Optimal Deposit Insurance

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Banks and the Threat of Runs

A run on American Union Bank, 1931
Banks and the Threat of Runs – Cont’d

- Banks provide maturity and liquidity transformation
- This can improve welfare, but
- It exposes banks to the risk of a run
  - Many investors demand early withdrawal out of the self fulfilling belief that others will do so
- History of many bank failures around the world
A Leading Solution: Deposit Insurance

- Insurance of deposits may reduce the incentive of investors to run
- Deposit insurance was enacted in the US in 1933 and had a great success in stabilizing the banking system
- Many countries in the world have followed this experience enacting different forms of deposit insurance
-Supported by theoretical literature, going back to Diamond and Dybvig (1983)
**Optimal Amount of Coverage**

- Key question in design of insurance:  
  — How much should be insured?
- In Diamond and Dybvig (1983):  
  — Unlimited insurance: insurance works to prevent failures altogether and so has no cost
- In the real world:  
  — Insurance always limited; e.g., in US current maximum for insurance is $250,000, which was increased from $100,000 in 2008
- What is different in the real world?  
  — Failures sometimes happen generating costs  
  — Insurance causes frictions
- **How to set the optimal amount?**
History of Deposit Insurance Amount in the US

![Graph showing the level of deposit insurance over time in the US.](image)
Sufficient Statistic Approach

• Rich theoretical literature on bank runs and government guarantees (e.g., Allen, Carletti, Goldstein, Leonello, 2015), but not much quantitative

• Usually, getting quantitative prescriptions from a model requires calibration and estimation of **exogenous deep parameters** of the model
  —This is a difficult task

• The sufficient statistic approach targets **endogenous high level variables that are potentially observable**

• Illustration in next slide is based on Chetty (2009)
Sufficient Statistic Approach – Cont’d

Primitives: \( \omega_1, \omega_2, \ldots, \omega_N \)

Sufficient statistics: \( \beta_1(t), \beta_2(t) \)

Welfare change: \( \frac{dW}{dt}(t) \)

\( \omega = \) preferences, constraints
\( \beta = f(\omega, t) \)
\( y = \beta_1 X_1 + \beta_2 X_2 + \varepsilon \)
\( \frac{dW}{dt} \) used for policy analysis

\( \omega \) not uniquely identified
\( \beta \) identified using program evaluation
Optimal Level of Deposit Insurance Based on Sufficient Statistic

Optimal level of DI

\[ \delta^* = \frac{A \times B}{C \times D} \]

- **Marginal benefit**
  - \( A \) Sensitivity of bank failure probability to DI change
  - \( B \) Drop in depositors consumption at failure threshold

- **Marginal cost**
  - \( C \) Probability of bank failure
  - \( D \) Expected marginal social cost of intervention in case of bank failure
Intuition

• **Benefit from deposit insurance:** reducing the probability of a run and increasing consumption as a result

• **Cost of deposit insurance:** causes fiscal costs in case a failure does happen

• **Note:** moral hazard concerns associated with banks’ behavior only enter the fiscal cost (which is not internalized by banks)
  —Other implications of banks’ behavior are internalized (envelope theorem, competition)
Model Description

Environment

- Three dates: 0, 1, 2
- Continuum of states: \( s \in [s, \bar{s}] \), distributed according to a cdf \( F(\cdot) \), becomes known at \( t=1 \)
- Double continuum of depositors deposit money in perfectly competitive banks
- Banks receive deposit insurance from government
- Government finances insurance from continuum of taxpayers
Model Description – Cont’d

**Depositors and Banks**

- At $t=0$, depositors hold deposit in the bank $D_{0i} \in [0, D]$.
- At $t=1$, proportion $\lambda$ of depositors find out they are impatient and need to consume immediately; Proportion $1 - \lambda$ can wait till $t=2$.
- Utility within a period is $U(c)$, where $U'(c) > 0$ and $U''(c) < 0$.
- The bank offers a return $R_1$ on deposits at $t=1$.
- At $t=1$, depositors decide how much deposit to keep in the bank $D_{1i}(s) \in [0, D_{0i}R_1]$. 
Model Description – Cont’d

**Technology**
- The technology that the bank has provides a return of $\rho_1(s)$ at $t=1$ and $\rho_2(s)$ at $t=2$

**Government**
- The government guarantees an amount of $\delta$ of deposits
- Upon bank failure, government takes over the bank and recovers $\chi \in [0,1]$ of the resources
- The government finances any shortfall with taxes $T(s)$ causing a resource loss of $\kappa(T(s)) \geq 0$
Timeline

- Deposit insurance determined
- Deposit rate $R_1$ determined
- Depositors choose deposit holdings $D_{1i}$

