Efficient or systemic banks: Can regulation strike a deal?

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CEMLA / Dallas Fed workshop, November 2023

Disclaimer: The views expressed here are those of the author, and not necessarily those of the Bank for International Settlements.
Evolution of the US banking sector ...

► 1980s and before: A large number of banks

► 1990s and 2000s: Branching deregulation and consolidation
  ► ... led to fewer and bigger banks

► 2008: Recognition of too-big-to-fail risks
  ► ... led to reforms that create disincentives to becoming large
... reflects an efficiency v.s. financial-stability trade-off

- Large banks tend to be more efficient...
  - Theory
    - Spread fixed costs more widely (Humphrey, 1990)
    - More diversified (Diamond, 1984)
    - Operational synergies (Kanatas and Qi, 2003)
    - Better screening, internal capital markets (Stein, 1997, 2002)
  - Empirics
    - Rise of larger banks is a testimony to the benefits of scale
    - Cost efficiency improves with size (Wong et al, 2008)
    - Even after considering risk-taking (Hughes and Mester, 2013)

- ... but large bank failures are socially more costly
  - While estimates vary, Lehman failure & GFC wiped 4% of global GDP
  - Aversion to close larger insolvent banks (Kang et al, 2015)
    - Size can matter due to implicit guarantees (Davila & Walther, 2020) and/or complexity (Caballero & Simsek, 2013)
This paper

Research question
▶ How should banks be organized – many small or few large?

Approach
▶ Stylized model to formalise the efficiency versus financial-stability trade-off
  ▶ Note: abstract from market-power, another key element of the trade-off
▶ Embed heterogeneous banks in a canonical macro framework
  ▶ Endogenous size distribution
  ▶ Endogenous default
  ▶ Calibrate to micro-data on US banks
▶ Analysis
▶ Use capital regulation as tool to influence banking dynamics
▶ Characterise optimal size-dependent regulation
Main takeaways

▶ Tighter regulation has opposing effects on bank dynamics
  ▶ Lower leverage (i.e. banks grow more slowly)
  ▶ Lower failure rate (i.e. banks survive longer)

▶ Regulation that equates leverage, riskiness, or expected default losses (as in case of the Basel III G-SIB framework) across banks is sub-optimal ...
  ▶ ... it does not internalize that both efficiency and financial-stability risks are size-dependent

▶ Optimal regulation should be flexibly bank size-dependent
  ▶ Calibration suggests tighter for larger banks

▶ Optimal distribution features more middle-sized banks
Related Literature

- **Banking dynamics / bank heterogeneity**: Competition for loans (Boyd and De Nicolo, 2005), imperfect competition among banks (Corbae and D’Erasmo, 2021; Jamilov, 2021), impact of risk-based capital and leverage requirements on heterogeneous banks (Muller, 2022) etc.

- **Industry dynamics more generally**: Productivity shocks in Hopenhayn (1992), Learning in Jovanovic (1982); Cost shocks in Asplund and Nocke (2006); Borrowing constraint due to limited enforcement and limited liability: Albuquerque and Hopenhayn (2004), Clementi and Hopenhayn (2006), Cooley and Quadrini (2006), etc.

- **Macro-finance models**: Gertler and Karadi (2010), Gertler and Kiyotaki (2010), Adrian & Boyarchenko (2012), etc.

Static Model
How to distribute capital across banks

- Planner must decide the number of banks $M$ to set up using a given capital endowment $K$

- Bank with capital $k_i$ raises deposit funding $f_i$ at rate $R$
  - Bank is subject to capital regulation: $k_i/(k_i + f_i) \geq \chi$

- Invest in $s_i = k_i + f_i$ projects
  - Project returns distributed as $\mathcal{N}(\mu, \sigma)$
  - Total return embeds diversification: $z_i \sim \mathcal{N}(\mu s_i, \sigma^2 s_i^d)$
    - Perfectly positively correlated: $d = 2$
    - Not correlated: $d = 1$
    - Negatively correlated: $d < 1$

