}{1 - \lambda_L} \right) + \lambda_H R(1 - \pi) u' \left( \frac{R(1 + f - y) - f}{1 - \lambda_H} \right),
\]

which determines \( y \) uniquely.

- Eq. (1) is equivalent to (6).
The no default equilibrium (4)

Proposition 2

The no-default equilibrium is unique and achieves the constrained efficient allocation.

Equilibrium asset prices:

\[ P_L = R > 1, \]  \hspace{1cm} (7)

\[ P_H = \frac{(1 - \pi)Ru'(c_{2H}^*)}{\pi(R - 1)u'(c_{2L}^*) + (1 - \pi)Ru'(c_{2H}^*)} < 1. \]  \hspace{1cm} (8)
The mixed equilibrium

- In equilibrium, not all banks default simultaneously.

- Suppose that all banks default at $t = 1$.
  - all depositors try to withdraw their funds in state $\theta = H$
  - all banks sell the long assets at $t = 1$.
  - the price must be $P_H = 0$.
  - Given $P_H = 0$, a bank would hold enough liquidity at $t = 0$ and make a large capital gain by purchasing the long assets at $t = 1$.

- Thus, an equilibrium where banks can default must be *mixed*. 
Two types of banks arise endogenously!

- **Safe banks** $[\rho]$:
  - hold a lot of the short asset at $t = 0$
  - offer deposit contracts promising low payments at $t = 1$ to remain solvent.

- **Risky banks** $[1 - \rho]$:
  - invest so much in the long asset
  - offer deposit contracts promising high payments at $t = 1$ that may cause defaults.
The optimization problem of the safe banks is similar to the one in the no default equilibrium.

The problem of the safe banks:

$$\max E_\theta [\lambda u(c_1^s) + (1 - \lambda) u(c_2^s)]$$

subject to

$$x^s + y^s \leq 1 + b_0^s + b_2^s,$$

$$\lambda c_1^s + b_0^s \leq y^s + b_1^s, \ \forall \theta$$

$$(1 - \lambda) c_2^s + b_1^s + b_2^s \leq R \left( x^s + \frac{y^s + b_1^s - b_0^s - \lambda c_1^s}{P_\theta} \right), \ \forall \theta$$

$$b_0^s + b_2^s \leq f,$$

$$b_1^s + b_2^s \leq f, \ \forall \theta$$

$$c_1^s \leq c_2^s \ \forall \theta.$$
Safe banks (2)

- Binding borrowing constraints:

\[ b_{01}^s + b_{02}^s = f, \quad (9) \]
\[ b_{1\theta}^s + b_{02}^s = f, \quad \forall \theta \quad (10) \]

Then,

\[ x^s + y^s = 1 + f, \quad (11) \]
\[ (1 - \lambda_\theta)c_{2\theta}^s + f = R \left( x^s + \frac{y^s - \lambda_\theta c_1^s}{P_\theta} \right), \quad (12) \]

- FOCs:

\[ [\pi \lambda_L + (1 - \pi)\lambda_H]u'(c_1^s) = \pi \lambda_L \frac{R}{P_L} u'(c_{2L}^s) + (1 - \pi)\lambda_H \frac{R}{P_H} u'(c_{2H}^s), \quad (13) \]
\[ \pi \left( 1 - \frac{1}{P_L} \right) u'(c_{2L}^s) \leq (1 - \pi) \left( \frac{1}{P_H} - 1 \right) u'(c_{2H}^s), \quad (14) \]

with equality if \( x^s > 0 \).
Risky banks default in state $\theta = H$.

The problem of the risky banks:

$$\max \pi[\lambda_L u(c_1^r) + (1 - \lambda_L)u(c_{2L}^r)] + (1 - \pi)u\left(\frac{c_1^r}{c_1^r + (1 + r_1)b_{01}^r} (y^r + P_H x^r)\right),$$

subject to

$$x^r + y^r \leq 1 + b_{01}^r + b_{02}^r,$$

$$\lambda_L c_1^r + (1 + r_1)b_{01}^r \leq y^r + b_{1L}^r + P_L x^r,$$

$$(1 - \lambda_L)c_{2L}^r + b_{1L}^r + (1 + r_2)b_{02}^r \leq R\left(x^r - \frac{(1 + r_1)b_{01}^r + \lambda_L c_1^r - y^r - b_{1L}^r}{P_L}\right),$$

$$b_{01}^r + b_{02}^r \leq f,$$

$$b_{1L}^r + b_{02}^r \leq f,$$

$$c_1^r \leq c_{2L}^r.$$
Risky banks (2)

