The state-dependent impact of changes in bank capital requirements

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DISCLAIMER

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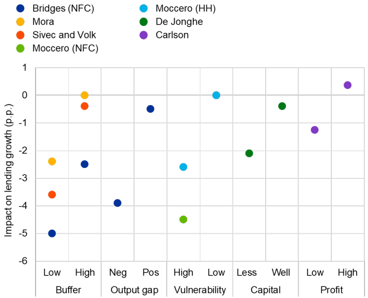
Outline

Motivation: Impact of bank capital is state-dependent

Data: close to zero impact on lending in good states, a few pp. in bad states. Standard macro models with banks lack this feature.

(a) Empirics: +1pp requirement



(b) Models: +1pp requirement

Model/Study	Lending reduction	GDP reduction	Country	Sample period
DJP	1.15	0.29	Euro Area	2001-2016
DKR	1.03	0.29	Euro Area	2001-2016
NAWM II	1.26	0.36	Euro Area	1985-2014
3D	1.52	0.14	Euro Area	2001-2016
Angelini and Gerali (2012)		0.05 [0-0.36]	Euro Area	
Bridges et al. (2014)	3.5		UK	1990-2011
De-Ramon et al. (2012)	1.6	0.3	UK	1992-2010
Fraisse et al. (2015)	1-8		France	2008-2011
LEI (2010)		0.09	13 OECD countries	
MAG (2010)	1.4	0.1-0.15	17 OECD countries	
Miles et al. (2013)		0.25*	UK	
Noss and Toffano (2014)	1.4		UK	1986-2008
Roger and Vitek (2012)		0.11 [0.09-0.24]	15 advanced and emerging	
Slovik abd Cournède (2011)		0.2	3 OECD countries	
Suturova and Teply (2013)	1.4-3.5		Europe	2006-2011

Notes. Results are reported in % deviation from steady-state. (*) Effect of a 1% increase in the cost of capital.

Notes: Panel (a) See Box 9 of November 2020 ECB FSR. Panel (b) Table 2 in Cozzi et al. (2020).

Key result: Impact can differ by two orders of magnitude

Our paper: Non-linear banking sector equilibrium model

- Monopolistic competition. Bank equity always more costly than debt
- Two occ. binding constraints: capital requirement, no equity issuance

Impact on loans of changes in capital requirements state-dependent

- In "normal" states impact is low: -0.1% loans for +1pp requirement
  - "Pricing channel": Equity available. Higher funding cost. Move up demand curve
- In "bad" states impact is high: +10% loans for -1pp requirement
  - "Quantity channel": Equity constrained. Requirement directly affects loan quantity

Related literature

Outline

Stylised but realistic bank balance sheet and P&L

Loans $L_{i,t}$ on asset side. Deposits $D_{i,t}$ and equity $E_{i,t}$ on liability side

$$L_{i,t} = D_{i,t} + E_{i,t}$$

Profits are net interest income less cost of risk and operating cost

$$\pi(\theta_{i,t}, L_{i,t}, E_{i,t}, L_t^A) = \underbrace{NII(L_{i,t}, E_{i,t}, L_t^A)}_{i(L_{i,t}, L_t^A)L_{i,t} - i^D(L_{i,t} - E_{i,t})} - \underbrace{COR(\theta_{i,t}, L_{i,t})}_{\theta_{i,t} L_{i,t}} - \underbrace{OC(L_{i,t})}_{\kappa L_{i,t}}$$

