

# The state-dependent impact of changes in bank capital requirements

**Jan Hannes Lang (ECB)**

**Dominik Menno (Bundesbank)**

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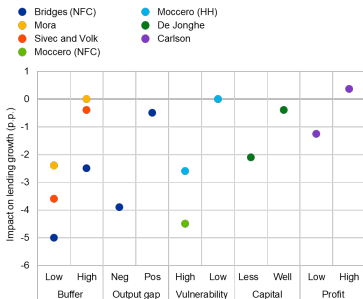
# Outline

- 1 Motivation and overview
- 2 Structural model set-up
- 3 Key results: analytical and quantitative
- 4 Conclusion

# 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 [0.0-0.36]	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 and 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

- 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

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# 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**

# 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  $\rho > i^D$**

**The decision problem can be represented by a Bellman equation**

$$V(\theta, L, E, L^A) = \max_{L', E'} d(\theta, L, E, L^A, E') + \frac{1}{1 + \rho} \mathbb{E} \left[ V(\theta', L', E', L^{A'}) \right]$$

s.t. equity LOM, no equity issuance, and regulatory capital requirement

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

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

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► 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":*

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

## Intuition for the "pricing channel"

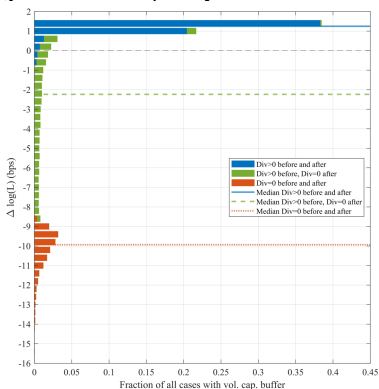
► Similar results hold with voluntary capital buffers

- 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



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"

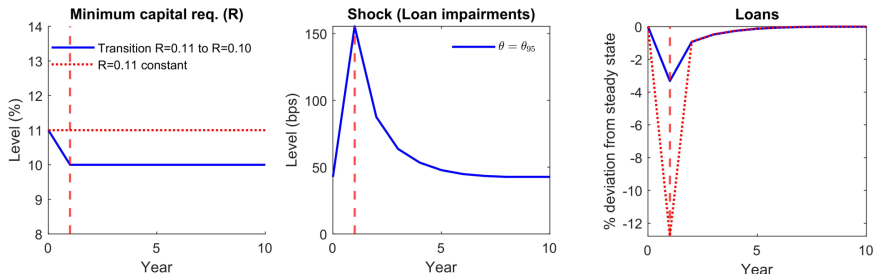
- Banks don't hold voluntary capital buffers and do not pay dividends
- Loans determined by equity, profits, requirement:  $R' = (E + \pi)/(\omega L')$
- Requirement changes directly affect loan quantity banks can supply

# "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.*

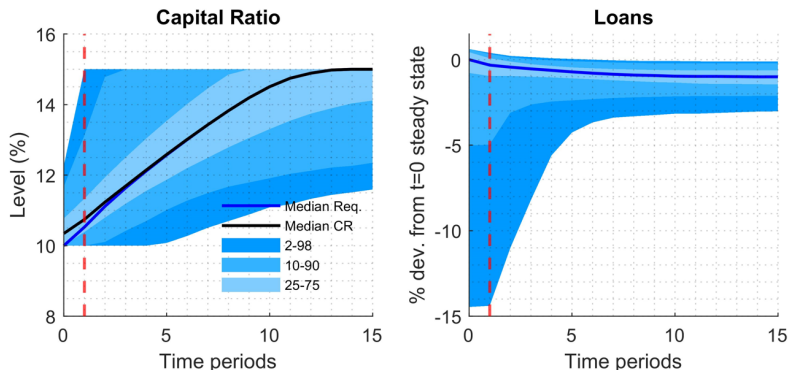
## Intuition for such a policy rule ► Examples of build-up speed

- 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.