- FOCs:

\[
\begin{align*}
    u'(c_1^r) + \frac{1 - \pi}{\pi \lambda_L} u' \left( \frac{c_1^r(y^r + P_H x^r)}{c_1^r + (1 + r_1)b_{01}^r} \right) \frac{(y^r + P_H x^r)(1 + r_1)b_{01}^r}{(c_1^r + (1 + r_1)b_{01}^r)^2} &= \frac{R}{P_L} u'(c_{2L}^r), \\
    \pi R \left(1 - \frac{1}{P_L} \right) u'(c_{2L}^r) &= (1 - \pi) u' \left( \frac{c_1^r(y^r + P_H x^r)}{c_1^r + (1 + r_1)b_{01}^r} \right) \frac{c_1^r(1 - P_H)}{c_1^r + (1 + r_1)b_{01}^r} + \mu_8,
\end{align*}
\]

(15)

(16)

\[
\begin{align*}
    \pi \left( r_2 - \frac{R}{P_L} r_1 \right) u'(c_{2L}^r) &= (1 - \pi) u' \left( \frac{c_1^r(y^r + P_H x^r)}{c_1^r + (1 + r_1)b_{01}^r} \right) \frac{(y^r + P_H x^r)(1 + r_1)c_1^r}{(c_1^r + (1 + r_1)b_{01}^r)^2} \\
    &\quad - \mu_5 - \mu_6 + \mu_7,
\end{align*}
\]

(17)

where \( \mu_5, \mu_6, \mu_7, \mu_8 \) are the multipliers on the non-negativity constraints for \( b_{1L}^r, b_{01}^r, b_{02}^r, \) and \( y^r \).
The mixed equilibrium

- The depositors must be indifferent between depositing their funds in a safe or risky bank
  \[ W^s = W^r \]  \hspace{1cm} (18)

- The market clearing conditions
  \[
  \rho (y^s + b^s_{1L} - \lambda_L c^s_1 - b^s_{01}) = (1 - \rho) ((1 + r_1)b^r_{01} + \lambda_L c^r_1 - y^r - b^r_{1L}), \hspace{1cm} (19)
  \]
  \[
  \rho (y^s + b^s_{1H} - \lambda_H c^s_1 - b^s_{01}) = (1 - \rho) P_H x^r. \hspace{1cm} (20)
  \]

- No-arbitrage conditions are:
  \[
  1 = \pi (1 + r_1) + (1 - \pi) \frac{(1 + r_1)(y^r + P_H x^r)}{c^r_1 + (1 + r_1)b^r_{01}}, \hspace{1cm} (21)
  \]
  \[
  1 = \pi (1 + r_2). \hspace{1cm} (22)
  \]
Term structure of interest rates

\[ r_1 < r_2. \]

The mixed equilibrium is characterized by the vector

\[ (c^s_1, \{ c^s_{2θ} \}, \{ b^s_{0t} \}, \{ b^s_{1θ} \}, y^s, c^r_1, c^r_{2L}, \{ b^r_{0t} \}, \{ b^r_{1θ} \}, y^r, \{ P_θ \}, \{ r_t \}, ρ) \]

satisfying (7)–(20).
Existence of Equilibria

- I analyze the parameter space in which two types of equilibria exist.
- Are the strategies of the risky banks optimal?
  - the no default equilibrium exists if no bank finds it optimal to default given $P_L$ and $P_H$.
  - the mixed equilibrium exists if some banks a risky portfolio.
Consider a problem of a bank that tries to choose a risky portfolio in the no-default equilibrium.

The deviating bank offers a risky contract to depositors given $P_L$ and $P_R$ defined by (7) and (8).

$$\max \pi [\lambda_L u(c_1^d) + (1 - \lambda_L) u(c_{2L}^d)] + (1 - \pi) u \left( \frac{c_1^d}{c_1^d + (1 + r_1)b_{01}^d} (y^d + P_H x^d) \right)$$

subject to

$$x^d + y^d = 1 + b_{01}^d + b_{02}^d,$$

$$\lambda_L c_1^d + (1 + r_1)b_{01}^d \leq y^d + b_{1L}^d + P_L x^d,$$

$$(1 - \lambda_L)c_{2L}^d + b_{1L}^d + (1 + r_2)b_{02}^d \leq R \left( x^d - \frac{(1 + r_1)b_{01}^d + \lambda_L c_1^d - y^d - b_{1L}^d}{P_L} \right),$$

$$b_{01}^d + b_{02}^d \leq f,$$

$$b_{1L}^d + b_{02}^d \leq f,$$

$$c_1^d \leq c_{2L}^d.$$
Let $W^d$ denote the corresponding maximized expected utility that the deviating bank can offer.