- Probability of failure: $p_i = Pr(z_i \leq R(s_i - k_i))$ is lower if capital is higher (despite same leverage)

- Large bank failures are more costly: $\Delta''(s_i) > 0$
How to distribute capital across banks

Planner maximises expected cash flow such that $\sum_{i=1}^{M} k_i = K$:

$$
\max_{M} \sum_{i=1}^{M} \left( \mu s_i - R(s_i - k_i) \right) - \sum_{m=0}^{M} \Delta(m) \text{Binomial}(m; M; p(M))
$$

**Expected Return**

**Expected Loss**

**Figura:** Optimal number of banks in red, while assuming that projects across banks, and thus bank failures, are not correlated. Parameter values are as follows: $K = 100, R = 1.04, \chi = 10\%, \mu = 1.05, \sigma = 0.05, \Delta(s) = 0.1s^2$. 
Dynamic Model
Setup

- Time is discrete, horizon is infinite

- No aggregate uncertainty; only bank-level shocks

- Entities:
  - Household:
    - Representative worker
    - Unit mass of atomistic bankers
  - Banks
  - Government
  - Regulator
Household

Maximizes utility under perfect consumption insurance:

$$\max_{C_t, D_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(C_t)$$

s.t. \( C_t + D_t = W_t + E_t + R_{t-1} D_{t-1} - T_t \)

- \( C \): consumption
- \( D \): deposits (risk-free)
- \( W \): wage income
- \( E \): dividend income
- \( R \): interest rate
- \( T \): lumpsum tax
Bankers

\[
V(n) = \max_{s,d,e} \left( H(e) + \beta \int_{\psi^c} V(n') dF_s(\psi') \right)
\]

where \( n' = \psi' s - Rd \); \quad \( n' \leq \tau \implies \psi^c = \frac{Rd + \tau}{s} \);

\[
\text{s.t. } \begin{array}{l}
n + d = s + e + td; \\
\text{Cash-flow constraint}
\end{array} \quad \begin{array}{l}
\chi(n) \leq \frac{n - e}{s}; \\
\text{Capital constraint}
\end{array} \quad \begin{array}{l}
0 \leq e; \\
\text{Limited liability}
\end{array}
\]

- \( H \): concave preference over dividends
- \( e \): dividends; \( d \): deposits
- \( s \): assets with return \( \psi' \)
- \( \psi \sim N(\theta(s), \sigma(s)) \) embeds diversification benefits via \( s \)
  - banks with more post-dividend capital fail less often
- \( \tau \): failure threshold
- \( t \): deposit insurance premium rate
Government

- Deposit insurance scheme covers shortfall in liabilities of failing banks

- Provide (random) seed-funding $n^e \sim G$ to entrants

- Runs a balanced budget each period via lumpsum tax on (or rebate to) the household

- Two key assumptions
  - Resolving a failed bank is costlier for bigger banks
  - Mis-priced insurance $\rightarrow$ banks over-borrow $\rightarrow$ rationalise capital regulation
Timeline

Bank-specific asset return shocks $\psi$ realised, payoff from assets determined

Insolvent banks (cannot pay depositors) resolved by deposit insurance program.

Solvent banks pay depositors. Net cash-flow $n$ is the working capital. New banks enter the industry with seed capital. Bank size distribution determined.

Banks pay dividends, raise deposits, cover the deposit insurance premium, and invest in risky assets subject to the capital constraint.

Figura: Intra-period sequence of events
Stationary size-distribution of banks...

