The system-wide effects of bank capital regulation on credit supply and risk-taking

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Fall 2015
Motivation

- **Debate about stricter bank capital regulation**
  - Rationale: Deposit insurance & bailouts create external agency problem
    ⇒ banks take on more risks than socially optimal
  - Debate revolves around two channels of capital requirements
    1) Incentives: Higher capital requirements ⇒ objective of banks and society better aligned
    2) Balance sheet effects: Capital requirements may affect credit supply

- **Missing**: A tractable framework that
  - allows us to understand how these channels interact and determine economy-wide financing decisions and bank risk-taking
  - accounts for public markets as an important source of firm credit
Substitution between banks and public markets

Pattern: Contraction of bank lending $\Rightarrow$ Increase in public lending

Source: Figure 2 Panel B in Adrian, Colla, and Shin (2012)
Introduction

Contribution

1 A flexible framework to understand the systemwide, real effects of equity-ratio (capital) requirements featuring
   1 Heterogeneous firms
   2 Heterogeneous financiers (banks vs. public markets)
   3 Deposit insurance and capital regulation for intermediaries

2 Model predictions:
   1 Effects of higher capital requirements on volume and decomposition of credit supply depend on bank capital scarcity
      1 Not scarce: reduction in inefficient risk-taking
      2 Scarce: credit-rationing of both bank-dependent firms with socially valuable projects and of firms with risky, surplus-destroying projects
         ⇒ Effect on welfare and risk of banking sector ambiguous

2 Optimal policies depend on firm distribution and public market access
   1 Implication: cross-country differences in optimal regulation
   2 Cyclicality depends on which variables move most with the cycle
Graphical illustration of model mechanics

Example

i) Two equi-probable macro states \( s \in \{L, H\} \)

ii) 2,500 firm types with heterogeneous state-contingent cash flows

iii) Special case of model:

▶ Firms have same threshold for public financing \( B \) (agency rent)
▶ Bank loans to all firms are subject to same equity ratio requirements \( e \)
▶ Banks cannot finance all firms with existing equity, require deposits
▶ Banks’ outside equity raising costs are prohibitively high
If bank capital is scarce (Panel C) $\Rightarrow$ credit rationing of both positive-NPV and risky, negative-NPV projects
**Literature**

- **GE framework of Holmstrom and Tirole (1997)**
  - adds heterogeneous firms (different quality and risk)
  - adds deposit insurance / asset substitution incentives ⇒ regulation
  - see Jimenez et al. (2014) for empirical relevance in credit risk-taking

- **Banks’ specialness:**

- **Competition, charter values and banking:**

- **Capital requirements:**
Model essentials

- A single-period, discrete-state model with risk-neutrality and a storage technology
- There are four types of agents:
  1) A continuum of entrepreneurs with firms with varying cash flow distributions and agency rents.
  2) A continuum of perfectly competitive banks that
     - can monitor firms
     - are subject to an outside equity-financing friction
     - can issue insured deposits
  3) A continuum of perfectly competitive public investors
  4) A government/ regulator that sets equity ratio requirements based on risk signals
Firms

- Cashless firms require outside financing from banks or public markets.
- Investment $I$ at time 0 and produces cash flows $C_s(q|e)$ at time 1. Cash flows depend on:
  - *observable* quality type $q(f)$ and
  - *unobservable* effort $e(f) \in \{0, 1\}$
- Shirking ($e = 0$) yields private benefit of $B$ unless monitored by banks.
- Assumptions:
  - $B(q) + \mathbb{E}[C_s(q|e = 0)] - I < 0 \Rightarrow$ Shirking socially wasteful
  - $C_s(q|e = 0) < I \forall s \Rightarrow$ Simplification of IC constraint

$$NPV(q) = \mathbb{E}[C_s(q|e = 1)] - I.$$
Public markets

- Competitive investors with sufficient wealth to finance all firms
- Investment opportunity set
  1) securities issued by firms
  2) bank deposits and bank equity
  3) storage technology with zero interest
  \[ \Rightarrow \text{equilibrium expected return on all investments is zero} \]
- Firm IC and investor IR constraint under (optimal) debt contract

\[
\mathbb{E} \left[ \max \{ C_s - FV, 0 \} \mid e = 1 \right] \geq B(q) + \mathbb{E} \left[ \max \{ C_s - FV, 0 \} \mid e = 0 \right]
\]

\[
\mathbb{E} \left[ \min \{ C_s, FV \} \mid e = 1 \right] \geq I
\]

\[ \Rightarrow \text{Firm } f \text{ has access to public markets if } NPV(f) \geq B(f) \]
Banks