**Proposition 3**

If $W^N > W^d$, then there exists a no-default equilibrium.
Utility function:

\[ u(c) = \log(c). \]

Parameters:

\[ \lambda_L = 0.8, \quad \lambda_H = 0.81, \quad \text{and} \quad R = 1.5. \]
## Basic Examples (2)

<table>
<thead>
<tr>
<th>Ex.</th>
<th>$\pi$</th>
<th>$f$</th>
<th>Types of eqm.</th>
<th>Price volatility ($P_L/P_H$)</th>
<th>$\rho$</th>
<th>$E[u]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>0.6</td>
<td>0.3</td>
<td>No default</td>
<td>$1.5000/0.6628=2.2631$</td>
<td>1.0000</td>
<td>0.1728</td>
</tr>
<tr>
<td>1B</td>
<td>0.6</td>
<td>0.5</td>
<td>No default</td>
<td>$1.5000/0.6628=2.2631$</td>
<td>1.0000</td>
<td>0.2316</td>
</tr>
<tr>
<td>1C</td>
<td>0.6</td>
<td>0.7</td>
<td>No default</td>
<td>$1.5000/0.6628=2.2631$</td>
<td>1.0000</td>
<td>0.2872</td>
</tr>
<tr>
<td>2A</td>
<td>0.8</td>
<td>0.3</td>
<td>Mixed</td>
<td>$1.2620/0.5189=2.4321$</td>
<td>0.9723</td>
<td>0.1741</td>
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<tr>
<td>2B</td>
<td>0.8</td>
<td>0.5</td>
<td>Mixed</td>
<td>$1.2947/0.4905=2.6396$</td>
<td>0.9707</td>
<td>0.2328</td>
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<tr>
<td>2C</td>
<td>0.8</td>
<td>0.7</td>
<td>Mixed</td>
<td>$1.3296/0.4646=2.8618$</td>
<td>0.9700</td>
<td>0.2883</td>
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</tbody>
</table>

**Table:** Numerical examples
### Basic Examples (3)

<table>
<thead>
<tr>
<th>Ex.</th>
<th>$\pi$</th>
<th>$f$</th>
<th>$(y, x)$</th>
<th>$(c_1, c_{2L}, c_{2H})$</th>
<th>$(b_{01}, b_{1L}, b_{1H}, b_{02})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>0.6</td>
<td>0.3</td>
<td>(0.8888, 0.4112)</td>
<td>(1.0973, 1.6389, 1.6674)</td>
<td>indeterminate</td>
</tr>
<tr>
<td>1B</td>
<td>0.6</td>
<td>0.5</td>
<td>(0.9427, 0.5573)</td>
<td>(1.1638, 1.7379, 1.7682)</td>
<td>indeterminate</td>
</tr>
<tr>
<td>1C</td>
<td>0.6</td>
<td>0.7</td>
<td>(0.9966, 0.7034)</td>
<td>(1.2304, 1.8370, 1.8689)</td>
<td>indeterminate</td>
</tr>
</tbody>
</table>

**Table:** Allocations in the no-default equilibrium
### Basic Examples (4)

#### Table: Allocations in the mixed equilibrium

<table>
<thead>
<tr>
<th>Ex.</th>
<th>$\pi$</th>
<th>$f$</th>
<th>$(y^s, x^s)$</th>
<th>$(c^s_1, c^s_{2L}, c^s_{2H})$</th>
<th>$(b^s_{01}, b^s_{1L}, b^s_{1H}, b^s_{02})$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(y^r, x^r)$</td>
<td>$(c^r_1, c^r_{2L}, y^r + P_H x^r)$</td>
<td>$(b^r_{01}, b^r_{1L}, b^r_{1H}, b^r_{02})$</td>
</tr>
<tr>
<td>2A</td>
<td>0.8</td>
<td>0.3</td>
<td>(0.9085, 0.3915)</td>
<td>(1.0979, 1.6155, 1.8040)</td>
<td>indeterminate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0000, 1.3000)</td>
<td>(1.3251, 1.5750, 0.6746)</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>0.8</td>
<td>0.5</td>
<td>(0.9652, 0.5348)</td>
<td>(1.1643, 1.7068, 1.9473)</td>
<td>indeterminate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0000, 1.5000)</td>
<td>(1.4026, 1.6250, 0.7358)</td>
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<tr>
<td>2C</td>
<td>0.8</td>
<td>0.7</td>
<td>(1.0212, 0.6788)</td>
<td>(1.2306, 1.7984, 2.0899)</td>
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<td></td>
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<td></td>
<td>(0.0000, 1.7000)</td>
<td>(1.4848, 1.6750, 0.7898)</td>
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<td></td>
<td>(0.0000, 0.0000, 0.0000, 0.3000)</td>
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<td></td>
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<td></td>
<td></td>
<td>(0.0000, 0.0000, 0.0000, 0.5000)</td>
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<td></td>
<td></td>
<td></td>
<td>(0.0000, 0.0000, 0.0000, 0.7000)</td>
<td></td>
</tr>
</tbody>
</table>
The ratio of short term debt to international liquidity reserves

