

A low-angle, upward-looking photograph of a classical building facade. The image features a large, dark, ornate metal sculpture, possibly a coat of arms or a decorative finial, mounted on a light-colored stone wall. The wall is composed of large, rectangular blocks. The lighting is bright, creating strong shadows and highlights on the stone and metal. The overall tone is formal and institutional.

FEDERAL RESERVE BANK *of* NEW YORK

Liquidity Policies and Systemic Risk

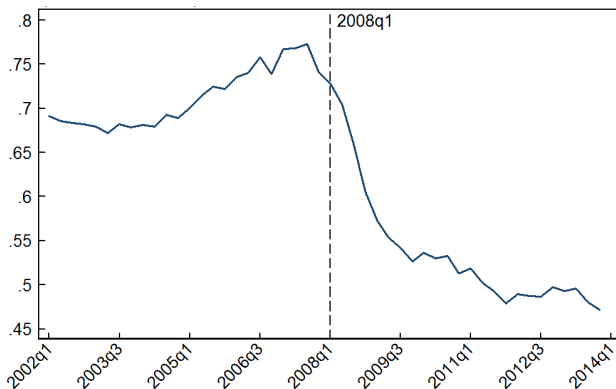
Tobias Adrian and Nina Boyarchenko

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Motivation for Liquidity Regulation

- Liquidity shortages are key characteristics of the financial crises
- Liquidity stress is caused by:
 - Short-term wholesale funding of non-traditional, illiquid assets
 - Mismanagement of contingent liquidity risk
 - Uncertainty about counterparties and collateral disruptions
- Basel III regulation promotes resilience to liquidity shocks by addressing two objectives:
 - Enhance resilience to short-term funding shocks by requiring FIs to hold a minimum pool of liquid assets (LCR)
 - Improve longer term liquidity management by requiring activity funded with core or stable funding (NSFR) [not finalized]

Ratio of Unstable Liabilities to Liquid Assets



- Fraction of liabilities that runs at a 30 day horizon under stress
- Liquid assets haircuted to account for illiquidity
- Haircuts are from the LCR, plot from Dong and Zhou (2014)

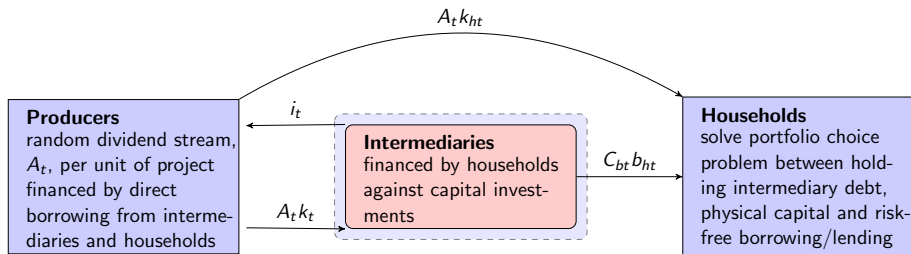
Our Approach

- We use a standard macro model with a financial sector
- We add two key assumptions:
 - Financial intermediaries have to hold liquidity against liabilities
 - Capital regulation is risk based as in Adrian and Boyarchenko (2012)
- Framework allows us to study the equilibrium implications of liquidity requirements on the quantity and price of credit
- Framework also features systemic financial crises

Preview of Results

- Within the context of our model, liquidity requirements are a preferable prudential policy tool relative to capital requirements
- Tightening liquidity requirements lowers the likelihood of systemic distress, without impairing consumption growth
- Capital requirements trade off consumption growth and distress risk

Economic Structure



Intermediaries' Balance Sheet

Assets	Liabilities
Productive capital ($A_t p_{kt} k_t$)	Risky debt ($A_t p_{bt} b_t$)
Risk-free debt ($A_t \mathcal{T}_t$)	Inside equity (w_t)

