Financial Risk Capacity
Saki Bigio (Working Paper - JMP - 2012)

Omar Rachedi
Outline

Introduction

The Model

Characterization

Analytic Examples

Quantitative Analysis
Motivation

• Many **financial crises** begin with collapses in **bank net-worth**

• Financial sectors capacity to intermediate is linked to bank net-worth

• Bernanke: “[the crisis will be over] when banks start raising capital on their own”
Research Question

• Why banks cannot attract capital in times of crises?
  • Literature: no distinction banks-bankers $\rightarrow$ no equity injections
  • Banks’ ROE increases after losses $\rightarrow$ at odds with data

• Banks’ asymmetric reaction to different losses
  • equity injections follows moderate financial losses
  • no equity injections in case of large losses
Economic Mechanism

- Financial Intermediation under *asymmetric information* between two sectors:
  - Capital producers in need of funds with *private info* about *quality of capital*
  - Agents without investment opportunities with resources
- Banks face limited-liability constraint → only internal funds to finance losses
- Reduction of banks’ net-worth → less intermediation and lower quality capital is traded
Economic Mechanism

- **Std Models**: Reductions in banks’ net-worth → less intermediation → higher ROE

- **Quantity & Quality Effects**:
  - Less Quantity → higher ROE
  - Lower Quality → lower ROE

- **Non-Linear reaction of the economy**
  - Small losses → quantity effect dominates → equity injections
  - Large losses → quality effect dominates → crisis
Economic Mechanism

- Std Models: Reductions banks’ net-worth → less intermediation → higher ROE

- Quantity & Quality Effects:
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Summary
Environment

- Every period divided in two stages $s \in \{1, 2\}$
- Two goods: consumption goods (*numeraire*) and capital goods
- Two aggregate shocks:
  - $A_t$ is a TFP shock realized in 1\textsuperscript{st} stage
  - $\phi_t$ is a depreciation shock realized in 2\textsuperscript{nd} stage
- Before $\phi_t$: Assets are traded
- After $\phi_t$: Claims are settled + decisions on consumption/investment
Demography

- Two population of agents: producers and bankers

- 1\textsuperscript{st} stage: Producers randomly segmented in capital-good (k-) producers (w.p. $\pi$) and consumption-good (c-) producers

- c-producers: 1 capital good $\rightarrow A_t$ consumption goods (1\textsuperscript{st} stage)

- k-producers: 1 consumption good $\rightarrow$ 1 capital good (2\textsuperscript{nd} stage)

- Need for trade:
  - k-producers need consumption goods to consume and operate the technology
  - c-producers have consumption goods but lack access to technology
  - consumption goods from c-prod to k-prod in exchange of capital goods
Demography

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Capital units

- At beginning of the period, capital held by k-producers is homogeneous

- 1\textsuperscript{st} stage: capital is divided in a continuum of units $\omega \in [0, 1]$

- Quality affects depreciation: $1 - \lambda(\omega, \phi)$ is the depreciation of unit $\omega$ given aggregate shock $\phi$

- After shock $\phi$, capital is scaled by $\lambda(\omega, \phi)$ and become homogeneous

- $\lambda(\omega, \phi)$ satisfies that $E[\lambda(\omega, \phi) | \omega < \omega^*]$ is weakly decreasing in $\phi$ for any $\omega^*$

- Law of motion k-producer’s capital

$$k' = i + k^b + k \int [1 - \Pi(\omega)] \lambda(\omega, \phi) d\omega$$
Information

- The $\omega$–quality is known only to its owner
- Capital buyers face two sources of uncertainty: $\phi$ and $\omega$
- Capital sellers face only the uncertainty due to $\phi$
- Public information: $N_{t,s} = \int n_{t,s}(j) dj$ and $K_t = \int k_t(z) dz$
- Financial risk capacity: $\kappa_{t,s} = \frac{N_{t,s}}{K_t}$
Bankers

- Enter the period with net-worth $n_{t,1}$ held in the bank
- Receive personal stochastic endowment $\tilde{e}$
- From 1st to 2nd stage: equity injections or dividends
- Purchase capital from k-producers in 1st stage and resell it to c-producers in 2nd stage
- Finance purchases issuing IUOs to c-producers. Intra-period → no interest rate
Bankers

