Procyclicality of Capital Requirements in a General Equilibrium Model of Liquidity Dependence

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Objective

Quantify the procyclicality of bank capital requirements in a general equilibrium environment

- Assess the effects of the regulatory constraints on output volatility
    1. Fixed requirements (Basel I)
    2. Procyclical regulation (Basel II): requirement ratio is higher (lower) during downturns (booms)
- Equity issuance cost is higher (lower) during downturns (booms)
    - Kashyap and Stein (2004), Repullo and Suarez (2008) etc.

Approach

- Use the moral hazard framework of Holmstrom and Tirole (1998) embedded in a GE framework (Kato (2006))
  - Explicit role of credit lines
- Firms increase their liquidity dependence on banks during economic downturns by drawing down loan commitments
- 80% of all C&I loans is made under loan commitments in the U.S.
- Alternatives:
  1. CSV: Bernanke et al. (1999), Carlstrom and Fuerst (1997)
  2. Double moral hazard: Chen (2001), Meh and Moran (2008)
     - No liquidity dependence feature

Main Idea

- Holmstrom-Tirole optimal contract ⇒ countercyclical dependence on credit lines
- Tighter capital requirements in a downturn ⇒ intermediation is more costly (capital is more costly) ⇒ discourage this dependence
  - Tighter capital requirements = higher capital requirement ratio and/or equity issuance cost is higher
- More positive NPV projects are destroyed

Results

- Average effects: output volatility (s.d. of cyclical component of aggregate output)
  - No requirement vs. Basel I: 3 – 5 bps
  - No requirement vs. Basel II: 8 – 10 bps
- Effects at business cycle peaks and troughs are much more significant
  - No requirement vs. Basel I: 10 – 15 bps
  - No requirement vs. Basel II: 20 – 25 bps

Outline

1. Model
2. Calibration
   - Utilization rate of credit lines
   - Cyclical pressure on bank capital positions (Kashyap-Stein)
3. Steady state effects of permanently higher capital requirement ratio from 8 to 12%
   - Transition dynamics
4. Business cycle effects
   - Comparison of the three economies: (i) no regulation economy, (ii) Basel I economy and (iii) Basel II economy

Model - Overview

- Four types of agents: households, entrepreneurs, banks and firms and two types of goods: capital and consumption goods
- Entrepreneurs borrow funds from households to produce the capital goods
- Intermediation is subject to a moral hazard problem (entrepreneurs may not exert enough effort)
- Banks are constrained by capital requirements
- Firms produce the consumption goods

Sequence of Events

1. The aggregate technology shock (ϵ) is realized.
2. Firms hire labor and rent capital and produce the consumption good.
3. Households make the consumption-saving decision.
4. The bank uses the resources obtained from the households to provide loans to the entrepreneurs.
5. The entrepreneurs borrow $i - n$ consumption goods from the bank and invests in capital-creation projects.
6. The idiosyncratic liquidity shocks (ω) are realized. The projects with $\omega \leq \bar{\omega}$ are financed through credit lines. Otherwise, are liquidated.
7. Outcomes of the continued projects are realized. The entrepreneurs with successful projects pay back the loan.
8. The entrepreneurs make the consumption-saving decision.

Financial Contract (Intra Period)

- Entrepreneur has net worth n and borrows $i - n$ from the bank. Entrepreneur's technology transforms i units of consumption good into Ri units of the capital good if the project is successful (if it fails, the return is zero).

- The probability of success is p_j where $j \in \{H, L\}$. Project has three stages:
  1. Stage 0: the investment i is put in place
  2. Stage 1: exogenous "liquidity shock" $\omega \in [0, \infty)$ is realized
     - If bank does not provide liquidity needs, project is liquidated at τi
  3. Stage 2: project is undertaken subject to moral hazard. If high effort is exerted the success probability is $p_H (> p_L)$, otherwise yields a private benefit of Bi

Capital Requirements and Equity Issuance Cost

- Issuing equity involves a resource cost: $c = \gamma(A)e$
- Zero profit condition (assuming the high effort)

$$\underbrace{i - n + qiE(\omega|\omega \leq \overline{\omega})\Phi(\overline{\omega})}_{\text{total loan}} = \underbrace{qi\int_0^{\bar{\omega}} p_H(R - R^e(\omega))\phi(\omega)d\omega}_{\text{return from successful projects}}$$

$$+ \underbrace{qi(1-\Phi(\bar{\omega}))\tau}_{\text{liquidation value}} - c$$

- Capital requirement:

$$e = \theta(A)[i - n + qiE(\omega|\omega \leq \overline{\omega})\Phi(\overline{\omega})]$$

