Bank Capital Regulation and Endogenous Shadow Banking Crises

Johannes Poeschl[1] Xue Zhang[2]

[1]Danmarks Nationalbank

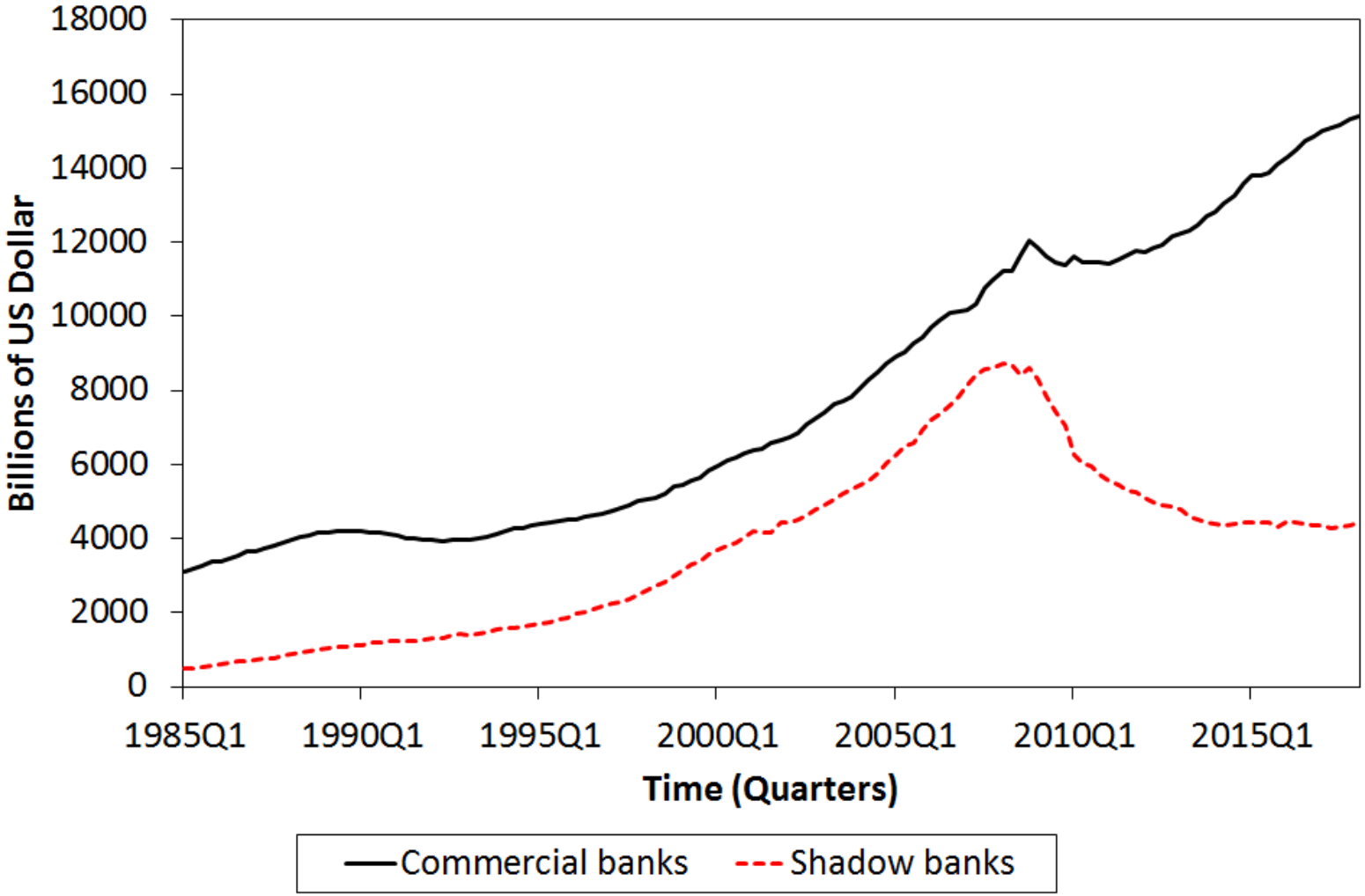
[2]KBC

Federal Reserve Day Ahead Conference

January 2019

Any views expressed in this presentation are our own and do not reflect those of Danmarks Nationalbank or KBC.