Production

- Total output evolves as

$$Y_t = A_t K_t$$

- Stochastic productivity of capital $\{A_t = e^{a_t}\}_{t \geq 0}$

$$da_t = \bar{a}dt + \sigma_a dZ_{at}$$

- $p_{kt}A_t$ denotes the price of one unit of capital in terms of the consumption good
- Aggregate amount of capital K_t evolves as

$$dK_t = (I_t - \lambda_k)K_t dt$$

Intermediaries

- Financial intermediaries create new capital

$$dk_t = (\Phi(i_t) - \lambda_k) k_t dt$$

- Investment carries quadratic adjustment costs (Brunnermeier and Sannikov (2012))

$$\Phi(i_t) = \phi_0 \left(\sqrt{1 + \phi_1 i_t} - 1 \right)$$

- Intermediaries finance investment projects through inside equity and outside risky debt giving the budget constraint

$$\mathcal{T}_t A_t + p_{kt} A_t k_t = p_{bt} A_t b_t + w_t$$

Intermediaries' Risk Based Capital Constraint

- Risk based capital constraint (Danielsson, Shin, and Zigrand (2011))

$$\alpha \sqrt{\frac{1}{dt} \langle k_t d(p_{kt} A_t) \rangle^2} \leq w_t$$

- Implies a time-varying leverage constraint

$$\theta_{kt} = \frac{p_{kt} A_t k_t}{w_t} \leq \frac{1}{\alpha \sqrt{\frac{1}{dt} \left\langle \frac{d(p_{kt} A_t)}{p_{kt} A_t} \right\rangle^2}}$$

- Equity is proportional to the Value-at-Risk of assets implying time varying default probabilities

Risk-based Capital Constraints

VaR is the potential loss in value of inventory positions due to adverse market movements over a defined time horizon with a specified confidence level. We typically employ a one-day time horizon with a 95% confidence level.

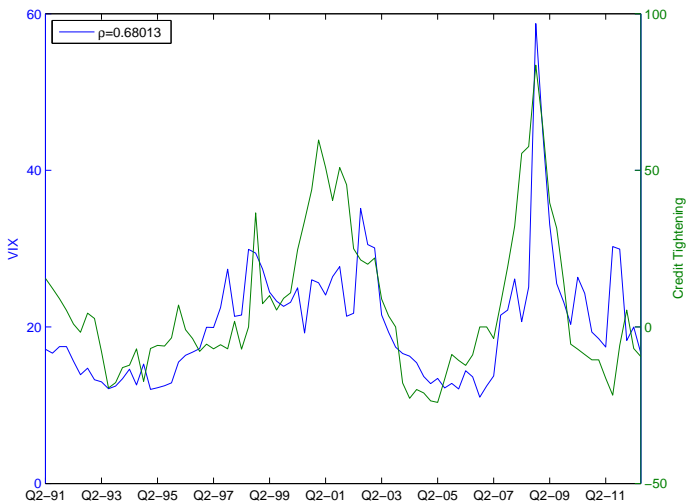
Average Daily VaR

in millions Risk Categories	Year Ended December		
	2011	2010	2009
Interest rates	\$ 94	\$ 93	\$176
Equity prices	33	68	66
Currency rates	20	32	36
Commodity prices	32	33	36
Diversification effect ¹	(66)	(92)	(96)
Total	\$113	\$134	\$218

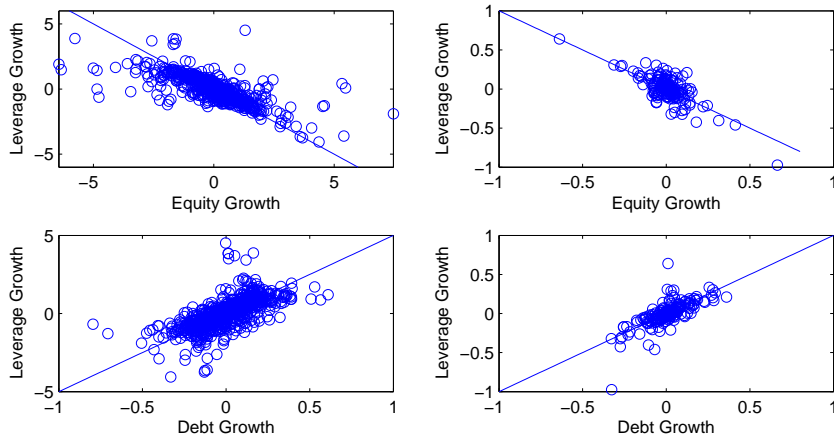
1. Equals the difference between total VaR and the sum of the VaRs for the four risk categories. This effect arises because the four market risk categories are not perfectly correlated.