- Combining these results in:

$$[1 + \theta(A)\gamma(A)]\left[i - n + qiE(\omega|\omega \leq \overline{\omega})\Phi(\overline{\omega})\right]$$

$$= qi\int_0^{\overline{\omega}} p_H(R - R^e(\omega))\phi(\omega)d\omega + qi(1-\Phi(\bar{\omega}))\tau$$

Optimal Contract

- Maximize entrepreneur's return

$$\max_{i,R^e,\bar{\omega}} qip_H \int_0^{\bar{\omega}} R^e(\omega)\phi(\omega)d\omega - n$$

subject to the incentive compatibility constraint:

$$p_H R^e \geq p_L R^e + B$$

and the bank's break-even constraint

- Binding IC constraint implies:

$$R^e = \frac{B}{p_H - p_L}$$

  - R^e is independent of ω

Solution of the Financial Contract

- Choose $\bar{\omega}$ for given levels of n and q
- FOC (when $\tau = 0$):

$$q \int_0^{\bar{\omega}} \Phi(\omega) d\omega = 1$$

- Zero profit condition implies:

$$i = \frac{1}{1 - qh(\bar{\omega}, \theta(A)\gamma(A))} n$$

where

$$h(\bar{\omega}, \theta(A)\gamma(A)) = \frac{\Phi(\bar{\omega}) p_H (R - \frac{B}{p_H - p_L})}{1 + \theta(A)\gamma(A)} - E(\omega | \omega \leq \overline{\omega}) \Phi(\overline{\omega})$$

Households

- Representative household maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t)$$

subject to

$$c_t + s_t = r_t k_t + w_t(1 - l_t)$$

$$k_{t+1} = (1 - \delta)k_t + \frac{1}{q_t} s_t$$

- FOCs:

$$q_t = \beta E_t \left(\frac{u_c(c_{t+1}, l_{t+1})}{u_c(c_t, l_t)} \right) \left[r_{t+1} + (1 - \delta) q_{t+1} \right]$$

$$w_t = -\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)}$$

Entrepreneurs

- Each entrepreneur maximizes:

$$E_0 \sum_{t=0}^{\infty} (\beta^e)^t c_t^e$$

- Entrepreneurs with successful projects

$$n_t = (1-\delta) q_t z_t + r_t z_t + w_t^e$$

$$c_t^e + q_t z_{t+1} = q_t R^e \frac{1}{1 - q_t h(\bar{\omega}_t, \theta(A_t)\gamma(A_t))} n_t$$

- FOC

$$q_t = \beta^e E_t [q_{t+1}(1-\delta) + r_{t+1}] \frac{q_{t+1} p_H R^e \Phi(\bar{\omega}_{t+1})}{1 - q_{t+1} h(\bar{\omega}_{t+1} \theta(\Omega_{t+1}))}$$

- Entrepreneurs with failed projects: $c_t^e = 0$ and $z_{t+1} = 0$

General Equilibrium

- Labor markets clearing:

$$H_t = (1-\eta)(1-l_t),\ J_t = \eta$$

- Consumption goods market:

$$A_t K_t^{\alpha} H_t^{\iota} J_t^{1-\alpha-\iota} = (1-\eta)c_t + \eta c_t^e + \eta i \Bigg(1 + q_t E(\omega | \omega \leq \overline{\omega}) \Phi(\overline{\omega}) + q_t \frac{\theta(A_t)\gamma(A_t)\Phi(\bar{\omega}_t)\omega_0 - (1-\Phi(\bar{\omega}_t))\tau}{1+\theta(A_t)\gamma(A_t)} \Bigg)$$

- Capital goods:

$$K_{t+1} = (1-\delta)K_t + \eta i p_H R \Phi(\bar{\omega})$$

- Evolution of technology $\ln A_{t+1} = \rho \ln A_t + \epsilon_{t+1}$

Calibration

- One period of the model is assumed to be 1 quarter.
- Parameters set externally: discount factors (β, β^e), CRRA parameter (ψ), capital share (α), labor share (ι), depreciation rate (δ), persistence and volatility of aggregate shock (ρ, σ), equity issuance cost (μ), and the fraction of entrepreneurs (η).
- Parameters set internally: volatility of liquidity shock σ_ω, expected total return $p_H R$, pledgeable income $p_H\left(R - \frac{B}{p_H - p_L}\right)$ liquidation value τ.