- Competitive banks with total wealth \( E_I \) (book value of inside equity)
- Banks monitor (at zero cost) \( \implies \) eliminate firm moral hazard
- Outside financing decisions to finance assets \( A = E_I + E_O + D \)
- Deviations from Modigliani-Miller: (microfounded in Appendix model)
  1) Insured deposits \( D \) \( \implies \) total payouts to security-holders increase in \( \frac{D}{A} \)
     - Microfoundation: deposits are subject to runs (Diamond & Dybvig)
     - Feature needed to generate risk-taking incentives
  2) Outside equity costly relative to inside equity, cost \( c(E_O) \geq 0 \)
     - Microfoundation: non-deposit financing induces inefficient cash flow diversion of bankers (Calomiris & Kahn)
     - Feature needed to generate balance sheet channel

- Market value of equity:

\[
E_M = \mathbb{E} \left[ \max \left\{ \left(1 + r_A^s\right) A - D \left(1 + r_D\right), 0 \right\} \right]
\]
Regulator

- Cannot condition regulation on firm quality, but can use signals $\rho_f$
- Risk signals generate a partition of firms: think of 24 S&P ratings
- Regulatory tools inspired by existing regulation (e.g., Basel I-III)
  - Full deposit insurance to avoid runs, $\Rightarrow$ deposit rate satisfies $r_D = 0$
  - Equity-ratio requirement constraint on banks with loan portfolio $\{x_f\}$

$$e = \frac{E}{A} \geq \sum_f x_f e(\rho_f).$$

Think of $e(\rho_f) = rw(\rho_f) \cdot e$ so that $rw(\rho_f)$ is risk-weight
Analysis Roadmap

1. Equilibrium given capital requirements
   - 1 Individual bank problem
   - 2 Capital allocation & surplus division in a competitive financial system
2. Comparative statics of capital requirements
3. Predictions
Individual bank problem

- Define banker’s levered ROE and objective function

\[ r_E(e, x) = \mathbb{E} \left[ \max \left\{ \frac{\sum_f x_f r_f^s}{e}, -1 \right\} \right] \]

\[ E_{I,M} = E_I + \max_{E_O} \left[ (E_I + E_O) \max_{e,x} r_E(e, x) - c_E(E_O) \right] \]

- Individual banks take loan returns for firm \( f \), \( r_f^s \), as given
- Upon bank default, government transfers \( A(-r_A^s - e) \) to depositors
  - Total \textit{ex-post} payouts to securityholders \( \uparrow \) (violation of MM)
  - Competing depositors pass on \textit{ex-ante} value \( \mathbb{E}(A \max \{-r_A^s - e, 0\}) \)
    - banks go to regulatory leverage constraint
    - choose loan portfolios with correlated downside risks
Competitive financial system

- Competitive public investors price public debt to break even
- Banks have 2 competitive advantages: monitoring & insured financing
- Bank funding of firm $f$ generates total *private* surplus

\[
\Pi(f) = NPV(f) \mathbb{1}_{B(f)>NPV(f)} + \mathbb{E} \left( \max \{ I \left( 1 - e(\rho_f) \right) - C_s(f), 0 \} \right)
\]

  Social advantage: monitoring
  Private advantage: deposit insurance

- General equilibrium effect: To extract maximum financing subsidy banking sector is endogenously segmented
  - Risky Greek banks do not want to hold safe German Bunds
  - Safe German banks do not want to hold Greek sovereign debt
Definition

Given $e(\rho)$, bank capital is scarce if $E_I < I \int_{f: \Pi(f) > 0} e(\rho_f) \, df$. 
Proposition (Bank capital not scarce)

1) Banks fund all borrowers with \( \Pi(f) > 0 \)
2) Public markets fund remaining firms if \( NPV(f) \geq B(f) \)
3) Funded firms extract all rents in the economy

\[
\Pi(f) + NPV(f) \mathbb{1}_{NPV(f) \geq B(f)}
\]

Public bond yield \( (y_P) \) vs. bank loan yield \( (y) \) pricing:

\[
\mathbb{E} \left[ \min \left\{ y_P(f), \frac{C_s(f) - I}{l} \right\} \right] = 0
\]

\[
\mathbb{E} \left[ \max \left\{ \min \left\{ y(f), \frac{C_s(f) - I}{l} \right\}, -e(\rho_f) \right\} \right] = 0
\]

\[\Rightarrow\] Signals (Ratings) matter for equilibrium prices (H\textsubscript{2}O, 2013; GP, 2011)
Scarce bank capital

- If bank capital scarce, banks cannot finance all firms in the economy
- Profit maximization $\Rightarrow$ drop firms with lowest profitability per unit of required capital (Profitability ranking $\neq$ Social ranking!)

