Bank Regulation under Fire Sale Externalities

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Motivation: Background

- The recent crisis was characterized by liquidity problems.
- The regulation before the crisis was predominantly micro-prudential and focused on capital requirements.
- Basel III supplements capital regulations with liquidity requirements (such as LCR and NSFR) and focuses on macro-prudential measures.

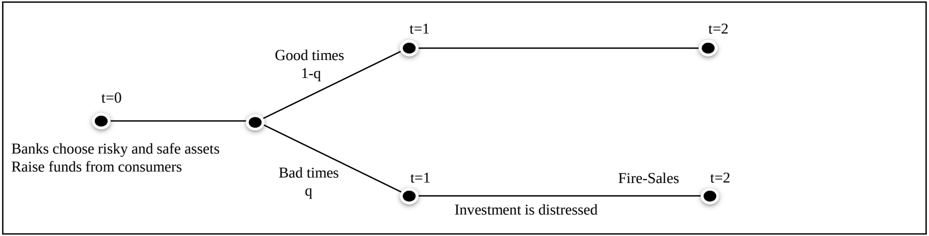
Research Questions

This paper investigates the optimal design of capital and liquidity regulations in a model characterized by systemic externalities generated by asset fire sales. Our research questions are:

- Can we trust the institutions to properly manage their liquidity, once excessive risk taking has been controlled by the capital requirement?

- What are -if any- the advantages and disadvantages of liquidity requirements that supplement the capital regulations?

Sketch and the Timing of the Model



Agents

A continuum of banks with a unit mass.

A continuum of consumers with a unit mass.

A continuum of outside investors with a unit mass.

A financial regulator (*e.g.* a central bank).

Related Literature

Financial Regulation
Holmstrom and Tirole (1998), Acharya (2003), Farhi and Tirole (2009), De Nicolo, Gamba and Lucchetta (2012), Goodhart et al (2013), Kashyap, Tsomocos and Vardoulakis (2014), Ahnert (2014), Walther (2014)

Asset Fire Sales
Williamson (1988), Shleifer and Vishny (1992, 2011), Kiyotaki and Moore (1997), Lorenzoni (2008), Gai et al. (2008), Korinek (2011), Stein (2012)

Incomplete Markets
Hart (1975), Stiglitz (1982), Geanakoplos and Polemarchakis (1986)

The Model: Basic Setup

Three dates: $t = 0, 1, 2$.

Two goods:
- A consumption good (liquid/safe asset)
- An investment good (illiquid/risky asset)

Banks can convert consumption goods into investment goods one-to-one at $t = 0$.

Banks choose risky asset level, n_i, at $t = 0$.

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Banks choose risky asset level, n_i, at $t = 0$.

Two states of the world at $t = 1$:
- Good state with probability $1 - q$
- Bad state with probability q

The risky assets pay a return of R at $t = 2$.

Technology and Notation I

Safe assets: Banks are endowed with a storage technology with unit returns.

A bank chooses how much safe assets to hold per unity of risky assets, $b_i \in [0, 1]$.

A bank hoards total safe assets of $n_i b_i$ at $t = 0$.

The total assets of a bank is $n_i + n_i b_i = (1 + b_i) n_i$.

Technology and Notation II

Assets	Liabilities
Risky assets (n_i)	Deposits (L_i)
Cash ($n_i\, b_i$)	Equity (E)

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Cash ($n_i\, b_i$)	Equity (E)

Banks are endowed with E units of fixed equity capital.

Banks raise $L_i = (1 + b_i)n_i - E$ units of consumption goods from depositors.

Risk weighted capital ratio of bank is E / n_i.

Capital regulation limits risky investment n_i since the equity is fixed.

Cost of funding and operating a bank

Banks' initial equity is sufficiently large to avoid default in equilibrium.

As a result, deposits are safe, and the net interest rate on deposits is zero.

The operational cost of a bank is $\Phi((1+b_i)n_i)$, where $\Phi'(\cdot) > 0$ and $\Phi''(\cdot) > 0$.