Parameters Set Externally

Discount factor of households	β	0.99
Discount factor of entrepreneurs	β^e	0.94
Relative risk aversion of households	ψ	1.50
Labor supply parameter	ν	2.68
Capital share	α	0.33
Household labor share	ι	0.66
Depreciation rate	δ	0.025
Fraction of entrepreneurs	η	0.30
Persistence of aggregate TFP shock	ρ	0.95
S.D. of aggregate TFP shock	σ	0.007

Parameters Set Internally

- For σ_ω, expected total return from the project, expected return to the lender, and τ we match (1) LGD on bank loans, (2) probability of default (PD), (3) utilization rate on lines of credit; and (4) ratio of unused commitments to total loans

Selected moments: data vs. model

Moments	Data (%)	Model (%)
LGD	39.8	35.4
PD	0.5	0.6
Utilization rate of credit lines	32.5	36.0
Ratio of unused commitments to loans	86.0	91.5

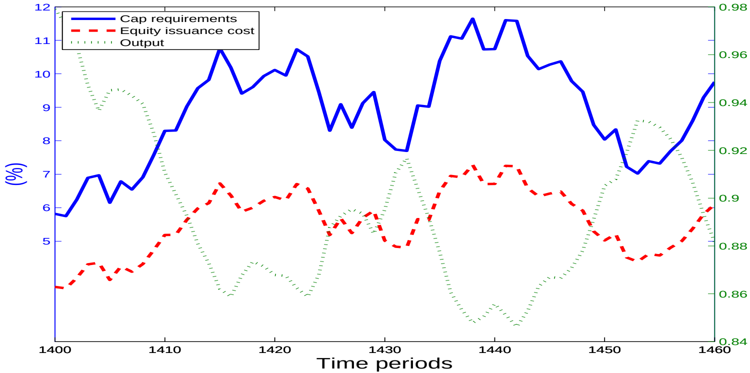
Capital Requirements and Equity Issuance Cost

- Specify exogenous processes for θ_t and γ_t:

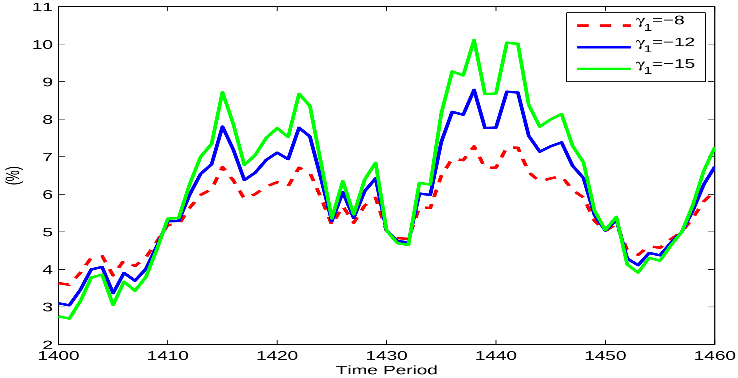
$$\theta_t = \theta_0 A_t^{\theta_1}$$
$$\gamma_t = \gamma_0 A_t^{\gamma_1}$$

- $\theta_0 = 0.08$
- $\theta_1 = 0$ for Basel I and $\theta_1 = -8$ for Basel II (using the Basel II formula)
- $\gamma_0 = 0.05$
- $\gamma_1 = -8, -12$, and -15
  - Kashyap and Stein: "The cyclical pressure on bank capital positions can be accounted for roughly equally by the higher requirement ratio under Basel II and the higher shadow cost of capital" $\Rightarrow -8$
  - Also try higher elasticities

Sample Paths



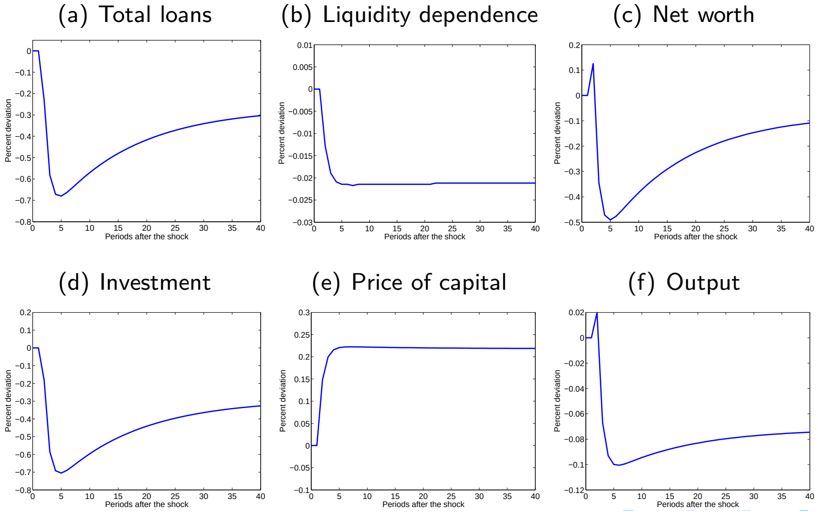
Sample Paths (Equity Issuance Cost)