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# 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

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 Gote (2018); Mendicino et al. (2020); Corbae and D'Erasmus (2019); Jamilov and Monacelli (2020)

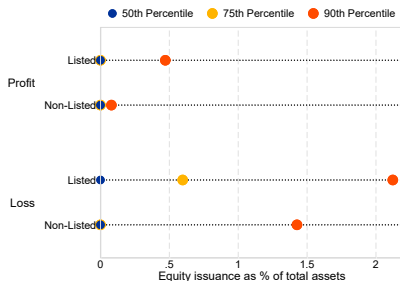
[▶ Back to overview of results](#)

# Empirical evidence on equity issuance and dividend payouts

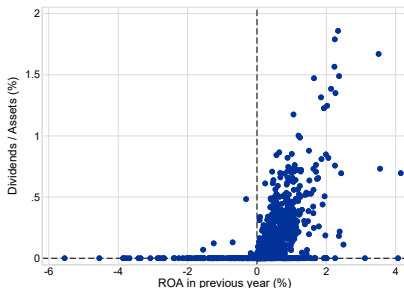
**Equity issuance is rare, even when banks make losses**

**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  $\epsilon$

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

**Banks face monopolistic competition with CES aggregator**

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

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

**The interest rate banks charge is endogenous and given by**

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

# Model equilibrium characterised by two key equations

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

- Condition for equilibrium equity choice

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

- Condition for equilibrium loan choice

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



# "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:*

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

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

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

# Model solved globally via policy function iteration

## Calibration to euro area bank data: [► Empirical moments](#) and [► Stochastic steady state](#)

Parameter	Value	Source
$\rho$	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
$\kappa$	0.014	Empirical: Average cost-to-asset ratio for euro area banks 2005-2019
$\omega$	0.48	Empirical: Average risk-weight for euro area banks 2005-2019
$R$	0.10	Empirical: Aggregate ECB minimum capital requirement 2019 - 2021
$\lambda$	0.1215	Scaling parameter set to target steady state loans of 1
$\epsilon$	3	Based on average of estimates from various empirical studies
$\mu$	100	Set to target the empirical mean of the price-to-book ratio of 1.2
$\alpha_0$	-2.40	Empirical: Estimated intercept of a log AR(1) process for cost of risk
$\alpha_1$	0.56	Empirical: Estimated persistence of a log AR(1) process for cost of risk
$\alpha_2$	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.

# Quantitative results: stochastic steady state

Variable	mean	sd	p1	p5	p25	p50	p75	p95	p99
<i>Exogenous shock</i>									
Loan impairments (bps)	58.3	53.2	6.7	11.6	24.9	42.8	72.4	157.9	271.5
<i>Endogenous variables</i>									
Loans	0.99	0.04	0.79	0.95	0.99	<b>1.00</b>	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	<b>1.17</b>	0.20	0.98	1.04	1.10	1.13	1.17	1.47	2.07
$Pr(d = 0)$	30.43								
$Pr(\text{quantity channel})^\dagger$	8.05								

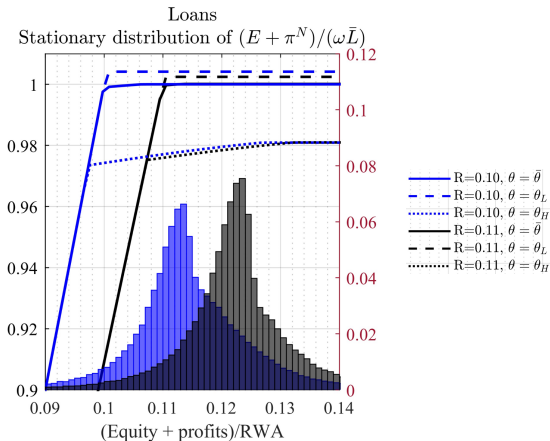
Notes: Calibration targets in bold. <sup>†</sup> Percent of years in which the quantity channel kicks in. This is the case when the equity issuance constraint and the capital requirement constraint are both binding ( $d = 0$  and  $CR' = R$ ).

► Calibration

# Loan policy functions for different requirements and states

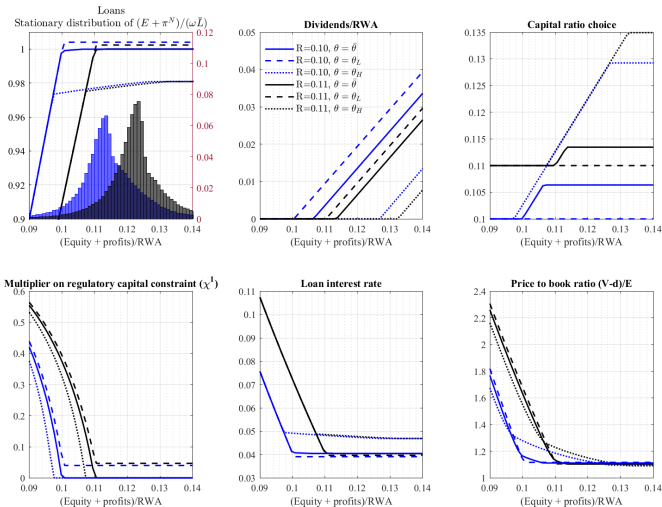
**Loan policies non-linear: kink where both constraints are binding**