- Risky assets (units of capital under asymm info) vs. risk-less liabilities (IOUs)
- Bear asymmetric info on capital and aggregate shock $\phi \rightarrow$ financial intermediation risk
- From 2\textsuperscript{nd} stage to next period: 1 consumption good $\rightarrow R^b$ consumption goods
- Limited Liability $\rightarrow$ only bank’s net-worth can be used to finance losses $\rightarrow$ borrowing constraint
- Exogenous constant probability of exit $\rho$
Timing

\[ X_{t,1} \equiv (A_t, \phi_{t-1}, \kappa_{t,1}) \quad \phi_t \text{ realized} \quad \text{consumption/investment} \]

\[ X_{t,2} \equiv (A_t, \phi_t, \kappa_{t,2}) \]

\[ \text{Pooling Market Trade} \quad \text{Resale Market} \]

\[ X_{t+1,1} \text{ updated} \]

\[ \text{dividend/equity} \]
Limited Liability Constraint

- The amount of issued IOUs cannot exceed bank’s net-worth plus the value of this capital under any realization of $\phi$

  $$pQ \leq qE[\lambda(\omega, \phi')|X]Q + n' \quad \text{for any}(X, X')$$

- Banker’s marginal profit from intermediation

  $$\Pi(X, X') = qE[\lambda(\omega, \phi')|X] - p$$
First Stage Problems

\[ V_1^k(k, X) = \max_{\mathbb{I}(\omega) \in \{0,1\}} E \left[ V_2^k \left( k' \left( \phi' \right), x, X' \right) \mid X \right] \]

\[ \text{s.t. } x = px \int \mathbb{I}(\omega) d\omega \quad k'(\phi') = k \int \left[ 1 - \mathbb{I}(\omega) \right] \lambda(\omega, \phi') d\omega \]

\[ V_1^c(k, X) = E \left[ V_2^c \left( k' \left( \phi' \right), x, X' \right) \mid X \right] \]

\[ \text{s.t. } x = Ak \quad k'(\phi') = k \int \lambda(\omega, \phi') d\omega \]

\[ V_1^b(n, X) = \max_{Q, e \in [0, \bar{e}], d \in [0, n]} c + E \left[ V_2^b \left( n' + \Pi(X, X') Q, X' \right) \mid X \right] \]

\[ \text{s.t. } -\Pi(X, X') Q \leq n', \forall X' \quad c = (\bar{e} - e) + (1 - \tau) d \quad n' = n + e - d \]
First Stage Problems

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s.t. \[ -\Pi(X, X')Q \leq n', \quad \forall X' \quad c = (\bar{e} - e) + (1 - \tau)d \quad n' = n + e - d \]
Second Stage Problems

\[ V_2^k(k, x, X) = \max_{c \geq 0, i, k^b \geq 0} \log(c) + E \left[ V_1^j(k', X') \mid X \right], \quad j \in \{c, k\} \]

s.t. \quad c + qk^b + i = x \quad k' = k^b + i + k

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s.t. \quad c + qk^b + i = x \quad k' = k^b + i + k

\[ V_2^b(n, X) = \beta^F E[V_1^b(R^b n, X') \mid X] \quad \text{if remain industry} \]

\[ V_2^b = (1 - \tau)\beta^F R^b n \quad \text{if exit} \]
Second Stage Problems

\[ V_2^k(k, x, X) = \max_{c \geq 0, i, k^b \geq 0} \log(c) + E \left[ V_1^j(k', X') | X \right], \quad j \in \{c, k\} \]

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Analytic Examples

Quantitative Analysis

Summary
• In equilibrium, the $k$-producer policy function in the 1\(^{st}\) stage is given by

$$
\mathbb{I}(\omega, k, X) = \begin{cases} 
1 & \text{if } \omega < \omega^* \\
0 & \text{otherwise}
\end{cases}
$$

• The cut-off quality $\omega^*$ is increasing in $p \rightarrow$ low $p$ implies low capital quality on the mkt

• $\omega^*$ indicates the highest quality of capital traded and the volume of intermediation
Inertia

- In equilibrium

\[ e^*(X) > 0 \text{ only if } \tilde{v}(X) \equiv \beta F \left[ E \left[ \nu^b_2 (X') \right] + \max \left\{ \frac{E \left[ \nu^b_2 (X') \Pi(X, X') \right]}{-\min_{\tilde{X}} \Pi(X, \tilde{X})}, 0 \right\} \right] \geq 1 \]

\[ d^*(X) > 0 \text{ only if } \tilde{v}(X) \equiv \beta F \left[ E \left[ \nu^b_2 (X') \right] + \max \left\{ \frac{E \left[ \nu^b_2 (X') \Pi(X, X') \right]}{-\min_{\tilde{X}} \Pi(X, \tilde{X})}, 0 \right\} \right] \leq (1 - \tau) \]