Steady-State Experiment

- Consider an experiment: the capital requirement ratio 8% to 12%
  - Other variables (incl. equity issuance cost) are kept constant

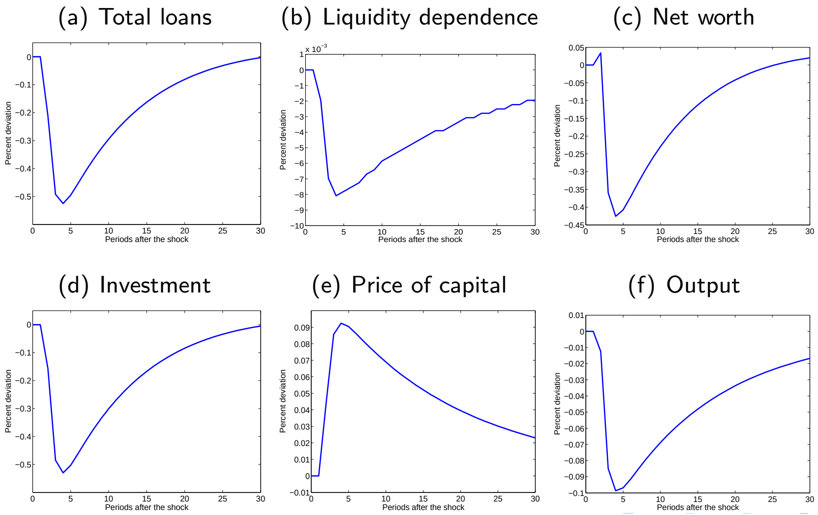
Transition Paths



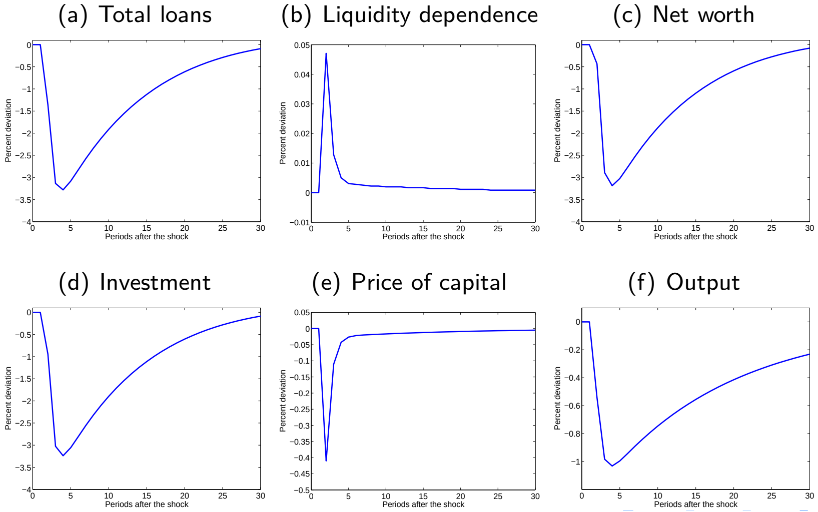
Exercises

1. Temporary increase in the capital requirement ratio
   - θ increases from 0.08 to 0.10 on impact and gradually returns to 0.08
2. Responses to the aggregate shock in the economy with no capital requirement
3. Compare responses in the (i) no requirement economy, (ii) Basel I economy, and (iii) Basel II economy
   - Basel I: only equity issuance cost is time varying
   - Basel II: both equity issuance cost and capital requirement are time varying