$\Phi(\cdot)$ is convex, that is, $\Phi'(\cdot) > 0$ and $\Phi''(\cdot) > 0$. Van den Heuvel (2008) and Acharya (2003, 2009).

The total cost of a bank is $D((1+b_i)n_i) = \Phi((1+b_i)n_i) + (1+b_i)n_i$.

Liquidity Shock at $t = 1$

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Two states of the world at $t = 1$:
- Good state with probability $1 - q$
- Bad state with probability q

Good state:
- No liquidity shock.
- Bank's assets yield $Rn_i + n_i b_i$ units of consumption goods at $t = 2$.

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Bad state:
- Investment distressed, has to be restructured to remain productive.
- Restructuring costs are c units per risky asset.
- Banks can use safe assets $n_i b_i$ to carry out the restructuring.
- Banks fire sale assets if safe assets are not sufficient.

The net expected return on the risky asset is positive: $R > 1 + qc$.

Outside Investors' Problem

Outside investors are endowed with large liquid resources at $t = 0$ and 1.

They can purchase assets from banks and employ them in a technology F.

F is concave ($F' > 0$ and $F'' < 0$), and satisfies $F'(0) \leq R$.

They choose how much investment goods y to buy from banks at $t = 1$

$$\max_{y \geq 0} \quad F(y) - Py$$

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First order conditions: $F'(y) = P$.

Outside investors' demand function $y = Q^d(P) \equiv F'(P)^{-1}$ is downward sloping!

Assume outside investors' demand is elastic to rule out multiple equilibria: $\epsilon_{P,y} = -\frac{\partial y}{\partial P}\frac{P}{y} = -\frac{F'(y)}{yF''(y)} > 1$

Crisis and Fire-Sales

A bank decides what fraction of investment to sell $(1-\gamma_i)$

$$\max_{0\leq\gamma_i\leq 1} \pi_i = R\gamma_i n_i + P(1-\gamma_i)n_i + b_i n_i - cn_i$$

subject to the budget constraint

$$P(1-\gamma_i)n_i + b_i n_i - cn_i \geq 0.$$

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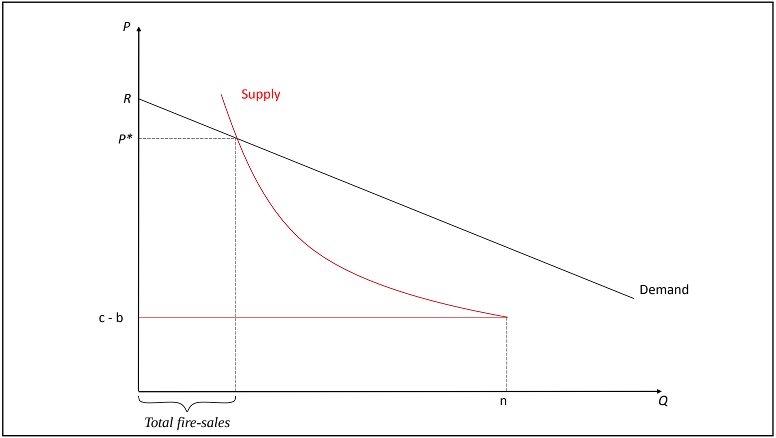
In equilibrium $c < P \leq R$. Hence, the BC binds, and we obtain

$$1-\gamma_i = \frac{c-b_i}{P}$$

and the total supply of assets is

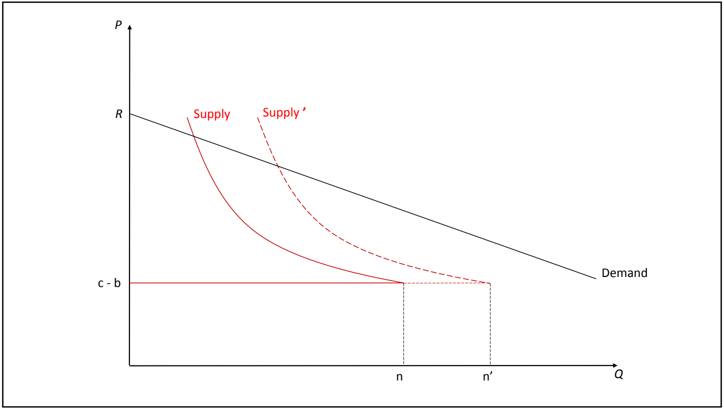
$$(1-\gamma)n = \frac{c-b}{P}n \quad \Longleftarrow \quad \boxed{\text{Downward Sloping Supply}}$$

Asset Market Equilibrium at t=1



Equilibrium price, P, and the fraction of assets sold in equilibrium, $1 - \gamma = (c - b)/P$, are functions of n and b.