- Banks have \((S,s)\)-bands for their dividend policies with \([(1 - \tau), 1]\) as the inaction region

- In absence of asymm info \(\rightarrow \tilde{v}(X)\) is monotone decreasing in \(\kappa\)

- If asymmetric info is severe \(\rightarrow \tilde{v}(X)\) is non-monotone \(\rightarrow\) Financial sector is not recapitalized at low \(\kappa\) although recapitalization occurs at higher levels
Monotonicity

- Resale market price $p$ is weakly increasing in the financial risk capacity $\kappa$

- Pooling market price $q$ is not monotone in $\kappa$
  
  - Quantity vs Quality
    - Quantity dominates $\rightarrow$ lower $\kappa$ implies higher $q$
    - Quality dominates $\rightarrow$ lower $\kappa$ implies lower $q$

- Without asymmetric info $\rightarrow$ $q$ is monotone in $\kappa$ $\rightarrow$ only quantity matters
Outline

Introduction

The Model

Characterization

Analytic Examples

Quantitative Analysis
No Asymmetric Information

- **Marginal Value and Cost of Capital**
- **Marginal Value of Equity**
- **Expected Profits (normalized)**
- **Worst Case Profits/Losses (normalized)**
Introduction

The Model

Characterization

Analytic Examples

Quantitative Analysis

Summary

No Asymmetric Information

Figure 4: Model without asymmetric information: Equilibrium objects as functions of $\kappa$.

Proposition 11 is useful to understand the dynamics of this economy. Recall that in equilibrium worst case losses are always negative because the converse would imply infinite leverage and infinite expected profits. In contrast, expected profits must be non-negative since otherwise no intermediation would be provided. This implies that $\kappa$ will increase or decrease depending on the realization of $\phi$. When $\phi_B$ is realized, profits are negative and drag $\kappa$ down. Below $\kappa_y$ profits attract equity injections that recapitalize banks and increase the financial risk capacity. Thus, injections stabilize a system with low financial risk capacity. When $\phi_G$ is realized, dividends work in the opposite direction and $\kappa$ increases in expectation. When it increases beyond $\bar{\kappa}$, dividend pays off financial risk downwards. Hence, without asymmetric information $\kappa$ fluctuates within a unique interval. The next example shows how asymmetric information changes incentives to inject equity in a way that precludes this stabilizing force.
Asymmetric Information

Introduction

The Model

Characterization

Analytic Examples

Quantitative Analysis

Summary

Asymmetric Information

Figure 5: Model with asymmetric information: Equilibrium objects as functions of $\omega$. Parameters are set to: $\pi = \tilde{\pi}$, $\beta = \tilde{\beta}$, $\beta_f = \tilde{\beta}_f$, $A = 1.45$, $\tau = \tilde{\tau}$, $\rho = 1$. The region between regions I and II is very small: regions I and II are close to each other. Note that to the left of the second region, the marginal value of equity $\tilde{v}$ is increasing for very low values of $\kappa$. The financial crisis regime can be barely observed because the volume of intermediation and losses associated with it are very small. Hence, $\kappa$ is very small in that region. This regime occurs when $\tilde{v}$ crosses the cost of equity injections. Thus, in presence of asymmetric information, $e$ and $d$ may cease to adjust $\kappa'$ for low values.

Figure 11 in the appendix illustrates equilibrium banking and economic activity indicators as functions of $\kappa$. Among other things, the figure shows the financial crises regime is characterized by lower growth and investment rates. By means of an example, we have shown:

Proposition 12 For sufficient asymmetric information, the return to financial intermediation is non-monotone in $\kappa$ and there exists a financial crises regime.

Dynamics. The immediate effects $\phi$ on $\kappa$ are the same as in the version without asymmetric information. However, the dynamics can be very different. With asymmetric information, a realization of $\phi = \phi_B$ can drive

$\kappa$.
Asymmetric Information

The following section of the paper studies a richer version of this model introducing some extensions. As a preview, and to get a sense of the dynamics just described, Figure 6 presents a sample path of the equilibrium variables from this richer version. The intuition is the same as explained above. The simulations correspond to 8y period. Periods where the states belongs to a financial crisis regime are identified by the shaded areas in each plot. The top-left panel describes the evolution of $\kappa$ and $\kappa'$. Most of the time, $\kappa$ fluctuates between a given band. The middle-left panel plots expected profits and actual profits, which cause the movements in $\kappa$. One can observe that expected profits are on average close to zero. Actual profits fluctuate around this quantity. When profits are high, $\kappa$ exceeds its equilibrium size and dividends are paid out (bottom-left panel). Losses...
Outline