... computed as the fixed point of the distribution evolution:

\[ \mu(N) = M \int_{\tau}^{N} dG(n^e) + \left( \int \int_{\psi} \mathbb{1}[\tau \leq \psi s(n) - Rd(n) \leq N] dF_s(\psi) \right) d\mu_{-1}(n) \]

\[ \text{Entrants} \]
\[ \text{Transition of incumbents net of exits} \]

- \( M \): mass of entrants (same as mass of failures in steady state)
- \( \mu \): cumulative distribution function for bank capital
# Main parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.99</td>
</tr>
<tr>
<td>Resolution loss rate</td>
<td>$\Delta$</td>
<td>20% to 24%</td>
</tr>
<tr>
<td>Benchmark regulation</td>
<td>$\chi$</td>
<td>4.5%</td>
</tr>
<tr>
<td>Insurance premium rate</td>
<td>$t$</td>
<td>20 bps</td>
</tr>
<tr>
<td>Distribution of asset returns</td>
<td>$\theta_\psi$</td>
<td>$1.02 - 0.0051/(1 + s)$</td>
</tr>
<tr>
<td>Std deviation of asset returns</td>
<td>$\sigma_\psi$</td>
<td>$0.0195 + 0.0055/(1 + s)$</td>
</tr>
<tr>
<td>Entrant distribution (lognormal)</td>
<td>$G(\theta_G, \sigma_G)$</td>
<td>165, 7.49</td>
</tr>
<tr>
<td>Default threshold</td>
<td>$\tau$</td>
<td>7.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of ROA</td>
<td>0.776%</td>
<td>0.803%</td>
</tr>
<tr>
<td>S.d. of ROA</td>
<td>0.914%</td>
<td>2.208%</td>
</tr>
<tr>
<td>Mean of ROA, larger versus smaller banks</td>
<td>23.8 bps</td>
<td>27.5 bps</td>
</tr>
<tr>
<td>S.d. of ROA, larger versus smaller banks</td>
<td>-25.5 bps</td>
<td>-29.7 bps</td>
</tr>
<tr>
<td>Dividend payout to capital ratio</td>
<td>4.996%</td>
<td>3.603%</td>
</tr>
<tr>
<td>Exit rate</td>
<td>3.966%</td>
<td>2.461%</td>
</tr>
<tr>
<td>Ratio to smallest to median bank</td>
<td>1.453%</td>
<td>1.003%</td>
</tr>
<tr>
<td>KS statistic</td>
<td>0.0</td>
<td>0.0515</td>
</tr>
<tr>
<td>Power-law exponent</td>
<td>-0.7715</td>
<td>-0.7186</td>
</tr>
</tbody>
</table>

- Bank value and policy functions
- Definition of Stationary Competitive Equilibrium
- Variation in bank efficiency
Steady-state bank capital distribution

**Density of bank capital**

![Graph showing the density of bank capital with data and model lines.]

**Cumulative distribution of bank capital**

![Graph showing the cumulative distribution of bank capital with data and model lines.]

**Power law estimation**: Model

![Graph showing the power law estimation of the model with a slope of -0.7186.]

**Power law estimation**: Data

![Graph showing the power law estimation of the data with a slope of -0.7715.]

**Figura**: A comparison of model generated distribution of bank capital with that observed in the data.
Uniform capital regulation
(i.e. independent of bank characteristics)
Effect of regulation: positive analysis

▶ Tighter regulation reduces bank lending and dividends (capital preservation) …
▶ … but also reduces the bank failure probability
Effect of regulation: positive analysis

- Tighter regulation reduces growth-rate, but improves survival
- Induces more middle-sized banks
Benevolent regulator maximises lifetime utility of the representative household (depositors and bankers):

$$\max \chi \frac{u(C)}{(1 - \beta)}$$
Effect of regulation: normative analysis

- Aggregate capital increases (more retained earnings)
- Welfare gain in consumption equivalent terms is 1.09%
- Role of industry dynamics and loss rate
Bank-specific capital regulation: A tale of three regimes
Regime I: Equating probability of default (PD) across banks

In order to equate PD across banks, $\chi$ is higher for the smaller banks since they are riskier.