Shadow banking sector: large and crisis-prone



Total financial assets of retail and shadow banks. Constructed as in Adrian and Shin (2011). Source: Financial Accounts of the U.S.

New challenges for bank regulators

- Systemic shadow banking crises
  - How costly are shadow banking crises?
  - Can capital requirements on traditional (retail) banks mitigate shadow banking crises?
- Interlinkages between retail and shadow banks
  - Do spillover effects mitigate the effectiveness of bank capital requirements?

This paper: Quantitative model addressing these new challenges

The main findings in a nutshell

1. Shadow banking crises are rare, but costly
   - Eliminating banking crises: **welfare gain of 1.7 percent**
   - 80 percent of the welfare gain: elimination of bank run fears
2. Higher retail bank capital requirements, fewer shadow banking crises
   - Traditional (retail) banks: **Smaller fire sale discounts**
3. Novel **spillover effect** of retail bank capital requirements
   - Reduction of bank run fears relaxes shadow bank leverage constraint

(Non-exhaustive) literature review

Shadow Banks:
Gennaioli, Shleifer, and Vishny (2013), Plantin (2014), **Gertler, Kiyotaki, and Prestipino (2016)**, Huang (2018), Moreira and Savov (2017), **Begenau and Landvoigt (2017)**, Meeks, Nelson, and Alessandri (2017), Farhi and Tirole (2017), Ferrante (2018) ...

Banking crises in macroeconomic models:
Gertler and Kiyotaki (2013), Garcia-Macia and Villacorta (2016), **Gertler, Kiyotaki, and Prestipino (2017)** Boissay, Collard, and Smets (2016), Paul (2018) ...

This paper

Endogenous & anticipated shadow banking crises

+ endogenous wholesale funding market

$\Rightarrow$ New spillover effect of retail bank capital requirements

Agenda

1. Introduction
2. Model
3. Equilibrium
4. Eliminating Shadow Banking Crises
5. Effects of Retail Bank Capital Requirements
6. Conclusion

Agents

Model follows Gertler et al. (2016)

- Time $t = 0, \ldots, \infty$
- Banks
  - Retail banks R, shadow banks S
  - issue deposits, lend on retail funding market, borrow & lend on wholesale funding market
  - differ by exit probability $\sigma^R < \sigma^S$ and investment inefficiency $\eta^R > \eta^S = 0$
- Households H
  - Lend on retail funding market, save in deposits
  - Own all banks and firms
  - Inefficient investors: $\eta^H \gg \eta^R$
- Firms
  - Consumption goods producers
  - Capital goods producers

Banks' objective function

Banks of type J maximize payouts to households

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \Lambda_{0,t} \underbrace{(1-\sigma^J)^{t-1}\sigma^J}_{\substack{\text{Probability of} \\ \text{exit in period } t}} n_t^J \right],$$

with net worth n_t^J, stochastic discount factor $\Lambda_{0,t}$, **exit probability** σ^J

Banks' balance sheet and net worth

- Balance sheet constraint

$$\underbrace{d^J_{t+1} + n^J_t}_{\text{Liabilities + Equity}} = \underbrace{b^J_{t+1} + (Q_t + f^J_t)a^J_{t+1}}_{\text{Assets}}$$

with deposits d^J_{t+1}, wholesale loans b^J_{t+1}, retail loans a^J_{t+1}, capital price Q_t, **retail loan servicing fee** f^J_t (increasing in η^J)

- Net worth

$$n^J_t = R^A_t a^J_t + R^B_t b^J_t - R^D_t d^J_t$$

with returns on retail loans R^A_t, on wholesale loans R^B_t, and deposits R^D_t

Financial friction and bank capital structure

- Banks can divert
  - a fraction ψ of deposit or equity financed retail loans
  - a fraction $\psi\gamma$ of wholesale (interbank) loans
  - a fraction $\psi\omega$ of wholesale financed retail loans
- Incentive constraint, e.g. for wholesale lenders ($b^J_{t+1} > 0$):

$$\psi \left[(Q_t + f^J_t) a^J_{t+1} + \gamma b^J_{t+1} \right] \leq V^J_t = \Omega^J_t n^J_t,$$