Introduction

The Model

Characterization

Analytic Examples

Quantitative Analysis

Summary
Calibration - Additional Features

- **Financial Management Costs:** Bankers pay constant equity every period and constant bonus if positive profits

- **Capital Requirements:** a $\theta$ wedge into LLC

  \[-\Pi(X, X')Q \leq (1 - \theta)n'\]

- **Physical Capital Cost:** additional parameter not to have a unitary cost of capital → equivalent to mean of TFP
## Calibration

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model Equivalent</th>
<th>Data Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposits / Loans</td>
<td>( p(\omega) \omega K )</td>
<td>C&amp;I + real estate + leases + consumer loans</td>
</tr>
<tr>
<td>Loans + Interest Income</td>
<td>( q(X) \mathbb{E}_\phi [\lambda(\omega)</td>
<td>\omega &lt; \omega^*(X)</td>
</tr>
<tr>
<td>Net Interest</td>
<td>( q(X) \mathbb{E}_\phi [\lambda(\omega)</td>
<td>\omega &lt; \omega^*(X)</td>
</tr>
<tr>
<td>Equity</td>
<td>( N )</td>
<td>Tangible net-worth</td>
</tr>
<tr>
<td>Size of Financial Sector</td>
<td>( \kappa )</td>
<td>Tangible net-worth / capital stock</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>( \psi )</td>
<td>Average non interest net-expenses / ( N )</td>
</tr>
<tr>
<td>Leverage</td>
<td>( \frac{p(\omega)}{\lambda} )</td>
<td>Loans / ( \kappa )</td>
</tr>
<tr>
<td>Bank ROE</td>
<td>( \frac{q(X) \mathbb{E}_\phi [\lambda(\omega)</td>
<td>\omega &lt; \omega^*(X)</td>
</tr>
<tr>
<td>Bank ROA</td>
<td>( \frac{q(X) \mathbb{E}_\phi [\lambda(\omega)</td>
<td>\omega &lt; \omega^*(X)</td>
</tr>
<tr>
<td>Dividends</td>
<td>( d )</td>
<td>((\Delta N - \text{profits})^-)</td>
</tr>
<tr>
<td>Equity Injections</td>
<td>( e )</td>
<td>((\Delta N - \text{profits})^+)</td>
</tr>
</tbody>
</table>
# Calibration