Interest rate $i(\cdot)$ endogenous: monopolistic comp. + demand curve

Impairment rate $\theta_{i,t}$ is stochastic. Follows a log AR(1) process

▸ Modelling of loan demand

Banks face two occasionally binding constraints

Equity is built through retained profits after dividend payouts $d_{i,t}$

$$E_{i,t+1} = E_{i,t} + \pi_{i,t} - d_{i,t}$$

Dividends are choice of banks, but no equity issuance is possible

$$d_{i,t} \geq 0$$

A (time-varying) capital requirement R_t must be met by banks

$$CR(L_{i,t}, E_{i,t}) = \frac{E_{i,t}}{\omega L_{i,t}} \geq R_t$$

Evidence on equity issuance

Banks maximise the present value of dividend payments

Discount rate determined by the required return on equity ρ $(> i^D)$

$$\beta = \frac{1}{1+\rho}$$

The decision problem can be represented by a Bellman equation

$$\begin{aligned} V(\theta, L, E, L^A) \quad = \quad & \max_{L', E'} d(\theta, L, E, L^A, E') + \beta \mathbb{E}\left[V(\theta', L', E', L^{A'}) \right] \\ & + \underbrace{\chi^1 \left[E' - R'\omega L' \right]}_{\substack{\text{Capital requirement} \\ \text{constraint } (\chi^1)}} + \underbrace{\chi^2 \left[d(\theta, L, E, L^A, E') \right]}_{\substack{\text{Equity issuance} \\ \text{constraint } (\chi^2)}} \end{aligned}$$

Equilibrium is determined by the First-order conditions **and** $L_{i,t} = L^A_t$

Note: Dividends are defined as $d(\theta, L, E, L^A, E') = \pi(\theta, L, E, L^A) + E - E'$

Outline

▸ Model calibration to euro area bank data

"Pricing channel" of changing bank capital requirements

Proposition 1

In the absence of an equity issuance constraint, equilibrium loans respond to changes in bank capital requirements via a "pricing channel":

$$\Delta log(L^{'}) = -\epsilon \left(\frac{\mu}{\mu - 1} \right) \left[(\rho - i^{D}) \omega \Delta R^{'} \right]$$

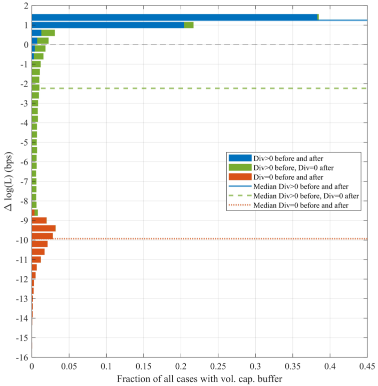
Intuition for the "pricing channel" ▸ Similar results hold with voluntary capital buffers

- Funding cost of loans increases, as equity is more costly than debt
- But funding cost impact is low: e.g. (0.08-0.02)*0.5*0.01 = 3 bps
- Passed on with mark-up. Move up loan demand curve ($\epsilon = 3$): -0.1%

"Pricing channel" impact on lending is very small

When banks hold capital buffers: -0.1% loans for +1pp requirement

When banks also pay dividends, impact on loans is close to zero



▸ IRFs for requirement increase

Notes: "Pricing channel" impact on lending when banks hold voluntary capital buffers before and after a capital requirement increases from 10% to 11%. Based on 200,000 simulations from the stochastic steady state.

"Quantity channel" of changing bank capital requirements

Proposition 2

In states where the equity issuance constraint and the capital requirement constraint are binding, equilibrium loans respond to changes in bank capital requirements via a "quantity channel":

$$\Delta log(L^{'}) = -\Delta log(R^{'})$$

Intuition for the "quantity channel"

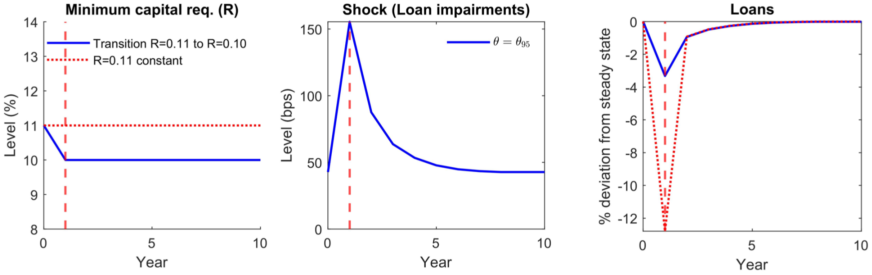
- Banks don't hold voluntary capital buffers and do not pay dividends
- Loans determined by equity, profits, requirement: $R^{'} = (E + \pi)/(\omega L^{'})$
- Requirement changes directly affect loan quantity banks can supply