  with continuation value V^J_t, unit continuation value Ω^J_t
- Implies an **endogenous** upper bound on bank leverage

$$\psi \phi^J_t \leq \Omega^J_t$$

▸ Details - retail banks ▸ Details - shadow banks

Bank Default

- We consider only **default on wholesale loans**. Deposits are non-defaultable.
- Insolvent banks liquidate their assets at discount $\xi < 1$
- **Recovery value** of wholesale creditors:

$$x_t = \xi \frac{R_t^A a_t^J}{R_t^B b_t^J}$$

Bank Regulation

- Regulator can impose a **minimum capital requirement**, which corresponds to an upper bound on bank leverage $\bar{\phi}_t^J$:

$$\phi_t^J \leq \bar{\phi}_t^J$$

- $\bar{\phi}_t^J$ is chosen according to a **modified incentive constraint**, e.g. for wholesale lenders

$$\psi \bar{\phi}_t^J (1 + \tau_t^J) \leq \Omega_t^J$$

- Interpretation: **Social cost of bank leverage** is by a factor of τ_t^J higher than private cost of leverage (e.g. due to externalities)

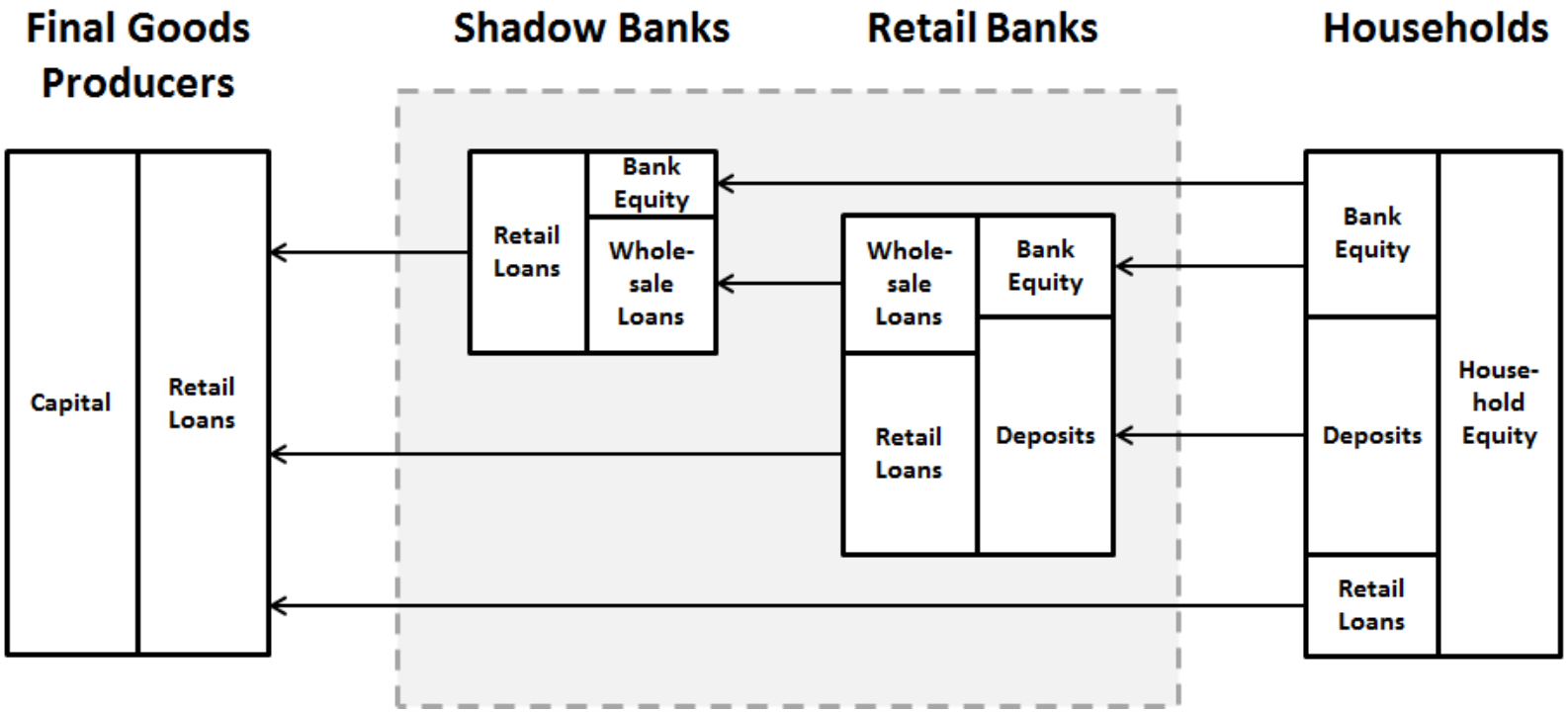
Rest of the Model

- Households
  - Consume
  - Supply labor inelastically
  - Invest in deposits and retail loans ▸ Details
- Final goods producers
  - Use retail loans to purchase capital
  - Transform capital and labor into consumption goods
  - Cobb-Douglas technology
  - Productivity shock ▸ Details
- Capital goods producers
  - Transform consumption goods into investment goods
  - Quadratic capital adjustment cost ▸ Details

Agenda

1. Introduction
2. Model
3. Equilibrium
4. Eliminating Shadow Banking Crises
5. Effects of Retail Bank Capital Requirements
6. Conclusion

Equilibrium flow of funds - model overview



Flow of funds in equilibrium.

Self-fulfilling and systemic bank runs

- Systemic shadow bank default reduces the return on retail loans (capital) from R_t^A to R_t^{A*}
- Net worth of incumbent shadow banks $N_t^{S,I}$ increases in the return on retail loans: $\partial N_t^{S,I}/\partial R_t^A > 0$