$PI(f) = \frac{\Pi(f)}{Ie(\rho_f)}$

- Define $PI(f_M)$ of marginal firm funded without outside equity $PI_{E_l}$:

$E_l = I \int_{f: PI(f) \geq PI_{E_l}} e(\rho_f) \, df$. 
Proposition (Scarce bank capital)

1) No bank raises equity if \( c'(0) \geq P I_{E_I} \). Otherwise, \( E^*_O \) is the unique solution to
\[
E_I + E^*_O = I \int_{i: PI(f) > c'(E^*_O)} e(\rho_f) df.
\]

2) Banks fund all firms with \( PI(f) > r^*_E = \min \{ PI_{E_I}, c'(E^*_O) \} \)

3) Public markets fund remaining firms if \( NPV(f) \geq B(f) \)

4) Funded firms extract
\[
\Pi(f) \max \left\{ 1 - \frac{r^*_E}{PI(f)}, 0 \right\} + NPV(f) \mathbb{1}_{NPV(f) \geq B(f)}
\]

Firms funded by scarce banks now need to give up a fraction \( \frac{r^*_E}{PI(f)} \) of \( \Pi \)
Algorithm for equilibrium given capital requirements

1. Determine firm access to public markets $NPV(f) > B(f)$
2. Calculate “bank” profitability index for all firms in the economy $PI(f)$
3. Determine whether bank capital is constrained:

$$E_i \geq I \int_{f: PI(f) \geq 0} e(\rho_f) \, df$$

1. If bank capital not scarce, all firms with $PI(f) \geq 0$ are financed. Loan yields are set so bankers make zero profits
2. If bank capital is scarce, firms with $PI(f) < r^*_E$ and $NPV(f) < B(f)$ are credit rationed. Banks earn scarcity rent.
Comparative statics of capital regulation

**Corollary**

*Without equity ratio requirements, bank capital is not scarce*

1) all firms are funded at a yield of \( y(f) = 0 \), and,
2) ex-ante welfare is given by \( W = \int_{f \in \Omega} NPV(f) \, df \).

Capital requirements operate via two channels:

1. *Incentives Channel*: inefficient financing subsidy reduced
2. *Balance sheet channel*: potential credit crunch

**Proposition**

Let \( e(\rho_f) = rw(\rho_f) \cdot e \) and consider comparative statics in \( e \)

1) If bank capital is not scarce, a marginal increase in \( e \) increases surplus.
2) If bank capital is scarce, a marginal increase in \( e \) decreases surplus if the marginal funded firm, \( f_M \), satisfies, \( B(f) > NPV(f) > 0 \).
Scarcity of bank capital may be non-monotonic in capital requirements!

**Intuition:** $\varepsilon$ also effects the set of profitable investment opportunities (\(\Pi\))
Effects of banks’ outside equity issuances on additional firm financing

1. Exacerbation of overinvestment: Financing of negative-NPV firms ↑
2. Reduction of underinvestment: Financing of bank-dependent firms ↑
3. Crowding out of public markets
Predictions

- **Long-run trend in public market finance competition**
  - As public markets become more efficient, $B(f) \downarrow$, $\Rightarrow \Pi \downarrow$
  - $\Rightarrow$ Fraction of private surplus creation $\Pi$ due to risk-taking $\uparrow$
  - Example: deregulation in Japan allows firms to bypass banks $\Rightarrow$ risk-taking by banks $\uparrow$ (Kashyap & Hoshi)
  - $\Rightarrow$ Optimal regulatory action: capital requirements $\uparrow$

- **Cyclicality of optimum capital requirements depends on which variables move most with the business cycle**
  - Level of bank capital $\Rightarrow$ Pro-cyclical capital requirements
  - Firm profits $\Rightarrow$ ambiguous. Depends on whether majority of firm types
    - *becomes so profitable in good times that* $NPV \geq B$, $\Rightarrow$ procyclical
    - *moves from* $NPV < 0$ to $0 < NPV < B$ in good times, $\Rightarrow$ countercyclical
  - Countercyclical variance of firm TFP shocks. (Bloom et al., 2015) $\Rightarrow$ countercyclical
Conclusion

- We develop a tractable framework to analyze systemwide effects of capital requirements.
- Key ingredients: Firms are heterogeneous according to cash flow distribution and access to public markets.
- Robust insight: An increase in capital requirements increases welfare as long as bank capital is not scarce. If capital is scarce, it is unclear which firm types are credit rationed.
- Regulatory policies require macroprudential perspective. Our framework provides a tool to gauge the “aggregate” effects of:
  - distribution of firm types
  - public markets as a substitution channel
  - the quality of risk signals
Example

Two state economy with $s \in \{L, H\}$ and two firm types

i) Fraction $\pi_g$ good & safe borrowers producing $R > I$ in both states

ii) Fraction $\pi_b$ bad, risky borrowers produce $R$ in $s = H$ and 0 otherwise

iii) Regulator sets equity ratio requirements $e$ and uses no signals

iv) Assume that raising outside equity is prohibitively costly

v) For all firms $B > NPV \Rightarrow$ no public market financing
Example: Horse-race between incentives and balance-sheet effects

**Incentives channel** $\Pi$

- $\Pi(g, e)$
- $\Pi(b, e)$

**Balance sheet channel**

- $\epsilon \int_{f: \Pi(f) > 0} Idf$
- $\epsilon \pi_g$

**Loan yields** $y(f)$

- Good firms
- Bad firms

**Welfare** $W^*$

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