"Quantity channel" impact on lending is very large

When banks capital constrained: +10% loans for -1pp requirement

Bad shock. Banks make big losses and need to deleverage (red line)

Release allows loss absorption and mitigates deleveraging (blue line)



More variables

Capital requirement rules that prevent the quantity channel

Proposition 3

Policy makers can avoid the quantity channel with time-varying capital requirements that satisfy $R^{'} > 0$ *and the following condition in all states:*

$$R^{'} < \left(CR + \frac{\pi}{\omega L}\right)\frac{1}{1+g^{*}}$$

where g^{*} *is desired loan growth in absence of equity issuance constraint.*

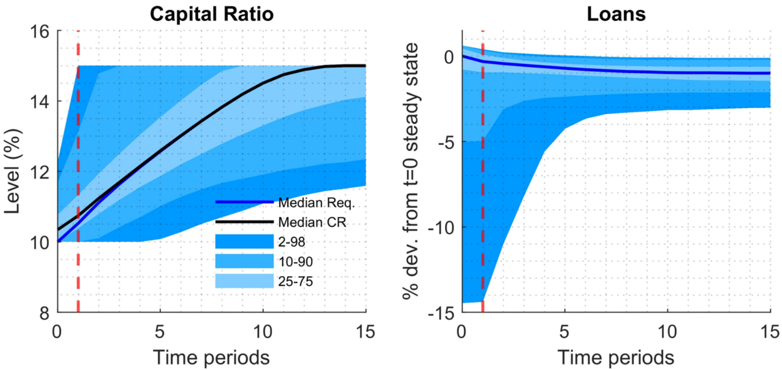
Intuition for such a policy rule ▸ Examples of build-up speed

- RORWA and loan growth determine speed limits for changes in CR
- When profits positive, gradual build-up of CR and therefore R possible
- In case of losses, release of R needed to accommodate CR decline

A state-dependent rule to build buffers when costs are low

We implement a simple ▸ state-dependent rule **consistent with proposition 3**

Large gain at moderate cost: after 5 years credit crunches are gone



Notes: Transition from $R = 0.1$ *to state-dependent rule. Solid lines and shaded areas show median and percentile ranges over 100,000 simulated economies.*

Outline

Policy implications: rationale for "positive neutral" CCyB

When and how should capital requirements be increased?

- When: Banking sector makes profits. Easily observable
- How: Gradual. Speed limit given by ROA and loan growth
- Easy to implement: time lag of CCyB and dividend payouts

When and how should capital requirements be released?

- When: Banking sector makes losses (recession not enough!)
- How: Immediate and of sufficient size (to absorb losses)
- Harder to implement: losses observed with lag

Recap of key results

Thank you for your attention!

Background slides

Contribution: Derive key results about state-dependence

Compared to micro banking literature: interest rate endogenous

- Van den Heuvel (2006); De Nicolò et al. (2014); Behn et al. (2019); Mankart et al. (2020)

Compared to macro banking models: focus on state-dependence

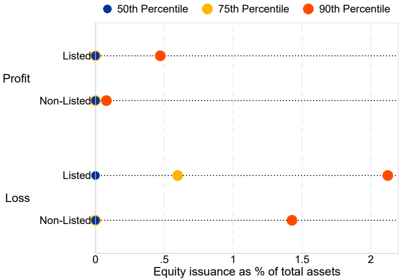
- Gertler and Kiyotaki (2010); Gerali et al. (2010); Darracq Pariès et al. (2011); Clerc et al. (2015); Mendicino et al. (2018); Gertler and Karadi (2011); Brunnermeier and Sannikov (2014); Gertler and Kiyotaki (2015); Van der Ghote (2018); Mendicino et al. (2020); Corbae and D'Erasmo (2019); Jamilov and Monacelli (2020)

▸ Back to overview of results

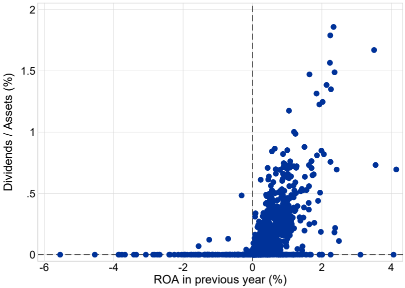
Equity issuance is rare, even when banks make losses

Banks often pay zero dividends, indicating limited smoothing

(a) Equity issuance in the data



(b) Dividend payouts in the data



Sources: SNL Financial. Authors' calculations.