Comparable to risk-weighted capital requirements, but is sub-optimal:

- Expected loss (which matters for welfare) also depends on bank size.
Regime II: Equating $EL = PD \times EAD \times LGD$ across banks

- In order to equate EL across banks, $\chi$ is higher for bigger banks since EAD is greater for bigger banks ...
  - ... and leads to higher EL despite lower PD

- Comparable to the G-SIB framework, but still sub-optimal:
  - Bank efficiency also varies with size
Regime III: Flexible bank-specific regulation

\[ \chi(n) = \chi_0 + \chi_1 n + \chi_2 n^2 \]  
(asymptotes for large banks)

- Optimal requirement close to 7% for big banks and 1% for small banks
- Similar in spirit to regime II (2.5% to 4.5%), but steeper
Extensions

- Endogenous return on assets
- Endogenous mass of banks
Conclusion

▶ Should regulation encourage or discourage large banks?
  ▶ Trade-off: scale economies versus financial stability risks

▶ Develop a tractable model to study this trade-off
  ▶ Endogenous size distribution that responds to regulation
  ▶ Explicit role of regulation enables normative analysis

▶ Main takeaways
  ▶ Regulation shapes bank size-distribution
  ▶ Size-dependent regulation is needed to address a trade-off that is size-sensitive
    ▶ Focusing only on how risks vary with size while ...
    ▶ ... ignoring how efficiency depends on size is sub-optimal
  ▶ Optimal regulation is tighter for larger banks ...
  ▶ ... and induces more middle-sized banks
Thank You
Appendix
Bank size and efficiency

Value and policy functions

- Bank value function
- Dividend policy
- Asset policy
- Deposit policy
Stationary competitive equilibrium

1. \( V(n), s(n), d(n) \) and \( e(n) \) solve the bank’s problem given \( R \):

2. Deposit market clears at interest rate \( R \)

\[
\int d(n)d\mu(n) = D
\]

3. Goods market clears

\[
Y = \int \int \psi' s(n)dF_s(\psi')d\mu(n) = C + S + O - W
\]

\[
S = \int s(n)d\mu(n); \quad O = \int \int \Delta(\psi' s(n))dF_s(\psi')d\mu(n)
\]

4. The distribution of bank capital is the unique fixed point of the distribution evolution operator \( T \) given entrant mass \( M \):

\[
\mu = T(\mu, M);
\]

5. Government runs balanced budget: \( T + tD = \) start-up funding + liabilities of failed banks
Variation in bank efficiency

![Graph showing variation in Return on assets (\%) and Standard deviation of return on assets (\%) with respect to Capital.](image)
Role of distribution and bankruptcy costs

- **Total assets**: The graphs show the relationship between total assets and the parameter $\chi$. The blue line represents the baseline scenario, while the orange line represents the counterfactual scenario. As $\chi$ increases, the total assets decrease.

- **Welfare**: The graphs illustrate the welfare levels under different values of $\chi$. The welfare increases as $\chi$ increases, with a benchmark and optimal point indicated.}

### Table

<table>
<thead>
<tr>
<th>$\chi$</th>
<th>Total assets $\times 10^4$</th>
</tr>
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<tbody>
<tr>
<td>4.5%</td>
<td>2.8</td>
</tr>
<tr>
<td>5%</td>
<td>2.6</td>
</tr>
<tr>
<td>5.5%</td>
<td>2.4</td>
</tr>
<tr>
<td>6%</td>
<td>2.2</td>
</tr>
<tr>
<td>6.5%</td>
<td>2.0</td>
</tr>
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</table>

### Welfare

<table>
<thead>
<tr>
<th>$\chi$</th>
<th>Welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5%</td>
<td>99.69</td>
</tr>
<tr>
<td>5%</td>
<td>99.7</td>
</tr>
<tr>
<td>5.5%</td>
<td>99.71</td>
</tr>
<tr>
<td>6%</td>
<td>99.72</td>
</tr>
<tr>
<td>6.5%</td>
<td>99.74</td>
</tr>
</tbody>
</table>

- Benchmark: $\Delta = 0.20$
- Optimal: $\Delta = 0.40$
**Endogenous return on assets**

Note: The size-dependence of asset returns is switched off in this extension.
Endogenous mass of banks

Note: Asset returns are also endogenous in this extension.