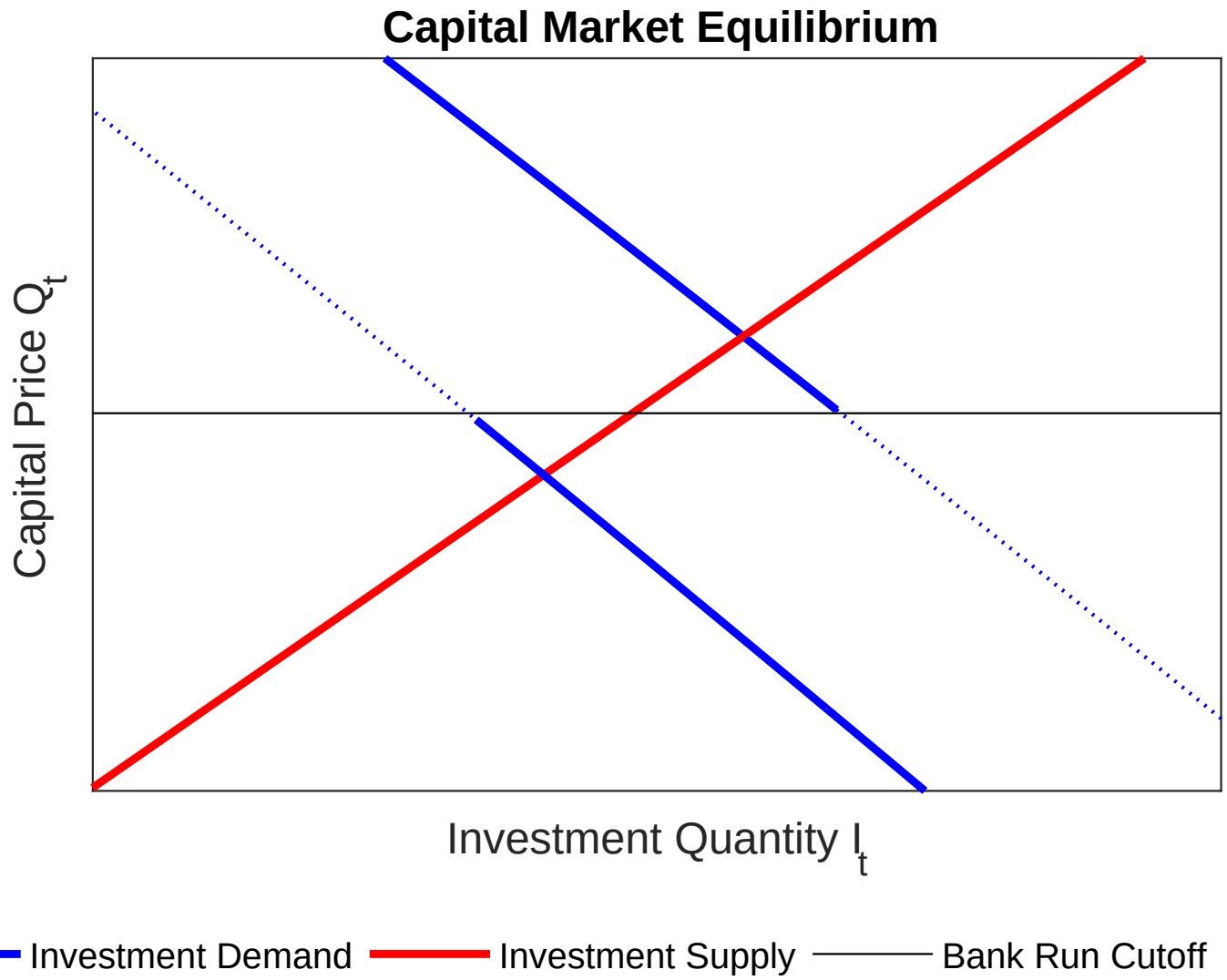
Two equilibria

- High return on retail loans, solvent shadow banks **(normal equilibrium)**
- Low return on retail loans, insolvent shadow banks **(shadow bank run equilibrium)**

- Run equilibrium selected if sunspot $\Xi_t \in \{0, 1\}$ is 1, with

$$\Pr(\Xi_t = 1) = \eta(1 - x_t^*)$$

A situation with two equilibria



Existence condition for two equilibria

- Existence condition for the shadow bank run equilibrium:

$$x_t^* \leq 1 \iff \xi R_t^{A*} A_t^S \leq R_t^B B_t.$$

  with fire sale return on retail loans R_t^{A*}, return on wholesale loans R_t^B, liquidation loss ξ

- Can be rewritten as

$$\xi \underbrace{\frac{R_t^{A*}/Q_{t-1}}{R_t^B}}_{\substack{\text{Shadow bank} \\ \text{fire sale} \\ \text{profit margin}}} \underbrace{\frac{\phi_{t-1}^S}{\phi_{t-1}^S - 1}}_{\substack{\text{Shadow bank} \\ \text{leverage}}} \leq 1$$