Notes: Based on a panel of around 320 euro area banks since 2005 at highest level of consolidation. Data on dividend payouts is available for around one third of these banks.

Back to equity issuance constraint

Modelling of the loan demand side

For tractability, aggregate loan demand is taken as given

- Aggregate loan demand L_t^A has constant interest semi-elasticity ϵ

$$log(L_t^A) = \lambda - \epsilon \cdot i_t^A$$

Banks face monopolistic competition with CES aggregator

- Bank i loan demand $L_{i,t}$ depends on aggregates and market power μ

$$L_{i,t} = \left(\frac{i_{i,t}}{i_t^A}\right)^{-\mu} L_t^A$$

The interest rate banks charge is endogenous and given by

$$i(L_{i,t}, L_t^A) = \left(\frac{L_{i,t}}{L_t^A}\right)^{-\frac{1}{\mu}} \frac{\lambda - log(L_t^A)}{\epsilon}$$

Back to bank set-up

Model equilibrium characterised by two key equations

FOCs plus representative bank assumption $(L_{i,t} = L_t^A)$ **yield**

- Condition for equilibrium equity choice

$$\underbrace{1+\chi^2}_{\substack{\text{Marginal cost} \\ \text{of more } E'}} = \underbrace{\chi^1 + \frac{1+i^D}{1+\rho}\mathbb{E}[1+\chi^{2'}]}_{\substack{\text{Marginal benefit} \\ \text{of more } E'}}$$

- Condition for equilibrium loan choice

$$\underbrace{\chi^1 R' \omega}_{\substack{\text{Marginal cost} \\ \text{today} \\ \text{of more } L'}} = \mathbb{E}\left[\frac{1+\chi^{2'}}{1+\rho}\left(\underbrace{\frac{\mu-1}{\mu}\frac{\lambda - log(L')}{\epsilon}}_{\substack{\text{Marginal benefit} \\ \text{tomorrow} \\ \text{of more } L'}} \underbrace{-i^D - \theta' - \kappa}_{\substack{\text{Marginal cost} \\ \text{tomorrow} \\ \text{of more } L'}}\right)\right]$$

Back to decision problem

"Pricing channel" with voluntary capital buffers

Proposition 4

In states where banks hold voluntary capital buffers before and after a capital requirement change, equilibrium loans respond to changes in bank capital requirements via a "pricing channel":

- *Case 1 when banks pay dividends:*

$$\Delta log(L^{'}) = -\epsilon \left(\frac{\mu}{\mu - 1}\right) \left(\frac{1 + i^{D}}{1 + \rho}\right) \Delta Cov(\chi^{2'}, \theta^{'})$$

- *Case 2 when banks do not pay dividends:*

$$\Delta log(L^{'}) = -\epsilon \left(\frac{\mu}{\mu - 1}\right) \left(\frac{1 + i^{D}}{1 + \rho}\right) \Delta \frac{Cov(\chi^{2'}, \theta^{'})}{1 + \chi^{2}}$$

Back to pricing channel

Model solved globally via policy function iteration

Calibration to euro area bank data: Empirical moments and Stochastic steady state