Asset Market Equilibrium: Comparative Statics



Lemma: A higher initial risky investment (n) or a lower a liquidity ratio (b) increases the severity (lower asset prices) and the cost (more asset fire-sales) of financial crises.

Three Cases

We will compare and contrast three cases:

- Competitive Equilibrium: No regulation (n, b).
- Partial Regulation: Only the risky investment level (n_i) is regulated, i.e. pre-Basel III regulation (n^*, b^*).
- Complete Regulation: Both risky investment level (n_i) and liquidity ratio (b_i) are regulated (n^{**}, b^{**}).

Competitive Equilibrium

Banks' problem at $t = 0$:

$$\max_{n_i, b_i} \Pi_i(n_i, b_i) = (1-q)(R+b_i)n_i + qR\gamma_i n_i - D(n_i(1+b_i))$$

where $\gamma_i = 1 - \frac{c-b_i}{P}$ as obtained from banks' problem at $t = 1$.

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First order conditions with respect to n_i and b_i are respectively:

$$\begin{aligned} (1-q)(R+b_i) + qR\gamma_i &= D^{'}(n_i(1+b_i))(1+b_i) \\ (1-q)n_i + qR\frac{1}{P}n_i &= D^{'}(n_i(1+b_i))n_i \end{aligned}$$

Regulator moves first and sets n. Given $n_i = n$, banks choose the liquidity ratio (b_i) to maximize their expected profits. FOCs of banks' problem wrt b_i yields:

Partial Regulation: Regulating only capital

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The regulator maximizes:

$$\max_n W(n) = \ (1-q)(R+b(n))n + qR\gamma n - D((1+b(n))n)$$

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Using $\gamma = 1 - \frac{c-b(n)}{P}$ the first order conditions with respect to n is:

$$(1-q)[R+b(n)+nb^{'}(n)] + qR[\gamma + n\Big(\frac{c-b}{P^2}\frac{dP}{dn} + \frac{1}{P}b^{'}(n)\Big)] = D^{'}(n(1+b(n)))[1+b(n)+nb^{'}(n)]$$

Complete Regulation: Regulating both capital and liquidity

Regulator's problem at $t = 0$:

$$\max_{n,b} W(n,b) = (1-q)(R+b)n + qR\gamma n - D(n(1+b))$$

First order conditions with respect to n, b are respectively:

$$\begin{aligned}(1-q)(R+b) + qR\left\{\gamma + n\frac{c-b}{P^2}\frac{\partial P}{\partial n}\right\} &= D^{'}(n(1+b))(1+b) \\ (1-q)n + qR\left\{\frac{1}{P} + \frac{c-b}{P^2}\frac{\partial P}{\partial b}\right\}n &= D^{'}(n(1+b))n\end{aligned}$$

Functional Assumptions

Demand side: $F(y) = R\ln(1+y)$.

For this return function we obtain the (inverse) demand function as

$$P = F'(y) = \frac{R}{1+y} \text{ and hence } y = F'^{-1}(P) = \frac{R-P}{P} \equiv Q^d(P)$$

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The operational cost of a bank: $\Phi(x) = dx^2$, and hence

$\Phi^{'}(\cdot)$ is increasing, that is, $\Phi^{'}(x) = 2dx$.

Partial Regulation

Proposition 3

Banks decrease their liquidity ratio as the regulator tightens the limit on risky investment, i.e. $b_i'(n) > 0$.

- Stricter limits on risky investment $\rightarrow$ lower liquidity ratios.
- Banks are restricted to take risk on the investment side, they switch to the liquidity channel.

