

Optimal Banking Regulation and Liquidity

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Banking regulations

Debates about sizes, profits, and incentives of banks

Reform focuses on capital and leverage regulations

Why regulate banks?

- positive externality of bank-produced *money*
- negative externality from *bank runs*

Most theoretical literature on banking regulation based on Diamond-Dybvig and focus on depositor incentives, or having a reduced-form demand for deposits

We focus on banks as **liquidity** providers to depositors, and focus on banks' incentive problem

What we do

A monetary model of bank deposits

- endogenous demand on bank deposits as means-of-payments
- liquidity provided by banks enters welfare endogenously
- based on Lagos-Wright (2005) to maintain tractability

Frictions in financial sector

- cost in asset-management/monitoring (Diamond, 1984)
- banks have limited commitment to repay deposits
(only a fraction of asset holdings pledgable)
- moral hazard in asset-management (Hellman et al., 2000)

Optimal Charter System

Policy parameters: number of charters and leverage ratio (capital requirement)

- Leverage ratio requirement
 - regulates **unsecured** deposits banks can issue to increases liquidity, but raises an incentive compatibility problem.
- Restricting the number of charters:
 - increases profits but reduces efficiency in asset management
 - profits help provide incentive to repay unsecured deposits
- Tradeoff: efficiency in banks' asset management and liquidity provision

Main result: If liquidity is constrained, optimal regulation has banks bigger, more profitable, and more leveraged than in free market

Heterogeneous banks: distribution of sizes and profits

The efficiency of asset-management differs across banks

- with free entry, more efficient banks hold more assets and enjoy higher profits, and it is an efficient outcomes
- leverage ratio is still bounded by limited pledgeability

Under optimal charter policy

- larger banks are allowed to issue more unsecured deposits and become larger, and have higher leverage ratios

Policy implication: higher concentration than free market can be optimal

Moral Hazard

Banks can shirk on asset-management, invest in risky projects

- market can discipline banks put effort through capital requirements (depends on the technological details of shirking)

Optimal capital regulation is a combination of

- proportional requirement as in market discipline
- an overall leverage ratio (depends on bank characteristics)

As moral hazard gets more serious, optimal to have

- stricter proportional requirement to control for moral hazard
- allow for more unsecured deposits to compensate for liquidity
- result: banks are larger and more profitable than otherwise

Is gambling always bad though it's beneficial to be prudent?

Related literature

Pledgeability constraints

- Kiyotaki and Moore (1997)
- Williamson (2012)

Charter value and banking regulations

- evidence: charter value induces prudent behavior (Keeley, 1990)
- charter value to discipline banks: Hellmann et al. (2000), Gorton and Winton (2017)
 - in Hellmann et al. (2000) restricting entry and deposit-rate ceilings are optimal, but it would be sub-optimal in our model
 - why? deposit demand, bank entry decision and sizes are endogenously determined in our model

Banking in monetary models

- cash/deposit-in-advance model: Chari and Phelan (2014)
- deposit-in-utility model: Phelan (2016)

Model

Environment

Agents: sellers, buyers, and bankers; each is of measure one

Infinite horizon, two stages in each period

1. decentralized market (DM)

- buyers randomly meet with sellers in pairs, prob. of meeting σ
- only buyers can consume: utility $u(q)$
- only sellers can produce: cost $c(q)$

2. centralized market (CM)

- All agents can produce and consume
- CM good z : all agents get utility z (negative value indicates production)

Environment (con't)

Agents have limited commitment and, except for banks, are anonymous

- means-of-payments are necessary to facilitate trades in DM

Agents maximize expected lifetime utility with $\beta = \frac{1}{1+r}$

First-best level of DM consumption

$$q^* = \arg \max [u(q) - c(q)]$$

Banking: asset management

One real asset: entrepreneurial projects

- each pays off τ units of CM good in one period
- average supply (per buyer) of projects is \bar{A}

Only banks have expertise to manage projects to obtain dividend

- An active bank has to pay fixed cost γ each period
- holding a units of projects costs $\psi(a)$ to monitor/manage

Banking: issuing deposits

Banks can issue deposits to fund their asset holdings

Deposit certificates

- payable to bearers
- durable, divisible, and cannot be counterfeited
- can be used as means-of-payments in DM

Financial frictions

- banks have limited commitment to repay depositors
- upon bankruptcy, only ρ fraction can be secured for depositors (as in Kiyotaki and Moore, 1997)

Banks buy assets and offer deposit contracts in competitive CM

Course of events

CM events

1. banks settle deposit obligations with depositors
2. banks buy real assets in CM at price ϕ (in terms of CM good)
3. banks may issue deposit contract, promising gross return R in exchange for CM good