Parameter	Value	Source
ρ	0.08	Based on bank cost of equity estimates in Altavilla et al. (2021)
i^D	0.02	Empirical: Average cost of liabilities for euro area banks 2005-2019
κ	0.014	Empirical: Average cost-to-asset ratio for euro area banks 2005-2019
ω	0.48	Empirical: Average risk-weight for euro area banks 2005-2019
R	0.10	Empirical: Aggregate ECB minimum capital requirement 2019 - 2021
λ	0.1215	Scaling parameter set to target steady state loans of 1
ϵ	3	Based on average of estimates from various empirical studies
μ	100	Set to target the empirical mean of the price-to-book ratio of 1.2
α_0	-2.40	Empirical: Estimated intercept of a log AR(1) process for cost of risk
α_1	0.56	Empirical: Estimated persistence of a log AR(1) process for cost of risk
α_2	0.67	Empirical: Estimated shock SD of a log AR(1) process for cost of risk

Back to key results

Key data moments used for model calibration

Variable	mean	sd	p1	p5	p25	p50	p75	p95	p99	N
Average yield on assets	3.4	1.5	0.4	1.2	2.3	3.2	4.3	6.1	7.7	3,527
Average cost of liabilities	2.0	1.3	0.1	0.3	1.0	1.7	2.8	4.5	5.9	3,496
Net interest margin	1.5	0.8	0.0	0.2	0.9	1.5	2.0	2.9	4.1	3,597
Other income to assets	0.8	0.7	-0.5	-0.1	0.4	0.8	1.1	1.8	3.5	3,520
Cost-to-asset ratio	1.4	0.8	0.0	0.1	0.9	1.4	1.9	2.8	4.0	4,046
Provisioning rate	0.6	0.9	-0.5	-0.1	0.1	0.3	0.8	2.4	4.9	3,591
Return on assets	0.5	1.0	-3.5	-1.1	0.2	0.5	0.9	1.7	2.7	4,072
CET1 capital ratio	13.0	5.1	4.3	5.9	9.2	12.5	15.9	22.7	26.8	3,093
Average risk-weight	48.3	20.8	5.0	14.9	32.6	48.0	63.3	82.3	95.6	3,446
Price-to-book ratio	1.2	0.9	0.1	0.2	0.5	0.9	1.7	3.0	4.3	7,311

Source: SNL Financial, Bloomberg

Notes: All variables except price-to-book ratio based on an unbalanced annual panel of around 320 euro area banks since 2005. All variables expressed in percent, except price-to-book ratio. The return on assets is measured before tax. Price-to-book ratio based on quarterly data from Bloomberg for around 70 listed banks.

▸ Calibration

Quantitative results: stochastic steady state

Variable	mean	sd	p1	p5	p25	p50	p75	p95	p99
Exogenous shock									
Loan impairments (bps)	58.3	53.2	6.7	11.6	24.9	42.8	72.4	157.9	271.5
Endogenous variables									
Loans	0.99	0.04	0.79	0.95	0.99	**1.00**	1.00	1.01	1.01
Loan interest rate	4.42	1.82	3.84	3.86	3.91	4.05	4.30	5.69	11.93
Return on assets	0.67	3.88	-1.34	-0.47	0.15	0.37	0.53	1.59	9.32
Capital ratio	10.51	0.61	10.00	10.00	10.00	10.34	10.76	11.66	12.83
Dividends/assets	0.46	0.75	0.00	0.00	0.00	0.32	0.59	1.40	4.08
Price-to-book ratio	**1.17**	0.20	0.98	1.04	1.10	1.13	1.17	1.47	2.07
$Pr(d = 0)$	30.43								
Pr(quantity channel)†	8.05								

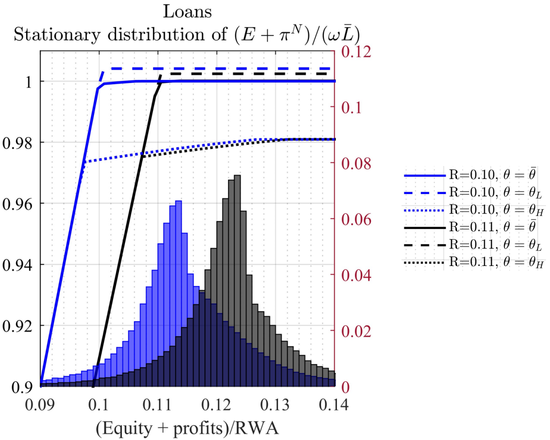
Notes: Calibration targets in bold. † *Percent of years in which the quantity channel kicks in. This is the case when the equity issuance constraint and the capital requirement constraint are both binding* ($d = 0$ *and* $CR' = R$).