\[
\eta \equiv \frac{\rho(\bar{\lambda}c_1^s + b_{01}^s) + (1 - \rho)(\bar{\lambda}c_1^r + (1 + r_1)b_{01}^r)}{\rho y^s + (1 - \rho)y^r},
\]

where \( \bar{\lambda} \equiv \pi \lambda_L + (1 - \pi)\lambda_H \).

Setting \( b_{01}^s = 0.2f \) and \( b_{02}^s = (1 - 0.2)f \)

In Example 2, \( \eta \) is increasing in \( f \).

- \( \eta = 1.0686 \) when \( f = 0.3 \)
- \( \eta = 1.1062 \) when \( f = 0.5 \)
- \( \eta = 1.1396 \) when \( f = 0.7 \)

Consistent with empirical evidence!
Extension (1): Risk Aversion

- CRRA utility function:

\[ u(c) = \frac{c^{1-\sigma}}{1 - \sigma}, \]

where \( \sigma \geq 1 \).

<table>
<thead>
<tr>
<th>Ex.</th>
<th>( \sigma )</th>
<th>( \pi )</th>
<th>( f )</th>
<th>Types of eqm.</th>
<th>Price volatility ( (P_L/P_H) )</th>
<th>( \rho )</th>
<th>( E[u] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>1</td>
<td>0.8</td>
<td>0.3</td>
<td>Mixed</td>
<td>1.2620/0.5189=2.4321</td>
<td>0.9723</td>
<td>0.1741</td>
</tr>
<tr>
<td>2B</td>
<td>1</td>
<td>0.8</td>
<td>0.5</td>
<td>Mixed</td>
<td>1.2947/0.4905=2.6396</td>
<td>0.9707</td>
<td>0.2328</td>
</tr>
<tr>
<td>2C</td>
<td>1</td>
<td>0.8</td>
<td>0.7</td>
<td>Mixed</td>
<td>1.3296/0.4646=2.8618</td>
<td>0.9700</td>
<td>0.2883</td>
</tr>
<tr>
<td>3A</td>
<td>2</td>
<td>0.8</td>
<td>0.3</td>
<td>Mixed</td>
<td>1.5000/0.3952=3.7955</td>
<td>0.9888</td>
<td>-0.8465</td>
</tr>
<tr>
<td>3B</td>
<td>2</td>
<td>0.8</td>
<td>0.5</td>
<td>Mixed</td>
<td>1.5000/0.4012=3.7388</td>
<td>0.9918</td>
<td>-0.7981</td>
</tr>
<tr>
<td>3C</td>
<td>2</td>
<td>0.8</td>
<td>0.7</td>
<td>Mixed</td>
<td>1.5000/0.4049=3.7046</td>
<td>0.9936</td>
<td>-0.7550</td>
</tr>
<tr>
<td>4A</td>
<td>3</td>
<td>0.8</td>
<td>0.3</td>
<td>No default</td>
<td>1.5000/0.4237=3.5402</td>
<td>1.0000</td>
<td>-0.3598</td>
</tr>
<tr>
<td>4B</td>
<td>3</td>
<td>0.8</td>
<td>0.5</td>
<td>No default</td>
<td>1.5000/0.4237=3.5402</td>
<td>1.0000</td>
<td>-0.3198</td>
</tr>
<tr>
<td>4C</td>
<td>3</td>
<td>0.8</td>
<td>0.7</td>
<td>No default</td>
<td>1.5000/0.4237=3.5402</td>
<td>1.0000</td>
<td>-0.2862</td>
</tr>
</tbody>
</table>

Table: Numerical examples for CRRA utility function.
Suppose that no long-term borrowing is allowed at period 0.