DM events

1. buyers meet sellers in pairs
2. buyer makes a take-it-or-leave-it offer to seller
3. buyer transfers deposit certificates to seller for DM good

Efficient level of entries

Suppose that banks cannot issue deposits, so they maximize profits

$$\pi(a, d; \phi, R) = -\phi a - \gamma - \psi(a) + \beta \tau a$$

- FOC: fundamental value of assets

$$\phi^* = \frac{\tau}{1+r} - \psi' \left(\frac{\bar{A}}{m^*} \right)$$

- bank's operating profit by holding A projects becomes

$$\Pi(A) = \psi'(A)A - \psi(A)$$

Free entry: equilibrium m^* solves $\Pi(\bar{A}/m^*) = \gamma$

- m^* also minimizes the cost of asset management:

$$m^* = \arg \min_{m \geq 0} m\gamma + m\psi \left(\frac{\bar{A}}{m} \right)$$

Static Contracts

Competitive market for deposits

Equilibrium objects:

- ϕ , asset price
- R , promised return on deposits
- m , number of active banks

Competitive equilibrium

- bank maximizes profits, subject to pledgeability constraint
- buyers chooses deposit holdings for DM trade and CM return
- market clearing for assets and deposits

Bank problem

Given ϕ and R , banks choose asset holding a and deposit issuance d to maximize profit ($\iota = \frac{1}{\beta R} - 1$)

$$\begin{aligned}\pi(a, d; \phi, R) &= \frac{d}{R} - \phi a - \gamma - \psi(a) + \beta\{\tau a - d\} \\ &= \beta\{\iota d + \tau a - (1+r)\phi a - (1+r)[\psi(a) + \gamma]\}\end{aligned}$$

subject to **pledgeability constraint**

$$d \leq \rho \tau a$$

- for $\iota > 0$, the constraint is binding

Asset demand, $A(\iota, \phi)$, solves the following FOC:

$$-(1+r)\phi + (1+\iota\rho)\tau = (1+r)\psi'(a)$$

Buyer DM problem

Buyer with d units of deposit makes offer (q, p) that solves

$$\max u(q) + W(d - p) \text{ s.t. } p - c(q) \geq 0, p \leq d$$

- $W(\cdot)$ is linear
- $p - c(q) \geq 0$ is seller IR
- $p \leq d$ is the liquidity constraint; no personal credit feasible

Solution: $q(d) = \min\{c^{-1}(d), q^*\}$, $p(d) = c(q(d))$

Depositor (buyer) CM problem

Given R , solves

$$\max_{d \geq 0} -\frac{d}{R} + \beta \{ \sigma [u(q(d)) - c(q(d))] + d \}$$

where

- $c(q(d)) = d$ if $d < c(q^*)$
- $q(d) = q^*$ otherwise

(note: d is the **promised value** of deposits in the coming CM)

$D(\iota)$, the deposit demand per depositor, is the solution to the FOC

$$\iota = \frac{\sigma [u'(q(d)) - c'(q(d))]}{c'(q(d))}$$

Equilibrium conditions

Market clearing conditions:

- for deposits, $D(\iota) = \rho(\tau + \phi)\bar{A}$
- for projects, $mA(\iota, \phi) = \bar{A}$

Free entry: m determined by zero-profit condition

Static contracts: results

Lemma

There is a unique equilibrium allocation, (m, ϕ, ι, q, d) , that can be characterized as follows:

- 1. If $\rho\tau\bar{A} \geq c(q^*)$, then $m = m^*$, $\phi = \phi^*$, $q = q^*$, $\iota = 0$.*
- 2. Otherwise, $m = m^*$, $\phi > \phi^*$, $q < q^*$, and $\iota > 0$.*

The first-best is implementable when $\rho\tau\bar{A}$ is high

- assets abundant; pledgeability high; returns on projects high

Otherwise,

- inefficiency in liquidity provision, $q < q^*$ and $\iota > 0$
- asset price exhibits liquidity premium $\phi > \phi^*$
- no inefficiency in asset management: $m = m^*$
- better than fiat money system only if $\iota < r$

Reserve requirements

Bank reserves: central bank liability without net returns

- but fully pledgeable and tradable in CM
- measured in terms of CM goods; quantity denoted by z

Reserve requirement: each bank needs to hold $z \geq \eta d$

- z is reserve holding
- d is deposit issuance
- $\eta \in [0, 1)$ is the required reserve ratio