Source: Goldman Sachs 2011 Annual Report

Commercial Bank Tightening Standards

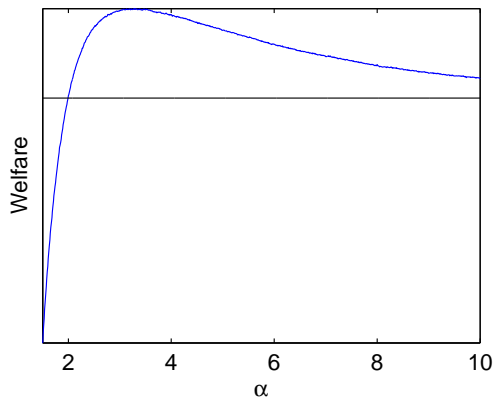


Procyclicality induced by Risk based Capital Constraint



Source: Adrian and Boyarchenko (2012)

Systemic Risk Return Tradeoff



Source: Adrian and Boyarchenko (2012)

Intermediaries' Liquidity Constraint

- Liquidity constraint (similar to Basel III's liquidity coverage ratio)
- Requires intermediaries to hold cash in proportion to outstanding debt

$$\underbrace{1 + \theta_{bt} - \theta_{kt}}_{\text{cash/equity}} \geq \tilde{\Lambda} \underbrace{\theta_{bt}}_{\text{debt/equity}}$$

where

$$\theta_{bt} = \frac{p_{bt} A_t b_t}{w_t}$$

- The constraint can be rewritten as

$$\theta_{bt} \geq \frac{1}{1 - \tilde{\Lambda}} (\theta_{kt} - 1) = \Lambda (\theta_{kt} - 1)$$

- Intermediaries are required to hold cash to buffer potential short term funding needs

Intermediaries' Optimization

- Intermediary are myopic mean-variance optimizers solving

$$\max_{\theta_t, \theta_{bt}, i_t} \mathbb{E}_t \left[\frac{dw_t}{w_t} \right] - \frac{\gamma}{2} \mathbb{V}_t \left[\frac{dw_t}{w_t} \right],$$

subject to the dynamic intermediary budget constraint

$$\frac{dw_t}{w_t} = \theta_t (dr_{kt} - r_{ft} dt) - \theta_{bt} (dr_{bt} - r_{ft} dt) + r_{ft} dt,$$

the risk-based capital constraint constraint

$$\theta_t^{-1} \geq \alpha \sqrt{\frac{1}{dt} \left\langle \frac{d(p_{kt} A_t)}{p_{kt} A_t} \right\rangle^2},$$

and the liquidity constraint

$$\theta_{bt} \geq \Lambda(\theta_{kt} - 1)$$

Systemic Distress

- Distress occurs when

$$\tau_D = \inf_{t \geq 0} \{w_t \leq \bar{\omega} p_{kt} A_t K_t\}$$

- Term structure of systemic distress

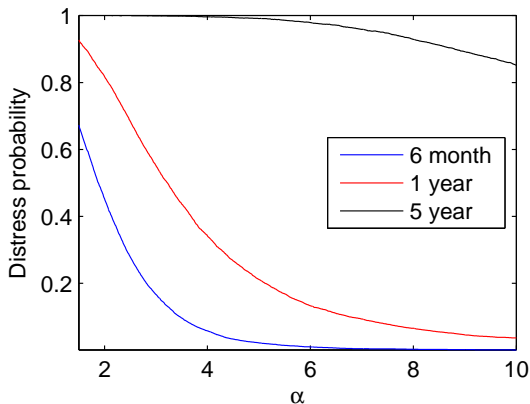
$$\delta_t(T) = \mathbb{P}(\tau_D \leq T | (w_t, \theta_t))$$