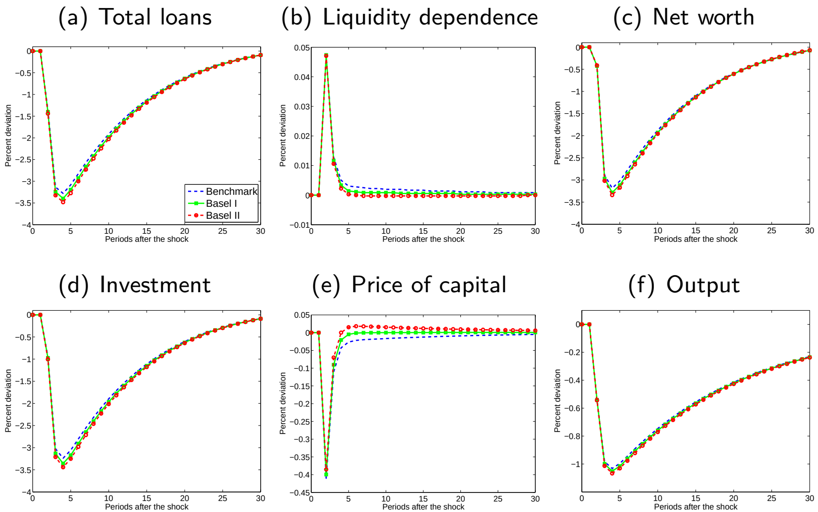
A Temporary Increase in Capital Requirement



A Negative TFP Shock (No Capital Requirement)



Responses Under Different Environments



Output Volatility

Table: Standard Deviations

	No Requirement	Basel I	Basel II
Baseline ($\gamma_1 = -8$)	1.84	1.87	1.92
	—	(1.016)	(1.043)
$\gamma_1 = -12$	—	1.89	1.94
	—	(1.027)	(1.054)
$\gamma_1 = -15$	—	1.91	1.97
	—	(1.038)	(1.071)

Notes: Results are based on 500 replications of 200 observations (after randomization of the initial condition). The standard deviations are based on logged HP-filtered series with a smoothing parameter of 1,600. Numbers in parentheses report relative volatilities compared to that under the economy with no capital requirement.

Closer Look at Output Differences

- Look at distributions of

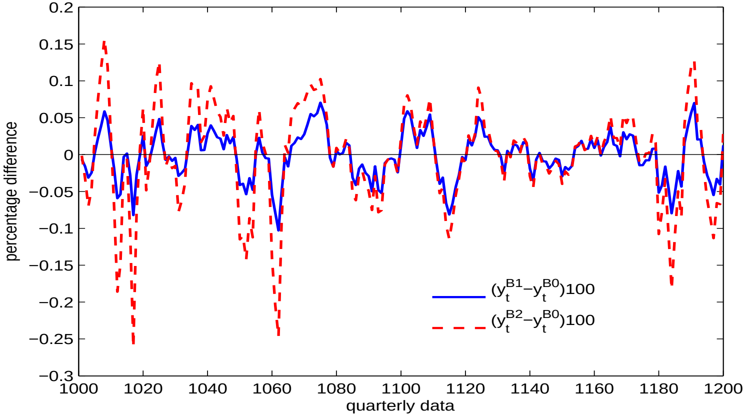
$$y_t^{B1} - y_t^{B0}$$

$$y_t^{B2} - y_t^{B0}$$

$$y_t^{B2} - y_t^{B1}$$

  - y_t^{B0}: Logged HP filtered output series in no requirement economy
  - y_t^{B1}: Logged HP filtered output series in Basel I economy
  - y_t^{B2}: Logged HP filtered output series in Basel II economy

Sample Paths of Differences in Output ($\gamma_1 = -8$)



Distribution of Output Differences

Table: Percentiles

Percentiles		1	5	95	99
Baseline	$(y_t^{B1} - y_t^{B0})100$	-0.12	-0.08	0.06	0.09
	$(y_t^{B2} - y_t^{B0})100$	-0.40	-0.18	0.15	0.25
	$(y_t^{B2} - y_t^{B1})100$	-0.27	-0.11	0.09	0.17
$\gamma_1 = -12$	$(y_t^{B1} - y_t^{B0})100$	-0.22	-0.12	0.10	0.15
	$(y_t^{B2} - y_t^{B0})100$	-0.61	-0.24	0.20	0.38
	$(y_t^{B2} - y_t^{B1})100$	-0.39	-0.13	0.11	0.25
$\gamma_1 = -15$	$(y_t^{B1} - y_t^{B0})100$	-0.32	-0.16	0.13	0.21
	$(y_t^{B2} - y_t^{B0})100$	-0.83	-0.30	0.25	0.53
	$(y_t^{B2} - y_t^{B1})100$	-0.51	-0.14	0.14	0.34

Conclusion

- Our focus: quantify business cycle effects of capital requirements
- Particularly significant at the bottom of the business cycles
- "Countercyclical" capital requirement is effective in our model
  - Lower capital requirement during downturns $\Rightarrow$ offset higher equity issuance cost
- Made several simplifying assumptions:
  1. No welfare improving effects of capital requirements
  2. Capital requirements are always binding (no buffer) = No net-worth channel of banks