Pledgeability constraint: $d \leq \rho \tau a + z$

Bank problem

Choose a , d and z to maximize profit:

$$\begin{aligned}\pi(a, d, z; \phi, R) &= \frac{d}{R} - \phi a - z - \gamma - \psi(a) + \beta\{\tau a + z - d\} \\ &= \beta\{\iota d + [\tau - (1+r)\phi]a - rz - (1+r)[\psi(a) + \gamma]\}\end{aligned}$$

subject to pledgeability and reserve requirement

- $d > 0$ optimal only if $\iota - \eta r \geq 0$
- in that case, both constraints are binding, and profits:

$$\beta \left\{ \frac{\iota - \eta r}{1 - \eta} \rho \tau a + [\tau - (1+r)\phi]a - (1+r)[\psi(a) + \gamma] \right\}$$

Equilibrium

Market clearing implies

$$\phi = \frac{\left(1 + \rho \frac{\iota - r\eta}{1 - \eta}\right) \tau - \psi' \left(\frac{\bar{A}}{m}\right) (1 + r)}{1 + r},$$

and $\iota \equiv \iota(\eta)$ solves

$$D(\iota) \leq \frac{\rho\tau}{1 - \eta} \bar{A},$$

with equality whenever $\iota > 0$

- to ensure that banks issue deposits, we need

$$\eta r \leq \iota(\eta)$$

Optimal reserve requirement

Theorem

In any equilibrium with free entry, we have $m = m^$.*

- 1. If $\rho\tau\bar{A} \geq c(q^*)$, optimal reserve requirement has $\eta = 0$.*
- 2. Otherwise, optimal reserve requirement is $\eta = \tilde{\iota}/r$ with $\tilde{\iota} \in (0, r)$ determined by*

$$D(\iota) = \frac{r\tau\rho\bar{A}}{r - \iota}.$$

- central bank has to anticipate equilibrium $\tilde{\iota}$ to set optimal reserve requirement
- under optimal reserve requirement, banks are **essential**

Bank leverage under free entry

In equilibrium, a bank's balance sheet has

- *book value* of assets (in terms of coming CM good): $z + \tau \frac{\bar{A}}{m^*}$
- deposit liability: $z + \rho\tau \frac{\bar{A}}{m^*}$
- equity $(1 - \rho)\tau \frac{\bar{A}}{m^*}$

Define *leverage* as the ratio between debt and assets; under free entry,

$$\mathcal{L} = \frac{\rho\tau \frac{\bar{A}}{m^*} + z}{\tau \frac{\bar{A}}{m^*} + z} = \frac{\rho}{1 - (1 - \rho)\eta}$$

Dynamic Contracts

Charter System

Policy parameters to maximize social welfare

- m : number of banking licences
- κ : unsecured lending each bank
- η : reserve requirement

Restricting the number of charters

- increases profits but reduces efficiency in asset management
- profits help provide incentive to repay unsecured deposits
- Tradeoff: efficiency in asset management and liquidity provision

Regulator can close a bank who does not repay deposits

New pledgeability constraint and reserve requirement:

$$\begin{aligned}d &\leq \rho\tau a + z + \kappa \\z &\geq \max\{0, \eta(d - \kappa)\}\end{aligned}$$

Characterization

Lemma

Let $m \in [\bar{m}, m^*]$ and let η, κ be given. There is a unique ι such that $\iota \geq 0$ and

$$D(\iota) \leq \frac{\rho\tau}{1-\eta}\bar{A} + m\kappa, \quad (1)$$

with equality whenever $\iota > 0$. Moreover, profit for each bank is given by

$$\Pi\left(\frac{\bar{A}}{m}\right) - \gamma + \frac{\iota \cdot \kappa}{1+r}.$$

Policy parameters have to respect incentive compatibility

- to have positive deposit issuance we still need $\eta \leq \iota/r$
- also need incentive compatibility for κ

Incentive compatibility for repayment

Only punishment for not repaying κ is to lose charter

- we may interpret κ as bank-specific capital requirement

A bank is willing to repay deposits iff

$$-\kappa - \rho\tau\bar{A}/m - z + \sum_{t=0}^{\infty} \beta^t \left[\Pi \left(\frac{\bar{A}}{m} \right) - \gamma + \frac{\iota \cdot \kappa}{1+r} \right] \geq -\rho\tau\bar{A}/m - z,$$

$$-(r - \iota)\kappa + (1+r) \left[\Pi \left(\frac{\bar{A}}{m} \right) - \gamma \right] \geq 0 \quad (2)$$

Lemma

Let $m \leq m^$ be given. Then, there exists the highest κ that satisfies (2).*

Optimal Charter System

Given measure of banks m and allocation (ϕ, ι, q, d) , welfare is given by

$$W = \sigma[u(q) - c(q)] - m\psi(\bar{A}/m) - m\gamma.$$

- first-best: $m = m^*$, $q = q^*$

Theorem

There exists an optimal policy (m, κ) that maximizes welfare subject to market-clearing conditions and (2).