In distress

- Management changes
- Intermediary leverage reduced to $\underline{\theta} \approx 1$ by defaulting on debt
- Intermediary instantaneously restarts with wealth

$$w_{\tau_D^+} = \frac{\theta_{\tau_D}}{\underline{\theta}} w_{\tau_D}$$

Systemic Distress and Capital Regulation



Source: Adrian and Boyarchenko (2012)

Households

- Household preferences are:

$$\mathbb{E} \left[\int_0^{+\infty} e^{-(\xi_t + \rho_h t)} \log c_t dt \right]$$

- Liquidity preference shocks (as in Allen and Gale (1994) and Diamond and Dybvig (1983)) are $\exp(-\xi_t)$

$$d\xi_t = \sigma_\xi dZ_{\xi_t}$$

- Households do not have access to the investment technology

$$dk_{ht} = -\lambda_k k_{ht} dt$$

Market Structure

Market	Intermediaries	Households	Total
Capital	k_t	k_{ht}	K_t
Consumption	$i_t k_t A_t$	c_t	$A_t K_t$
Risky Debt	$-b_t$	b_{ht}	0
Risk-Free Debt	$\mathcal{T}_t A_t$	$\mathcal{T}_{ht} A_t$	$\mathcal{B} A_t$

Equilibrium

An equilibrium in this economy is:

- A set of price processes $\{p_{kt}, p_{bt}, r_{ft}\}_{t \geq 0}$
- A set of household decisions $\{k_{ht}, b_{ht}, c_t\}_{t \geq 0}$
- A set of intermediary decisions $\{k_t, \rho_t, i_t, \theta_t, \theta_{bt}\}_{t \geq 0}$

Such that:

- 1 Household's optimize
- 2 Intermediary's optimize
- 3 The capital market clears
- 4 The risky bond market clears
- 5 The risk-free debt market clears
- 6 The goods market clears

Solution Strategy

- Equilibrium is characterized by two state variables, leverage θ_t and relative intermediary net worth ω_t

$$\omega_t = \frac{w_t}{w_t + w_{ht}} = \frac{w_t}{p_{kt}A_tK_t}$$

- Represent state dynamics as

$$\begin{aligned}\frac{d\omega_t}{\omega_t} &= \mu_{\omega t}dt + \sigma_{\omega a,t}dZ_{at} + \sigma_{\omega \xi,t}dZ_{\xi t} \\ \frac{d\theta_{kt}}{\theta_{kt}} &= \mu_{\theta t}dt + \sigma_{\theta a,t}dZ_{at} + \sigma_{\theta \xi,t}dZ_{\xi t}\end{aligned}$$

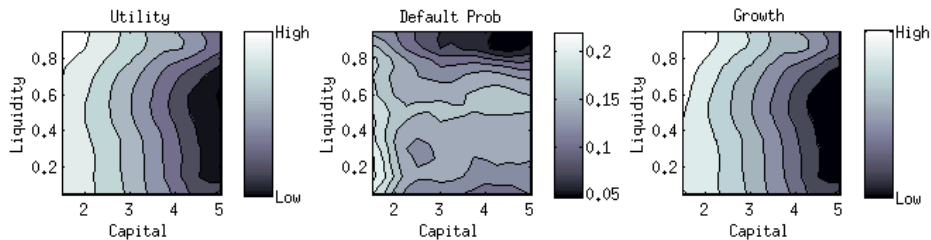
- Numerical solution

Roadmap

Examine the trade-off between

- Liquidity requirements and capital requirements
 - Liquidity requirements and supply of risk-free debt
-
- Varying the tightness of liquidity and capital regulation affects
 - the risk-taking behavior of intermediaries
 - the intermediaries' leverage cycle
 - endogenous volatility amplification
 - endogenous systemic risk
 - Varying the supply of risk-free debt affects the equilibrium risk-free rate and thus the equilibrium cost of issuing risky debt