$t = 0$ $s$ is realized
$t = 1$
$t = 2$
Equilibrium

- The bank fails if total remaining deposits are below a threshold such that the bank cannot pay back to the depositors in t=1 or 2:

  \[
  \begin{align*}
  \text{Bank Failure,} & \quad \text{if } \tilde{D}_1(s) > D_1 \\
  \text{No Bank Failure,} & \quad \text{if } \tilde{D}_1(s) \leq D_1,
  \end{align*}
  \]

  — Threshold decreases in state \( s \)

- In a run equilibrium, everyone withdraws their uninsured deposits; remaining deposits increase in \( \delta \):

  \[
  D_1 = D_1^{-}(\delta, R_1) = (1 - \lambda) \int_0^{\bar{D}} \min \{D_0 R_1, \delta\} dG(i).
  \]
Equilibrium – Cont’d

• In a no-run equilibrium, only impatient agents withdraw, so remaining deposits are:

\[ D_{1} = D_{1}^{+}(R_{1}) = (1 - \lambda) D_{0} R_{1}. \]

• Given these properties of deposits in the two equilibria and threshold for failure, we get:

- Unique (Failure) equilibrium, if \( \underline{s} \leq s < \hat{s}(R_{1}) \)
- Multiple equilibria, if \( \hat{s}(R_{1}) \leq s < s^*(\delta, R_{1}) \)
- Unique (No Failure) equilibrium, if \( s^*(\delta, R_{1}) \leq s \leq \bar{s} \),
Equilibrium Outcome for given $\delta$

\[ D_1^\delta (s) = \frac{(R_1 - \rho_1(s))D_0}{1 - \rho_2(s)} \]

\[ D_1^+ (R_1) = (1 - \lambda) D_0 R_1 \]

\[ D_1^- (\delta, R_1) = (1 - \lambda) \int_{0}^{T^\delta} \min \{ D_0 \delta, R_1, \delta \} dF (i) \]

- Fundamental Failures
- Panic Failures

State ($s$)

Unique (Failure) Equilibrium

Multiple Equilibria

Unique (No Failure) Equilibrium
The Effect of $\delta$ on Equilibrium Outcome

- $\rho^{-1}_1 (R_1)$
- $s^*(\delta, R_1)$
- $\hat{s}_1 (R_1)$
- Unique (No Failure) Equilibrium
- Multiple Equilibria
- Unique (Failure) Equilibrium
Run Probabilities

- Assume that in the multiple-equilibria range, failure happens with probability $\pi$:
- Failure probability $q^F$ decreases in deposit insurance $\delta$ and increases in deposit rate $R_1$:

\[
\frac{\partial q^F}{\partial \delta} = \pi f(s^*(\delta, R_1)) \frac{\partial s^*}{\partial \delta} \leq 0
\]
\[
\frac{\partial q^F}{\partial R_1} = (1 - \pi) f(\hat{s}(R_1)) \frac{\partial \hat{s}}{\partial R_1} + \pi f(s^*(\delta, R_1)) \frac{\partial s^*}{\partial R_1} \geq 0.
\]
Agents’ Consumption

- Given these equilibrium outcomes, depositors’ consumption in case of failure (F) and no failure (N) for early (1) and late (2) consumers is determined as follows:

\[ C_{1i}^N (s) - C_{1i}^F (s) = (1 - \alpha_F(s)) \left\{ D_{0i} R_1 - \delta, 0 \right\} \]

Partially Recovered Uninsured Deposits

\[ C_{2i}^N (s) - C_{2i}^F (s) = (\alpha_N(s) - 1) D_{0i} R_1 + (1 - \alpha_F(s)) \left\{ D_{0i} R_1 - \delta, 0 \right\} \]

Net Return Partially Recovered Uninsured Deposits

(Early Depositors)

(Late Depositors)

—Where,

\[ \alpha_F(s) = \frac{\max \left\{ \chi(s) \rho_1(s) D_0 - \int_0^D \min \{D_{0i} R_1, \delta\} dG(i), 0 \right\}}{\int_0^D \max \{D_{0i} R_1 - \delta, 0\} dG(i)} \quad \text{and} \quad \alpha_N(s) = \rho_2(s) \frac{\rho_1(s) - \lambda R_1}{(1 - \lambda) R_1}. \]
Government Problem

- Government sets deposit insurance $\delta$ to maximize welfare of depositors and taxpayers:

\[ W(\delta) = \int V_j(R_1; \delta) \, dj = \int_{\text{Depositors}} V_i(R_1; \delta) \, dG(i) + \int_{\text{Taxpayers}} V_\tau(R_1; \delta). \]

- Taxpayers are affected by taxes, given by:

\[ T(s) = \max \left\{ \int_0^{D_0} \min \{D_0, R_1, \delta\} \, dG(i) - \chi(s) \rho_1(s) D_0, 0 \right\}. \quad \text{(Fiscal Shortfall)} \]
Determining the Optimal Deposit Insurance