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calibrated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.987259</td>
<td>3% annual time discount rate</td>
</tr>
<tr>
<td>$\beta^f$</td>
<td>0.945742</td>
<td>3% annual time discount rate</td>
</tr>
<tr>
<td>$R^b$</td>
<td>1</td>
<td>0 interest on reserves</td>
</tr>
<tr>
<td>$\pi$</td>
<td>0.097342</td>
<td>Cooper et al. (1999)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.08</td>
<td>Hennessy and Whited (2005)</td>
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<tr>
<td>$\psi$</td>
<td>0.08</td>
<td>Bank non-interest expense per net-worth</td>
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<tr>
<td>$\theta$</td>
<td>0.08</td>
<td>Basel-II capital requirements</td>
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<tr>
<td><strong>Estimated</strong></td>
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<tr>
<td>$\mu_A$</td>
<td>-0.885</td>
<td>Estimated TFP process</td>
</tr>
<tr>
<td>$\rho_A$</td>
<td>0.993</td>
<td>Estimated TFP process</td>
</tr>
<tr>
<td>$\sigma_A$</td>
<td>0.0083</td>
<td>Estimated TFP process</td>
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<tr>
<td><strong>Matched</strong></td>
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<tr>
<td>$A_L$</td>
<td>3.9</td>
<td>To match bank ROA and leverage</td>
</tr>
<tr>
<td>$A_h$</td>
<td>4</td>
<td>To match bank ROA and leverage</td>
</tr>
<tr>
<td>$B_L$</td>
<td>6.2</td>
<td>To match bank ROA and leverage</td>
</tr>
<tr>
<td>$B_H$</td>
<td>5.2</td>
<td>To match bank ROA and leverage</td>
</tr>
<tr>
<td>$\Phi$</td>
<td>[0.95 0.95; 0.05 0.05]</td>
<td>To match profit transition of banks</td>
</tr>
</tbody>
</table>
Results of the Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unconditional</th>
<th>Crisis</th>
<th>Historical</th>
<th>Great Recession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation Times</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Occupation Time</td>
<td>100%</td>
<td>32.6%</td>
<td>100%</td>
<td>14.5%</td>
</tr>
<tr>
<td>Duration (quarters)</td>
<td>-</td>
<td>10.26</td>
<td>20.8</td>
<td>6</td>
</tr>
<tr>
<td>Economic Activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Growth Rate</td>
<td>4.3%</td>
<td>-10.3%</td>
<td>2.98%</td>
<td>-2.36%</td>
</tr>
<tr>
<td>Investment/Output</td>
<td>39.9%</td>
<td>-0.935%</td>
<td>8.51%</td>
<td>5.64%</td>
</tr>
<tr>
<td>Investment/Capital</td>
<td>3.58%</td>
<td>-0.0644%</td>
<td>6.09%</td>
<td>3.92%</td>
</tr>
<tr>
<td>Financial GDP/GDP</td>
<td>12.3%</td>
<td>1.59%</td>
<td>4.4%</td>
<td>5.44%</td>
</tr>
<tr>
<td>Financial Intermediation Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average κ</td>
<td>0.0659</td>
<td>0.0048</td>
<td>0.0162</td>
<td>0.0148</td>
</tr>
<tr>
<td>Financial Leverage</td>
<td>6.56</td>
<td>1.99</td>
<td>9.87</td>
<td>11.3</td>
</tr>
<tr>
<td>Loans Output</td>
<td>6.68%</td>
<td>0.0832%</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>Return to Assets (ROA)</td>
<td>6.94%</td>
<td>16.9%</td>
<td>1.18%</td>
<td>-0.0839%</td>
</tr>
<tr>
<td>Return to Equity (ROE)</td>
<td>31.3%</td>
<td>48.1%</td>
<td>16.4%</td>
<td>-1.07%</td>
</tr>
<tr>
<td>Financing Premia</td>
<td>39.5%</td>
<td>106%</td>
<td>6.25%</td>
<td>5.89%</td>
</tr>
<tr>
<td>Financial Equity Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Dividend Rate</td>
<td>0.643%</td>
<td>0.0193%</td>
<td>1.12%</td>
<td>-18.8%</td>
</tr>
<tr>
<td>Financial Stocks Index</td>
<td>100%</td>
<td>8.31%</td>
<td>100%</td>
<td>42.9%</td>
</tr>
</tbody>
</table>
Results of the Model

Figure 8: Invariant distribution and empirical distributions. The figure reports the invariant distribution of $\kappa$ obtained from the model and its empirical counterparts. The analog for the growth rate of the capital stock is also included.

Can notice this from the reduction in the loans to output ratio in the models. Volumes of intermediation and quality also fall in these episodes. This explains also the striking reduction in the investment to GDP ratios. In the model, this ratio is high in comparison with the data's historical averages. There are no further margins of improvement here unless the discount factor is lowered. This ratio is affected by the process for $A$ and the calibration of $\pi$ and $\beta$.

In addition, the model also delivers predictions about the contribution of the financial sector's added value to GDP. In the model, this figure is close to $v_{wi}$ in normal times. This contribution falls to $v_{wi}$ during the crisis regime because the profits of the sector are very low. Financial GDP during the Great Recession slightly increased.

The second block of moments reports indicators for measures of financial intermediation. The most important of these is the value of $\kappa$. This figure is larger than in the data's historical averages but falls to a smaller number when comparing a financial crises regime with the Great Recession. During a financial crisis, $\kappa$ can fall up to $9\%$ in a given period, given the nature of the LLCs. This is a more dramatic swing than during the Great Recession, where $\kappa$ decreased by $x\%$. Clearly, the dynamics of the model are more extreme than $y\%$. 
Asymmetric IRFs to Depreciation Shocks

The figure plots the responses of the model to realizations $\phi$ corresponding to high and small losses for banks.

Figures include:
- Value of Loans and Deposits
- Expected and Actual Profits
- $\kappa$ (financial sector size)
- $\omega$ (financial intermediation)
- d–e (net dividends)
- v(X)$\kappa$ (value of financial equity)
- Investment
- Output Growth Rate
- Log–Output
Summary

- This paper presented a general equilibrium model of financial intermediation with asymmetric information.

- Non-Linear reaction of the economy to financial losses:
  - Small losses $\rightarrow$ quantity effect dominates $\rightarrow$ equity injections
  - Large losses $\rightarrow$ quality effect dominates $\rightarrow$ crisis

- Quantitative results overestimate the impact of negative financial shocks.

- Extension: different sector to study how shocks to value of collateral in one sector (e.g., housing) spill over other sector through banks’ balance sheets.