Trading off Liquidity and Capital Regulation



Conclusion

- Impact of liquidity and capital requirements in general equilibrium
- The model features
 - Procyclical financial intermediary leverage cycle
 - Endogenous volatility
 - Endogenous systemic risk
- Within the context of our model, liquidity requirements are a preferable prudential policy tool relative to capital requirements
 - Tightening liquidity requirements lowers the likelihood of systemic distress, without impairing consumption growth
 - In contrast, capital requirements trade off consumption growth and distress probabilities

Related Literature

- **Liquidity Regulation:** Goodhart, Kashyap, Tsomocos, and Vardoulakis (2012), Perotti and Suarez (2011), Calomiris and Heider (2013)
- **Leverage Cycles:** Geanakoplos (2003), Fostel and Geanakoplos (2008), Brunnermeier and Pedersen (2009)
- **Amplification in Macroeconomy:** Bernanke and Gertler (1989), Kiyotaki and Moore (1997)
- **Financial Intermediaries and the Macroeconomy:** Gertler and Kiyotaki (2012), Gertler, Kiyotaki, and Queralto (2011), He and Krishnamurthy (2012, 2013), Brunnermeier and Sannikov (2011, 2012)

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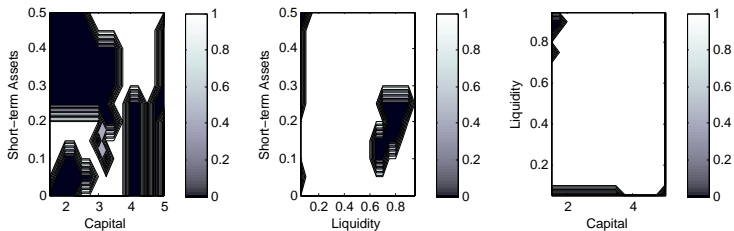
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Mark Gertler, Nobuhiro Kiyotaki, and Albert Queralto. Financial Crises, Bank Risk Exposure, and Government Financial Policy. Unpublished working papers, Princeton University, 2011.

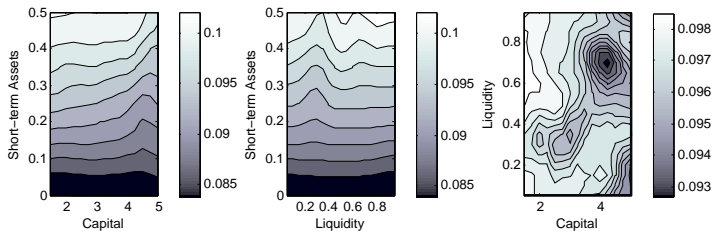
Charles A.E. Goodhart, Anil K. Kashyap, Dimitrios P. Tsomocos, and Alexandros P. Vardoulakis. Financial Regulation in General Equilibrium. NBER Working Paper No. 17909, 2012.

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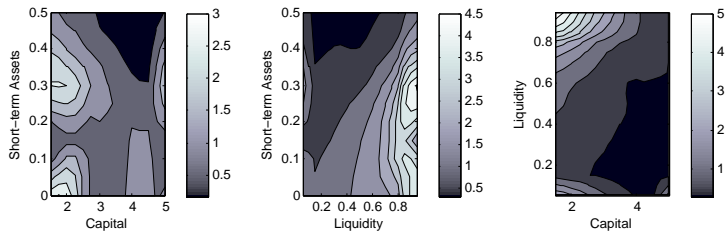
Intermediaries' binding Liquidity Constraints



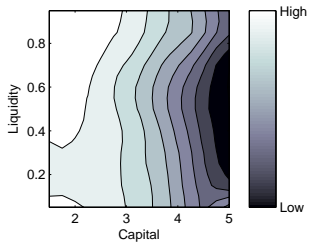
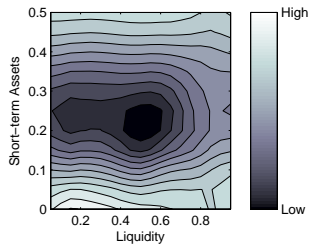
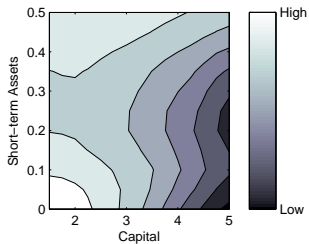
Risk Free Rate