Competitive Equilibrium vs Partial Regulation

Lemma 2

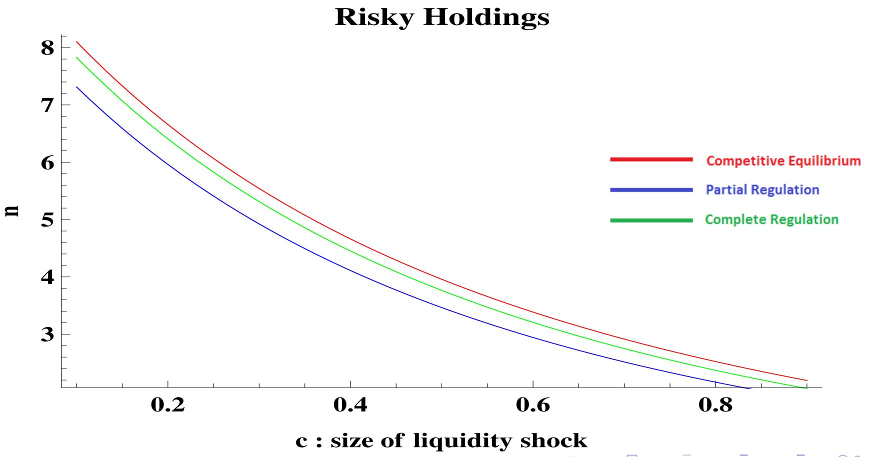
$n > n^*$
$b > b^*$

- There is over investment in the risky asset under competitive equilibrium.
- Banks are less liquid under partial regulation: They undermine the purpose of regulation.

Comparing Risky Holdings (n)

Proposition 4 (a)

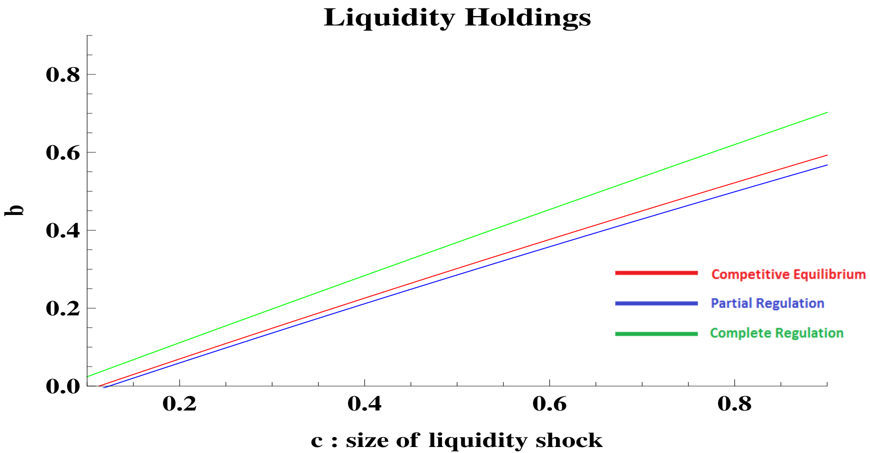
$n > n^{**} > n^{*}$



Comparing Liquidity Hoarding (b)

Proposition 4 (b)