- \( b_{02} = 0 \) or \( r_2 = \infty \).
- Transaction costs, information costs

<table>
<thead>
<tr>
<th>Ex.</th>
<th>( \pi )</th>
<th>( f )</th>
<th>Types of eqm.</th>
<th>Price volatility ( (P_L/P_H) )</th>
<th>( \rho )</th>
<th>( E[u] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5A</td>
<td>0.8</td>
<td>0.3</td>
<td>Mixed</td>
<td>1.3743/0.4579=3.0013</td>
<td>0.9831</td>
<td>0.1734</td>
</tr>
<tr>
<td>5B</td>
<td>0.8</td>
<td>0.5</td>
<td>Mixed</td>
<td>1.4433/0.4271=3.3793</td>
<td>0.9846</td>
<td>0.2320</td>
</tr>
<tr>
<td>5C</td>
<td>0.8</td>
<td>0.7</td>
<td>Mixed</td>
<td>1.5000/0.4063=3.6919</td>
<td>0.9856</td>
<td>0.2874</td>
</tr>
</tbody>
</table>

**Table**: Numerical examples for foreign short-term debt
“Sudden Stop”
- capital net outflow at period 0:
  \[-f < 0.\]
- capital net outflow at period 1 in state $H$:
  \[
  \rho b_{01}^s + (1 - \rho)(1 - \varphi)(y^r + P_H x^r) - (\rho b_{1H}^s + (1 - \rho)b_{1H}^r)
  \]
  \[
  = (1 - \rho)(1 - \varphi)(y^r + P_H x^r) > 0.
  \]
  where \(\varphi = c_1^r/(c_1^r + (1 + r_1)f).\)
Q. Is the mixed equilibrium constrained efficient?

<table>
<thead>
<tr>
<th>Ex.</th>
<th>$\pi$</th>
<th>$f$</th>
<th>mixed eqm., $E[u]$</th>
<th>constrained efficient, $E[u]$</th>
</tr>
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<tr>
<td>2A</td>
<td>0.8</td>
<td>0.3</td>
<td>0.1741</td>
<td>0.1729</td>
</tr>
<tr>
<td>2B</td>
<td>0.8</td>
<td>0.5</td>
<td>0.2328</td>
<td>0.2318</td>
</tr>
<tr>
<td>2C</td>
<td>0.8</td>
<td>0.7</td>
<td>0.2883</td>
<td>0.2873</td>
</tr>
</tbody>
</table>

A. No. The mixed equilibrium attains higher welfare than the planner.

Why?

- Default relaxes the constraint of non-contingent contracts.
- No justification for policy interventions!
Realistic features that are not modeled here can justify the policy.
- a crisis may have significant negative impacts on the real sector.
- e.g., increasing unemployment, decreasing output, etc.

Q. Can the government eliminate a crisis at the expense of welfare?

Two policies:
- Liquidity regulation
- Public deposit insurance
Liquidity Regulation

- Liquidity regulation:

\[ y \geq \xi(1 + f), \quad 0 \leq \xi \leq 1 \]

<table>
<thead>
<tr>
<th>Ex.</th>
<th>( \pi )</th>
<th>( f )</th>
<th>( \xi )</th>
<th>Types of eqm.</th>
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<td>0.9723</td>
<td>0.1741</td>
</tr>
<tr>
<td>2B</td>
<td>0.8</td>
<td>0.5</td>
<td>0</td>
<td>Mixed</td>
<td>1.2947/0.4905=2.6396</td>
<td>0.9707</td>
<td>0.2328</td>
</tr>
<tr>
<td>2C</td>
<td>0.8</td>
<td>0.7</td>
<td>0</td>
<td>Mixed</td>
<td>1.3296/0.4646=2.8618</td>
<td>0.9700</td>
<td>0.2883</td>
</tr>
<tr>
<td>5A</td>
<td>0.8</td>
<td>0.3</td>
<td>0.2</td>
<td>Mixed</td>
<td>1.3114/0.4802=2.7309</td>
<td>0.9619</td>
<td>0.1739</td>
</tr>
<tr>
<td>5B</td>
<td>0.8</td>
<td>0.5</td>
<td>0.2</td>
<td>Mixed</td>
<td>1.3265/0.4371=3.0348</td>
<td>0.9600</td>
<td>0.2325</td>
</tr>
<tr>
<td>5C</td>
<td>0.8</td>
<td>0.7</td>
<td>0.2</td>
<td>Mixed</td>
<td>1.4526/0.4007=3.6252</td>
<td>0.9593</td>
<td>0.2879</td>
</tr>
<tr>
<td>6A</td>
<td>0.8</td>
<td>0.3</td>
<td>0.5</td>
<td>No default</td>
<td>1.5000/0.4243=3.5352</td>
<td>1.0000</td>
<td>0.1729</td>
</tr>
<tr>
<td>6B</td>
<td>0.8</td>
<td>0.5</td>
<td>0.5</td>
<td>No default</td>
<td>1.5000/0.4243=3.5352</td>
<td>1.0000</td>
<td>0.2318</td>
</tr>
<tr>
<td>6C</td>
<td>0.8</td>
<td>0.7</td>
<td>0.5</td>
<td>No default</td>
<td>1.5000/0.4243=3.5352</td>
<td>1.0000</td>
<td>0.2873</td>
</tr>
</tbody>
</table>