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



► More variables

# Policy functions as function of capital ratio plus profits

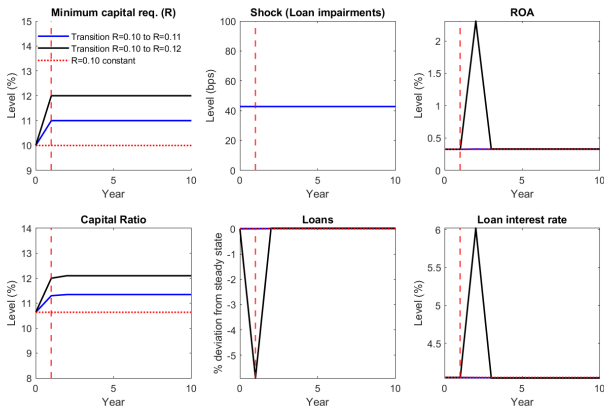


► Loan policies

# Unanticipated increase of capital requirement, normal state

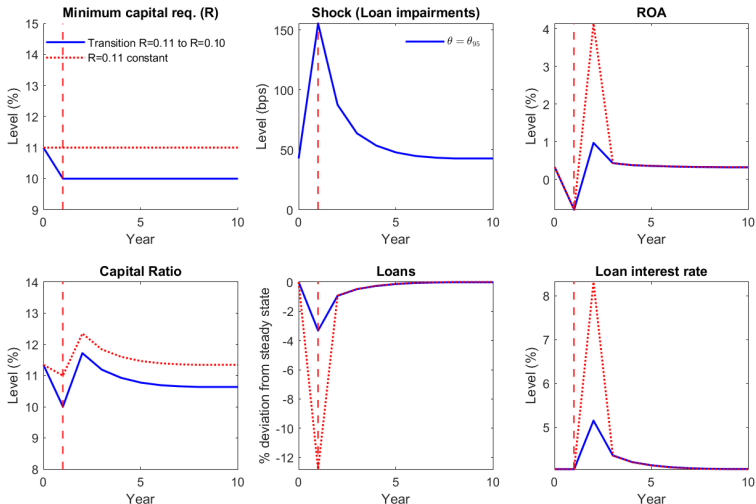
**Moderate  $R$  increase: no impact (blue vs. red), pricing channel**

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



► Back to pricing channel magnitudes

# Unanticipated release of capital requirements in bad state

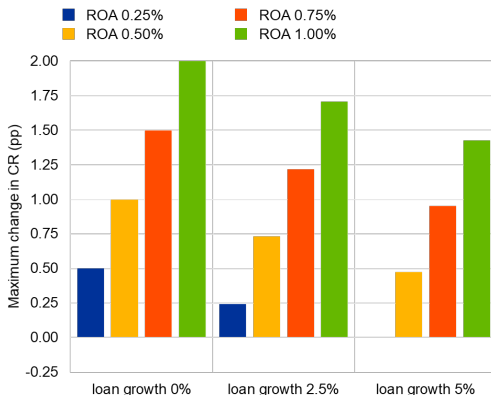


► [Back to release](#)



# 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.

# State-dependent capital requirement rule

**Based on principles from proposition 3 and observable variables:**

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

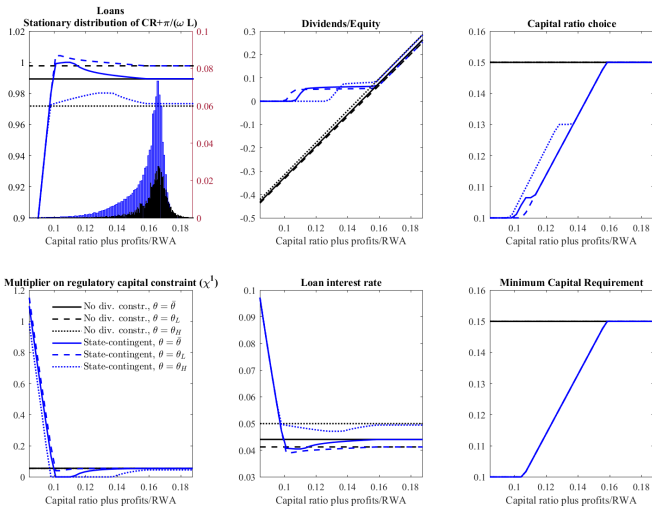
We set  $R^{min} = 0.10$ ,  $R^{max} = 0.15$ , and  $\xi = 0.95$