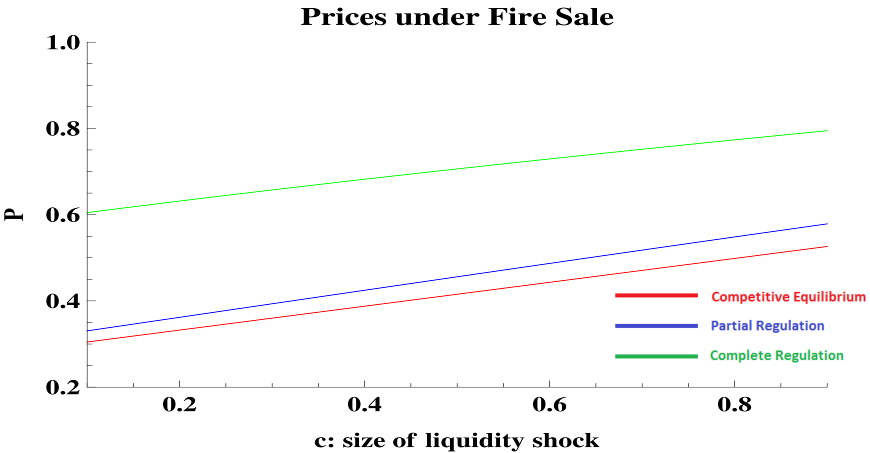
$b^{**} > b > b^{*}$



Fire-sale price of risky asset

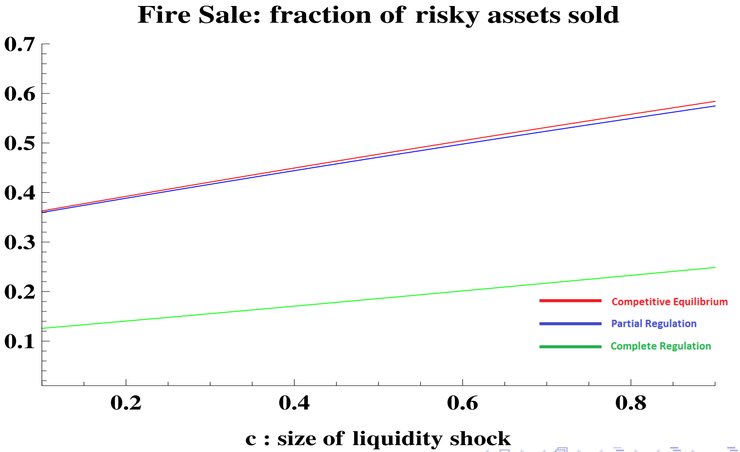
Proposition 4 (c)

$P^{**} > P^{*} > P$



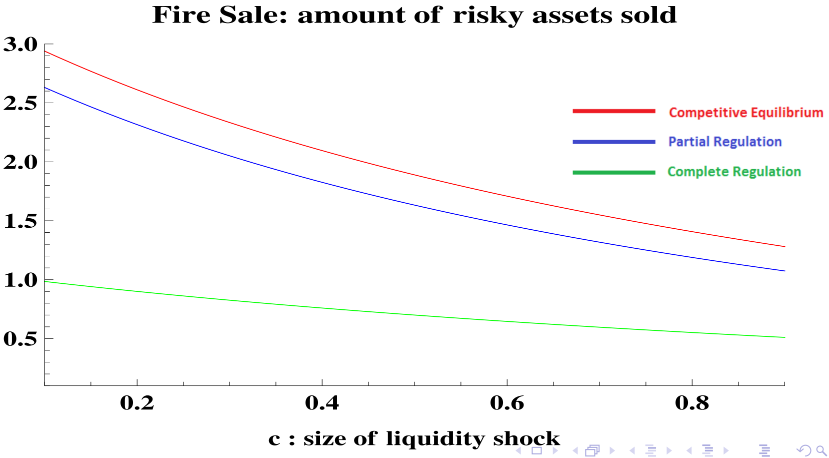
Proposition 4 (c)

$1 - \gamma > 1 - \gamma^{*} > 1 - \gamma^{**}$



Proposition 4 (c)

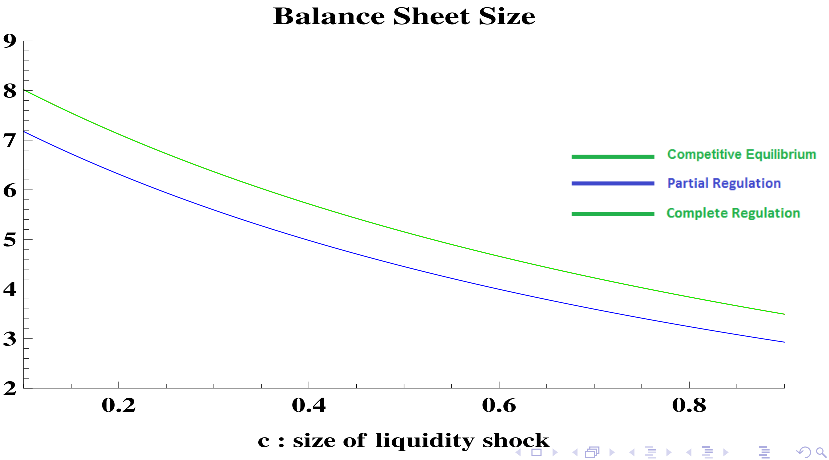
$$(1-\gamma)n > (1-\gamma^*)n^* > (1-\gamma^{**})n^{**}$$