**Table:** The effects of liquidity regulations: \( y \geq \xi(1 + f) \)
In state $H$ at period 1, the government

- imposes a lump-sum tax on the safe banks, $\tau$.
- transfer $\phi$ to the depositors of the risky banks.

$$ (1 - \rho)\phi = \rho\tau. $$
### Public Deposit Insurance (2)

<table>
<thead>
<tr>
<th>Ex.</th>
<th>$\pi$</th>
<th>$f$</th>
<th>$\text{DI}(\phi, \tau)$</th>
<th>Eqm.</th>
<th>$P_L/P_H$</th>
<th>$\rho$</th>
<th>$E[u]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>0.8</td>
<td>0.3</td>
<td>(0.0000, 0.0000)</td>
<td>Mixed</td>
<td>1.2620/0.5189=2.4321</td>
<td>0.9723</td>
<td>0.1742</td>
</tr>
<tr>
<td>2B</td>
<td>0.8</td>
<td>0.5</td>
<td>(0.0000, 0.0000)</td>
<td>Mixed</td>
<td>1.2947/0.4905=2.6396</td>
<td>0.9707</td>
<td>0.2321</td>
</tr>
<tr>
<td>2C</td>
<td>0.8</td>
<td>0.7</td>
<td>(0.0000, 0.0000)</td>
<td>Mixed</td>
<td>1.3296/0.4646=2.8618</td>
<td>0.9700</td>
<td>0.2888</td>
</tr>
<tr>
<td>7A</td>
<td>0.8</td>
<td>0.3</td>
<td>(0.1000, 0.0084)</td>
<td>Mixed</td>
<td>1.1704/0.5794=2.0200</td>
<td>0.9222</td>
<td>0.1721</td>
</tr>
<tr>
<td>7B</td>
<td>0.8</td>
<td>0.5</td>
<td>(0.1000, 0.0069)</td>
<td>Mixed</td>
<td>1.2190/0.5251=2.3215</td>
<td>0.9356</td>
<td>0.2311</td>
</tr>
<tr>
<td>7C</td>
<td>0.8</td>
<td>0.7</td>
<td>(0.1000, 0.0060)</td>
<td>Mixed</td>
<td>1.2638/0.4854=2.6036</td>
<td>0.9431</td>
<td>0.2878</td>
</tr>
<tr>
<td>8A</td>
<td>0.8</td>
<td>0.3</td>
<td>(0.2000, 0.0553)</td>
<td>Mixed</td>
<td>1.1350/0.5493=2.0663</td>
<td>0.7834</td>
<td>0.1662</td>
</tr>
<tr>
<td>8B</td>
<td>0.8</td>
<td>0.5</td>
<td>(0.2000, 0.0339)</td>
<td>Mixed</td>
<td>1.1836/0.5050=2.3438</td>
<td>0.8550</td>
<td>0.2281</td>
</tr>
<tr>
<td>8C</td>
<td>0.8</td>
<td>0.7</td>
<td>(0.2000, 0.0249)</td>
<td>Mixed</td>
<td>1.2286/0.4701=2.6135</td>
<td>0.8894</td>
<td>0.2842</td>
</tr>
</tbody>
</table>

**Table:** The effects of government deposit insurance
Conclusion

This paper have developed a small-open-economy version of a banking model with financial market.

The model generates two types of equilibria:
- the no-default equilibrium
- the mixed equilibrium

The model matches many features of East Asia crisis in 1997.

Liquidity regulation may stabilize the financial system, but public deposit insurance may not.