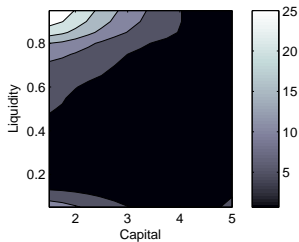
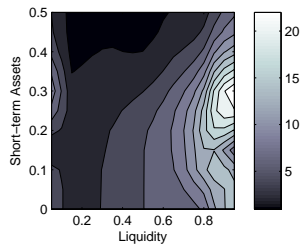
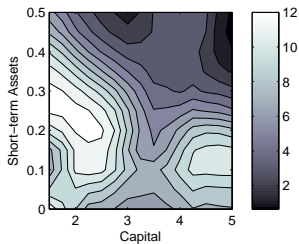
Households' Risky Assets



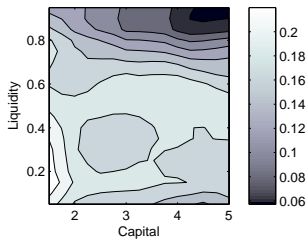
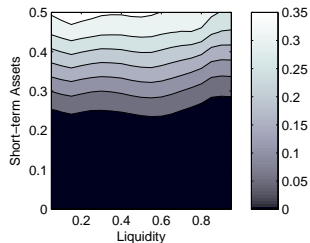
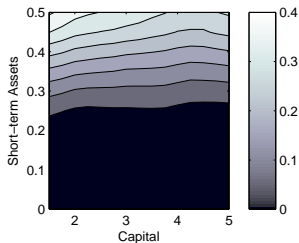
Household Welfare



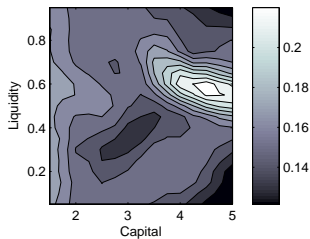
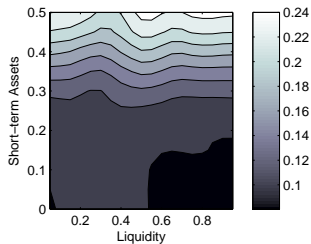
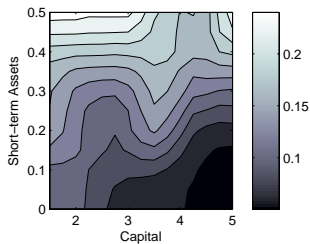
Debt-to-equity Ratios



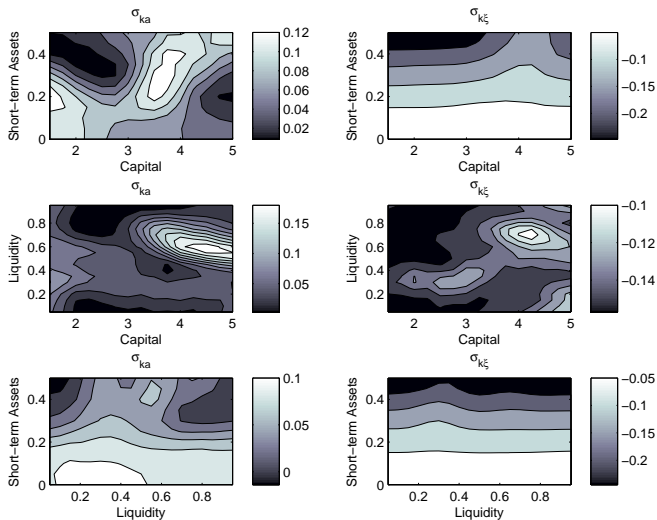
Distress probability



Local Volatility



Exposures of Return to Capital to Fundamental Shocks



Consumption Growth