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

► Equilibrium policy functions

► Back to simulation results

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



# 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)

# References I

- Altavilla, Carlo, Paul Boehmann, Jeroen De Ryck, Ana-Maria Dumitru, Maciej Grodzicki, Heinrich Kick, Cecilia Melo Fernandes, Jonas Mosthaf, Charles O'Donnell, and Spyros Palligkinis**, “Measuring the cost of equity of euro area banks,” Occasional Paper Series 254, European Central Bank January 2021.
- Behn, Markus, Claudio Daminato, and Carmelo Salleo**, “A dynamic model of bank behaviour under multiple regulatory constraints,” Working Paper Series 2233, European Central Bank January 2019.
- Brunnermeier, Markus K. and Yuliy Sannikov**, “A Macroeconomic Model with a Financial Sector,” *American Economic Review*, February 2014, 104 (2), 379–421.



# References II

- Clerc, Laurent, Alexis Derviz, Caterina Mendicino, Stephane Moyen, Kalin Nikolov, Livio Stracca, Javier Suarez, and Alexandros P. Vardoulakis**, “Capital Regulation in a Macroeconomic Model with Three Layers of Default,” *International Journal of Central Banking*, June 2015, 11 (3), 9–63.
- Corbae, Dean and Pablo D’Erasmus**, “Capital Requirements in a Quantitative Model of Banking Industry Dynamics,” Working Paper 25424, National Bureau of Economic Research January 2019.
- Cozzi, Gabriele, Matthieu Darracq Pariès, Peter Karadi, Jenny Körner, Christoffer Kok, Falk Mazelis, Kalin Nikolov, Elena Rancoita, Alejandro Van der Gote, and Julien Weber**, “Macroprudential policy measures: macroeconomic impact and interaction with monetary policy,” Working Paper Series 2376, European Central Bank February 2020.

# References III

- den Heuvel, Skander Van**, “The Bank Capital Channel of Monetary Policy,” Technical Report 2006.
- der Ghote, Alejandro Van**, “Coordinating monetary and financial regulatory policies,” Working Paper Series 2155, European Central Bank June 2018.
- Gerali, Andrea, Stefano Neri, Luca Sessa, and Federico M. Signoretti**, “Credit and Banking in a DSGE Model of the Euro Area,” *Journal of Money, Credit and Banking*, 09 2010, 42 (s1), 107–141.
- Gertler, Mark and Nobuhiro Kiyotaki**, “Financial Intermediation and Credit Policy in Business Cycle Analysis,” in Benjamin M. Friedman and Michael Woodford, eds., *Handbook of Monetary Economics*, Vol. 3, Elsevier B.V., 2010.

## References IV

- **and** — , “Banking, Liquidity, and Bank Runs in an Infinite Horizon Economy,” *American Economic Review*, July 2015, 105 (7), 2011–43.
- **and Peter Karadi**, “A model of unconventional monetary policy,” *Journal of Monetary Economics*, January 2011, 58 (1), 17–34.
- Jamilov, Rustam and Tommaso Monacelli**, “Bewley Banks,” CEPR Discussion Papers 15428, C.E.P.R. Discussion Papers November 2020.
- Mankart, Jochen, Alexander Michaelides, and Spyros Pagratis**, “Bank capital buffers in a dynamic model,” *Financial Management*, June 2020, 49 (2), 473–502.

- Mendicino, Caterina, Kalin Nikolov, Javier Suarez, and Dominik Supera,** “Optimal Dynamic Capital Requirements,” *Journal of Money, Credit and Banking*, September 2018, 50 (6), 1271–1297.
- , —, —, **and** —, “Bank capital in the short and in the long run,” *Journal of Monetary Economics*, 2020, 115 (C), 64–79.
- Nicolò, Gianni De, Andrea Gamba, and Marcella Lucchetta,** “Microprudential Regulation in a Dynamic Model of Banking,” *Review of Financial Studies*, 2014, 27 (7), 2097–2138.

**Pariès, Matthieu Darracq, Christoffer Kok, and Diego**

**Rodriguez-Palenzuela**, “Macroeconomic Propagation under Different Regulatory Regimes: Evidence from an Estimated DSGE Model for the Euro Area,” *International Journal of Central Banking*, December 2011, 7 (4), 49–113.