Balance Sheet Size

Proposition 4 (d)

$(1+b)n = (1+b^{**})n^{**} > (1+b^{*})n^{*}$



Partial vs Complete Regulation

- Looking at $n^{**} > n^*$, one may think that entering the interim period with n^* rather than n^{**} should be safer.
- However, fire-sales are bigger under *partial* regulation:
  - Ratio: $1 - \gamma^* > 1 - \gamma^{**}$
  - Level: $(1 - \gamma^*)n^* > (1 - \gamma^{**})n^{**}$
- Level of risky investment is not as informative for fire-sales.
- The important thing is not the level of risky investment; it is how the risky investment is backed by liquid assets.

Advantages of Regulating Liquidity

- More funds for high return projects: $n^{**} > n^{*}$
- More liquidity: $b^{**} > b^{*}$
- Less fire-sales:
  - Ratio: $1 - \gamma^{*} > 1 - \gamma^{**}$
  - Level: $(1 - \gamma^{*})n^{*} > (1 - \gamma^{**})n^{**}$
- Higher fire sale prices: $P^{**} > P^{*}$

Conclusion

- If we regulate capital but not liquidity, banks will undermine the regulation by taking more risk through the liquidity channel.

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- Capital ratios alone would not reveal the severity of fire sales.
- Regulation of liquidity is essential to address fire sales related financial instability.
- Basel III liquidity regulations are a step in the right direction.

Appendix I: Endogeneizing the deposit rate

Let $L_i = (1 + b_i)n_i - E$ be the initial deposits at bank i.

Each bank is a local monopsony and chooses n_i, b_i, r_i to maximize:

$$(1 - q)[(R + b_i)n_i - r_i L_i] + q\ max\{R\gamma_i n_i - r_i L_i, 0\} - E - \Phi(n_i(1 + b_i))$$

subject to the Individual Rationality (IR) condition of its depositors:

$$(1 - q)r_i L_i + q\ min\{R\gamma_i n_i, r_i L_i\} \geq L_i$$

IR will bind. We have two cases, depending on parameters:

Case 1: No bank failure in equilibrium and hence banks will set $r_i = 1$.

Case 2: Bank failure in equilibrium. The IR condition will imply:

$$(1 - q)r_i L_i + qR\gamma_i n_i = L_i \ \Rightarrow\ r_i = [L_i - qR\gamma_i n_i]/[(1 - q)L_i] \qquad (1)$$

In both cases, substituting optimal r_i back into bank's problem yields the same problem as before:

$$(1 - q)(R + b_i)n_i + qR\gamma_i n_i - (1 + b_i)n_i - \Phi(n_i(1 + b_i))$$

Appendix II: Deposit insurance

Fairly priced deposit insurance: Banks pay deposit insurance fees in good times, and in exchange the deposit insurance agency covers any deficits in bad times.

Banks can offer zero net interest to depositors.

$$(1-q)[(R+b_i)n_i - L_i - \tau_i L_i] + q max\{R\gamma_i n_i - L_i, 0\} - E - \Phi(n_i(1+b_i)$$

The fair pricing of deposit insurance requires

$$(1-q)\tau_i L_i = q \ max\{L_i - R\gamma_i n_i, 0\}$$

Substitute this back into the bank's problem above:

$$(1-q)(R+b_i)n_i + qR\gamma_i n_i - E - L_i - \Phi(n_i(1+b_i))$$

Using $L_i = (1+b_i)n_i - E$ this can be written as:

$$(1-q)(R+b_i)n_i + qR\gamma_i n_i - n_i(1+b_i) - \Phi(n_i(1+b_i))$$