- 1. If first-best is implementable with static contract, then $(m, \eta, \kappa) = (m^*, 0, 0)$ is an optimal policy.*
- 2. Otherwise, any optimal policy has $m < m^*$, $\eta > 0$, and $\kappa > 0$.*

Leverage under optimal charter system

Suppose that the first-best is not implementable

- optimal $m < m^*$, $\eta = \iota/r > 0$, and $\kappa > 0$
- bank leverage: $\mathcal{L} = \frac{\rho\tau\frac{\bar{A}}{m} + z + \kappa}{\tau\frac{\bar{A}}{m} + z} = \frac{\rho\tau\frac{\bar{A}}{m} + (1-\eta)\kappa}{\tau\frac{\bar{A}}{m}[1-(1-\rho)\eta]}$
higher than the one without charter

Regulation on κ can be interpreted as leverage requirement

- optimal κ depends on characteristics of assets and banks

Deposit insurance and charter system can implement the optimal eqm uniquely by allowing the issuance of unsecured debt and terminating banks that fail to repay deposits

Heterogeneity

Heterogeneity in management efficiency

N type of banks, measure μ_n of type- n banks with $\sum_{n=1}^N \mu_n = 1$

- cost function for type- n bank is $\lambda_n \psi(a) + \gamma$
- $\lambda_n \in [1, \bar{\lambda}]$ is strictly increasing in n

Lemma

Under static contract, there is a unique equilibrium. The measures of active banks, $\mathbf{m}^ = (m_n^*)_{n=1}^N$, is given by \bar{n} and $0 < m_{\bar{n}} \leq \mu_{\bar{n}}$ such that*

$$\mathbf{m}^* = (\mu_1, \dots, \mu_{\bar{n}-1}, m_{\bar{n}}^*, 0, \dots, 0),$$

$$\lambda_n \Pi(A_n(\mathbf{m}^*)) \geq \gamma, \text{ for all } n = 1, \dots, \bar{n},$$

$$\lambda_n \Pi(A_{\bar{n}}(\mathbf{m}^*)) = \gamma \text{ if } m_{\bar{n}} < \mu_{\bar{n}},$$

$$\lambda_n \Pi(A_n(\mathbf{m}^*)) < \gamma, \text{ for all } n = \bar{n} + 1, \dots, N.$$

Heterogenous banks and reserve requirements

The profit of a type- n bank is

$$\pi_n(a, z, d; \phi, R) = \beta \{ \iota d - [(1+r)\phi - \tau]a - rz - (1+r)[\lambda_n \psi(a) + \gamma] \}$$

subject to the pledgeability constraint and reserve requirement

Theorem

In any equilibrium with free entry, we have $\mathbf{m} = \mathbf{m}^$.*

- 1. If $\rho\tau\bar{A} \geq c(q^*)$, optimal reserve requirement has $\eta = 0$.*
- 2. Otherwise, optimal reserve requirement is $\eta = \tilde{\iota}/r$ with $\tilde{\iota} \in (0, r)$ determined by*

$$D(\iota) = \frac{r\tau\rho\bar{A}}{r - \iota}.$$

Allowing for varying η across bank types does not increase welfare.

Heterogenous bank leverages

Policy parameters under charter system: $\{m_n\}$ and $\{\kappa_n\}$ (λ_n observable)

- type- n bank pledgeability constraint: $d \leq \rho\tau a + z + \kappa_n$
- for all $n < \bar{n}$, $\kappa_n(\mathbf{m}^*) > 0$ is implementable

Theorem

Suppose that $\psi(A) = A^x$ for some $x > 1$. If first-best is not implementable, then for any optimal policy $(\mathbf{m}, \{\bar{\kappa}_n(\mathbf{m})\})$, the leverage ratio for bank n

$$\mathcal{L}_n = \frac{\rho\tau A_n(\mathbf{m}) + z_n + \bar{\kappa}_n(\mathbf{m})}{\tau A_n(\mathbf{m}) + z_n}$$

is strictly decreasing in n .