• Suppose that $R_1$ is exogenous:

$$\frac{dW}{d\delta} = -\frac{\partial q^F}{\partial \delta} \int [U(C_j^N(s^*)) - U(C_j^F(s^*))] dj + q^F E_s \left[ \int U'(C_j^F) \frac{\partial C_j^F}{\partial \delta} dj \right]$$

• Or, under an approximation (eliminate dependence on utility specification):

$$\frac{dW}{d\delta} \approx -\frac{\partial q^F}{\partial \delta} \int [C_j^N(s^*) - C_j^F(s^*)] dj + q^F \int \frac{\partial C_j^F}{\partial \delta} dj,$$
Sufficient Statistics

Four sufficient statistics are needed to determine if an increase in deposit insurance limit is desirable:

- Decrease in consumption following a failure (+):

\[
E_j \left[ C_j^N (s^*) - C_j^F (s^*) \right] = (\rho_2 (s^*) - 1) (\rho_1 (s^*) - \lambda R_1) D_0 + (1 - \chi (s)) \rho_1 (s^*) D_0 + \kappa (T (s^*))
\]

- Effect of deposit insurance on failure probability (+):

\[
\left( -\frac{\partial q^F}{\partial \delta} \right)
\]
Sufficient Statistics – Cont’d

• Probability of a failure (-):

\[ q^F \]

• Net cost of taxation as a result of fiscal shortfall (-):

\[
E_s^F \left[ E_j \left[ \frac{\partial C_j^F}{\partial \delta} \right] \right] = \int_{\delta}^{\frac{D}{K_i}} \frac{\text{Fraction of Partially Insured}}{dG(i)} \\
\text{Mg. Cost of Public Funds}^\kappa
\]
Measurement

• The variables in the formula are either observable or could be inferred from the data
• The one that is most challenging is the effect of deposit insurance on failure probability
  — Need more data to figure out historical sensitivity
  — Theory tells us what we need to measure
  — Ideally, regression of failures on deposit insurance amount
# Measurement - Example

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathbb{E}_j \left[ C_j^N (s^<em>) - C_j^F (s^</em>) \right]$</td>
<td>Marginal resource drop induced by bank failure</td>
<td>75% of total deposits</td>
</tr>
<tr>
<td>$\varepsilon^q_\delta$</td>
<td>Semi-elasticity of bank failure to change in coverage</td>
<td>Inferred</td>
</tr>
<tr>
<td>$q^F$</td>
<td>Probability of bank failure</td>
<td>0.436%</td>
</tr>
<tr>
<td>$\kappa' (\cdot)$</td>
<td>Net marginal cost of public funds</td>
<td>11%</td>
</tr>
<tr>
<td>$\int_{D_\delta}^{D_\delta} dG (i)$</td>
<td>Share of partially insured depositors</td>
<td>7%</td>
</tr>
</tbody>
</table>
Optimal Deposit Insurance in Explicit Form

• The previous arguments are used to investigate optimality of increasing or decreasing deposit insurance
• One can develop above first-order condition to show explicit formula:

$$\delta^* = \frac{\epsilon^q \mathbb{E}_j \left[ U \left( C^F_j \left( s^* \right) \right) - U \left( C^N_j \left( s^* \right) \right) \right]}{q^F \mathbb{E}_s \left[ \mathbb{E}_j \left[ U' \left( C^F_j \right) \frac{\partial C^F_j}{\partial \delta} \right] \right]} \approx \frac{\epsilon^q \mathbb{E}_j \left[ C^F_j \left( s^* \right) - C^N_j \left( s^* \right) \right]}{q^F \mathbb{E}_s \left[ \mathbb{E}_j \left[ \frac{\partial C^F_j}{\partial \delta} \right] \right]}$$

• Where:

$$\epsilon^q = \frac{\partial q^F}{\partial \log(\delta)}$$
Summary of Uses of Formula

• Use formula to find optimal amount
  — Usually interim maximum (see example on the next slide)
  — Too ambitious?
• Use cost vs. benefit to tell whether an increase or a decrease is desirable at current level of coverage
• Back out change in failure probability or sensitivity that would rationalize recent insurance coverage increases
Global Effect of Deposit Insurance - Example
Endogenizing Deposit Rate and Deposit Insurance Premium

- Formula does not change much when $R_1$ is endogenized:
  - Banks internalize effect on run probability
  - Only additional effect to be taken into account in setting deposit insurance comes through the fiscal externality
- One can consider deposit insurance premium:
  - Used to make banks internalize the effect of their deposit rates on fiscal costs
  - Formula can be adjusted to tell optimal coverage given the pricing of premiums
Conclusion

• Optimal amount of deposit insurance is first-order question with little quantitative guidance to date
• Paper provides characterization of optimal deposit insurance as a function of a few sufficient statistics
  — For a wide range of environments
  — Additional characterization of optimal ex-ante policies, such as insurance premium
• Paper provides guidance for what we need to measure in the data