▸ Calibration

Loan policy functions for different requirements and states

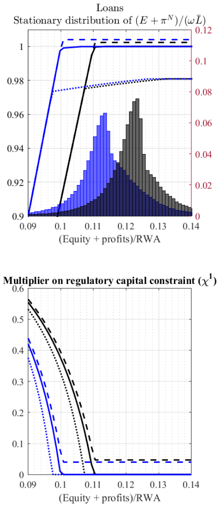
Loan policies non-linear: kink where both constraints are binding

Black (11%)/blue (10%) policies close with profits, far apart with losses



More variables

Policy functions as function of capital ratio plus profits

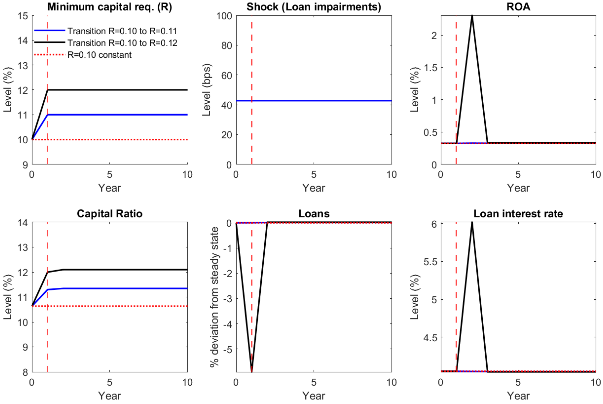


Loan policies

Unanticipated increase of capital requirement, normal state

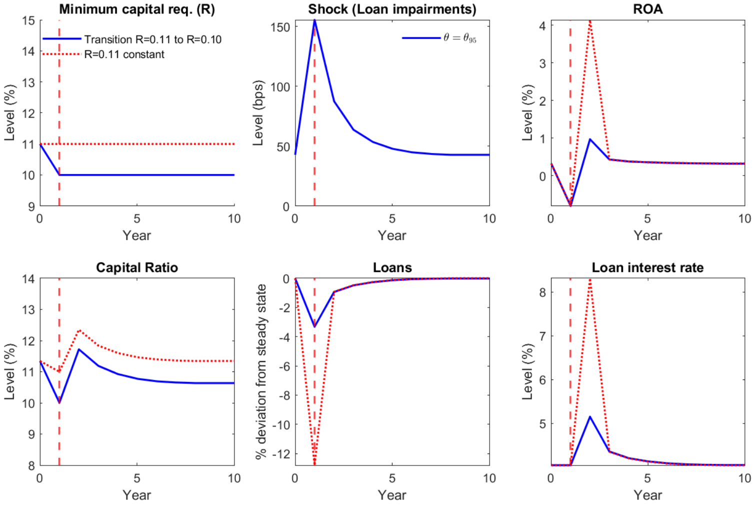
Moderate R increase: no impact (blue vs. red), pricing channel

Large R increase: large impact (black vs. red), quantity channel



Back to pricing channel magnitudes

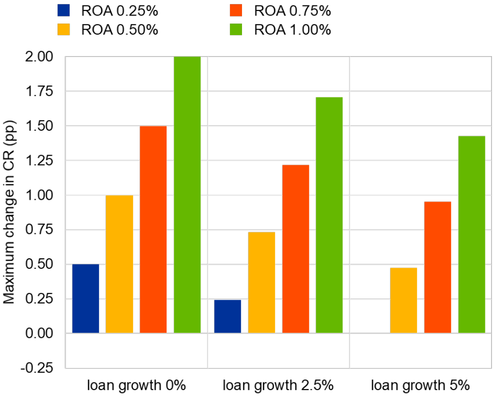
Unanticipated release of capital requirements in bad state



Back to release

Quantitative examples of feasible buffer build-up speeds

Build-up of 0.5pp to 1pp per year feasible in "normal" times



Notes: A capital requirement of 10% and a risk-weight of 50% are assumed.