Moral Hazard and Capital Requirements

Moral Hazard

Banks may gamble on their assets; by gambling,

- cost of managing a units of assets is $\psi(a) - ea + \gamma$

Return under gambling is stochastic:

- with prob. q return is $\tau_h > \tau$
- with prob. $1 - q$ return is $\tau_\ell < \tau$
- when τ_h realizes, the difference $\tau_h - \tau$ is not observable
 - private gain to bank

Assume

$$(1 + r)e < \tau - [q\tau_h + (1 - q)\tau_\ell] \quad (3)$$

and hence it is socially beneficial for banks not to gamble

Static contracts

Prudent behavior can be implemented with pledgeability constraint:

$$d \leq \rho\tau_\ell a + \omega(\tau - \tau_\ell)a + z$$

- ω is capital requirement imposed by market discipline
- lower ω means more bank capital to finance banks' asset holdings
- $1 - \omega$ stands for bank's own share for effort

A *prudent equilibrium* consists of an ω (with an equilibrium allocation) such that

- banks are willing to be prudent
- no banks can credibly issue more deposits than what the pledgeability constraint requires

Static contract: prudent equilibrium

Lemma

In equilibrium $m = m^$. The highest ω under which no bank gambles in equilibrium is given by $\min\{\omega_1, \rho\}$ with*

$$\omega_1 \equiv 1 - \frac{(1+r)e + q(\tau_h - \tau)}{(1-q)(\tau - \tau_\ell)}. \quad (4)$$

- ω_1 only depends on shirking technology
- $e \uparrow, \tau_h \uparrow, q \uparrow \Rightarrow \omega_1 \downarrow$
- for ρ sufficiently large, optimal ω is independent of ρ

Under moral hazard, free entry still implies $m = m^*$

Charter system with moral hazard

Regulator sets m , pledgeability constraint (κ and ω) and reserve requirement η :

$$\begin{aligned}d &\leq \rho\tau_\ell a + \omega(\tau - \tau_\ell)a + z + \kappa \\z &\geq \max\{\eta(d - \kappa), 0\}\end{aligned}$$

- banks that default or has return τ_ℓ are terminated
- a gambling bank pays d_ℓ to depositors under return τ_ℓ :

$$d_\ell = \rho\tau_\ell a + z$$

Incentive compatibility

Given that banks are prudent, incentive for η and κ the same as before; incentive not to gamble trades off

- benefits from gambling:
 - (1) saving of repaying less when the return is τ_ℓ
 - (2) lower cost of effort
 - (3) not paying κ when fails
- cost of gambling:
 - (4) lower average rate of return
 - (5) future profits lost when fails

$$\Pi(A^s) - \Pi(\bar{A}/m) + \underbrace{\beta(1-q)\kappa}_{(3)} \leq \underbrace{\frac{\beta(1-q)}{1-\beta} \left[\Pi\left(\frac{\bar{A}}{m}\right) - \gamma + \frac{l \cdot \kappa}{1+r} \right]}_{(5)},$$

where A^s satisfies the FOC:

$$\psi'(A^s) = \beta \left\{ \underbrace{q\tau_h + (1-q)\tau_\ell - \tau + \omega(1-q)(\tau - \tau_\ell)}_{(4)} + \underbrace{\omega(1-q)(\tau - \tau_\ell)}_{(1)} + \underbrace{(1+r)e}_{(2)} + (1+r)\psi'\left(\frac{\bar{A}}{m}\right) \right\}$$

Optimal capital and leverage requirements

Theorem

Let $m < m^$ be given. Suppose that $\rho \in (0, 1)$. The optimal reserve requirement is $\eta = \iota/r$, optimal capital requirement is such that $\omega = \min\{\rho, \omega_1\}$ given by (4), and κ is the highest κ that satisfies (2).*

- given the theorem, we can then solve for optimal m as before

Theorem

Suppose that $\psi(A) = \lambda A^x/x$, $x > 1$, and $c(q) = q$, and that $\iota + D'(\iota)/D(\iota)$ is strictly increasing. If the first-best is not implementable under market discipline, then, as τ_h increases, optimal m decreases, and optimal profit increases.

Is gambling always bad?

Trade-off between gambling and stricter capital requirement

- to induce prudent behavior, $\omega = \omega_1$ is optimal, which decreases deposit supply

An equilibrium with all banks gambling exists if and only if $\omega_1 \leq \rho$

Theorem

Let $m \leq m^$ be given. The optimal gambling equilibrium yields a higher welfare than the optimal prudent equilibrium if and only if first-best is not implementable under prudent equilibrium and $\omega_1 < \rho q$.*

Concluding remarks

Regulation and bank capital

- predicts that optimal charter and DI will increase bank leverage
- broadly consistent with US banking sector before Great Depression and Great Recession (Koch et al., *AER*, 2016)

Bank size and profits

- optimal charter system requires banks be inefficiently large and make economic profits
- precise optimal size depend on fundamentals
- size and concentration have implications on stable leverage ratio