Back to policy rule proposition

State-dependent capital requirement rule

Based on principles from proposition 3 and observable variables:

$$R' = \begin{cases} R^{max} & \text{if } \xi\left(\frac{E+\pi}{\omega \bar{L}}\right) > R^{max} \\ \xi\left(\frac{E+\pi}{\omega \bar{L}}\right) & \text{if } R^{min} \leq \xi\left(\frac{E+\pi}{\omega \bar{L}}\right) \leq R^{max} \\ R^{min} & \text{if } \xi\left(\frac{E+\pi}{\omega \bar{L}}\right) < R^{min} \end{cases}$$

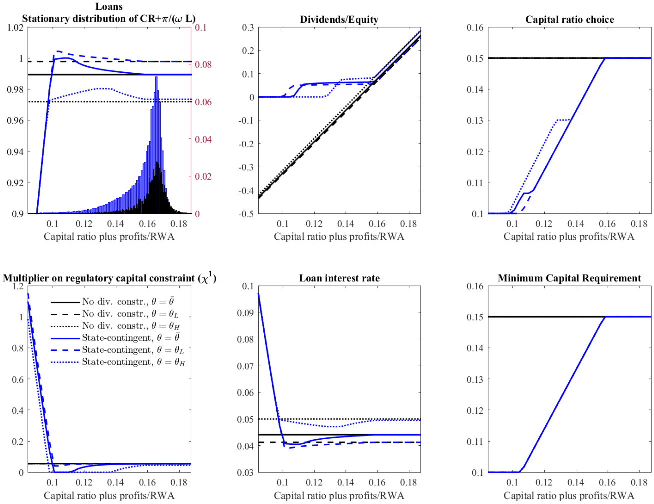
We set $R^{min} = 0.10$, $R^{max} = 0.15$, and $\xi = 0.95$

Allows banks to pay dividends. Release happens when banks make losses

Equilibrium policy functions

Back to simulation results

State-dependent policy rule: policy functions, $\xi = 0.95$



▸ State-dependent rule

Recap of key findings

We present a tractable non-linear banking sector equilibrium model

- Analysis of key mechanisms leading to state-dependence

Impact of capital requirement changes can differ by factor 100!

- "Pricing channel": in normal states +1pp R leads to -0.1pp loans
- "Quantity channel": in bad states -1pp R can lead to +10pp loans

We derive a policy rule that switches off the "quantity channel"

- Voluntary capital buffers and profitability of key importance

Back to policy implications

Qualitative discussion of possible model extensions I

Deposit costs go down as capital increases (some M&M offset)

- Would make higher requirements in good states even less costly
- Would not change result that impact is state-dependent

Some equity issuance possible, but costly (quadratic or fixed cost)

- State-dependent impact would remain, but likely smaller difference
- In good states no equity issuance necessary. Results unaffected
- In bad states marginal costs would increase (issuance costs)...
- ...pricing channel stronger in bad states than in good states

Qualitative discussion of possible model extensions II

Additional mechanisms that induce higher voluntary buffers

- E.g. funding costs depend on buffers, or loan liquidation costly
- If voluntary buffers change 1-to-1 with requirements, no effect
- If vol. buffers vary, quantity channel should become less likely

Preference for dividend smoothing by banks

- E.g. through risk-aversion (curvature) or habit persistence
- Could increase self-insurance motive of banks. Higher vol. buffers
- Quantity channel could become less likely
- Low costs of gradual requirement increases should remain

Qualitative discussion of possible model extensions III

General equilibrium effects: Loan demand correlated with credit risk

- Loan demand could go down when credit risk increases (TFP shock)
- Impact of a given credit risk shock on bank profits amplified
- Should mainly affect model calibration, not so much state-dependence

General equilibrium effects: Loan demand affected by requirements

- Less loans could lower production, potentially lowering loan demand
- Impact on loan quantities could maybe be amplified in GE...
- ...but unlikely to be of importance for pricing channel (-0.1% loans)
- State-dependence should remain (due to equity issuance constraint)

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