- **This condition is not internalized by banks**

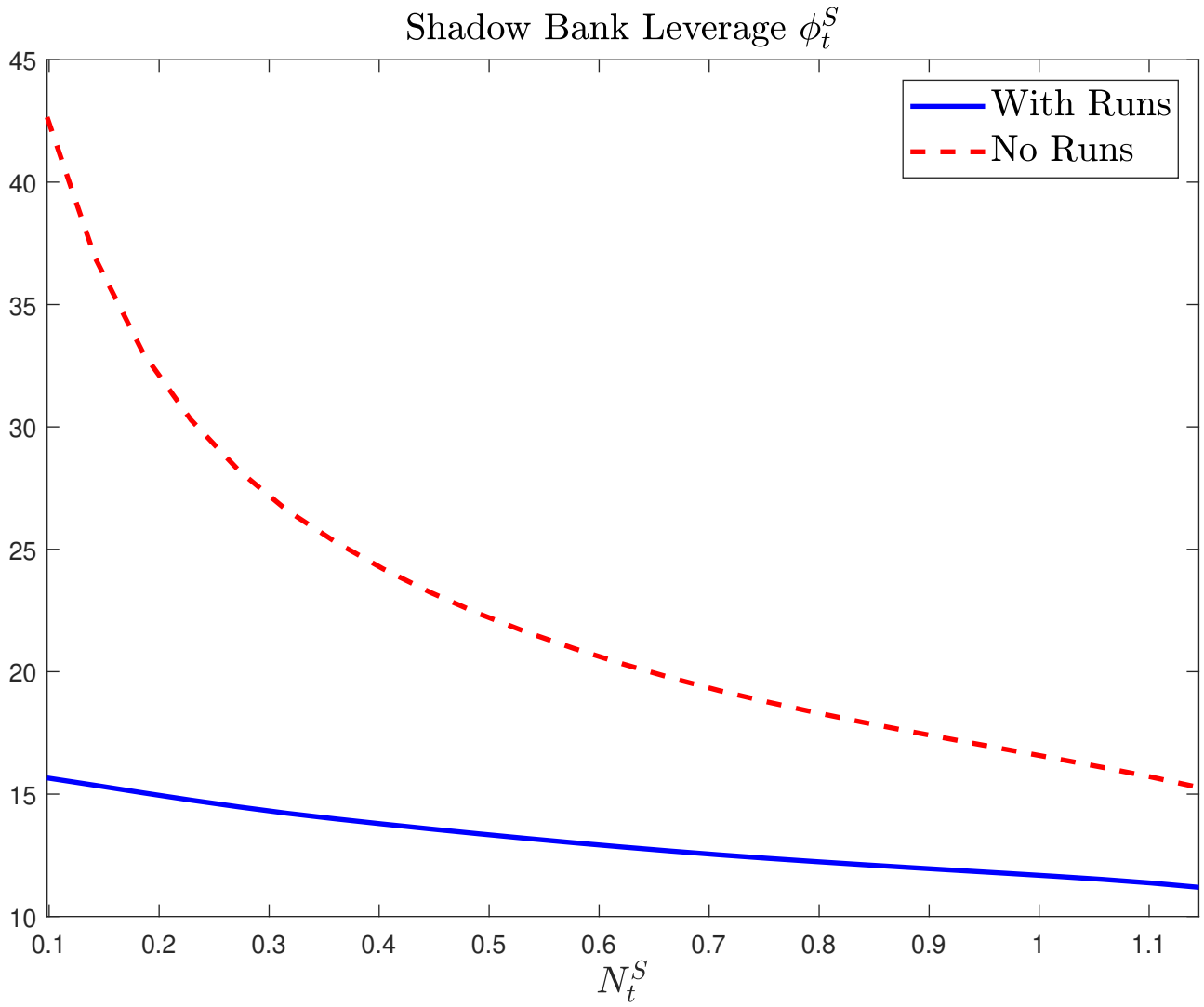
Agenda

1. Introduction
2. Model
3. Equilibrium
4. Eliminating Shadow Banking Crises
5. Effects of Retail Bank Capital Requirements
6. Conclusion

Calibration

Role	Name	Value	Target or Source
(a) Technology and Preferences			
Capital share in production	α	0.36	Standard value
Depreciation Rate	δ	0.025	Standard value
Risk Aversion	σ	2	Standard value
Household discount factor	β	0.9902	$R^D - 1 = 4\%$ p.a.
Capital adjustment cost	θ	10	$\left\|\frac{\partial \ln(Q_t)}{\partial \ln(I_t)}\right\| = 0.25$
(b) Financial Sector			
Banks' initial equity	υ	0.001	Planning horizons of banks
Diversion benefit of wholesale lending	γ	0.6676	$R^B - R^D = 0.8\%$ p.a.
Household capital holding cost	η^H	0.0286	$R^K - R^D = 2.4\%$ p.a.
Retail bank capital holding cost	η^R	0.0071	$R^{K,R} - R^D = 1.2\%$ p.a.
Retail bank exit rate	σ^R	0.0521	$K^R/K = 0.4$
Shadow bank exit rate	σ^S	0.1273	$K^S/K = 0.4$
Asset diversion share	ψ	0.2154	$\phi^R = 10$
Diversion benefit of wholesale funding	ω	0.5130	$\phi^S = 20$
(c) Bank Runs and Stochastic Processes			
Autocorrelation, productivity	ρ^Z	0.9	$\rho(Y_t, Y_{t-1}) = 0.9$
Standard Deviation, productivity shock	σ^Z	0.01	$\sigma(Y_t) = 0.03$
Loss in Default	ξ	0.9	**Retail bank net worth in run -30 %**
Sunspot probability shifter	η	0.25	**Crisis freq. of $\approx 0.75\%$ per quarter**
Reentry probability after bank run	π	12/13	**Runs last 3.25 yrs on avg**

Shadow bank run risk reduces shadow bank leverage



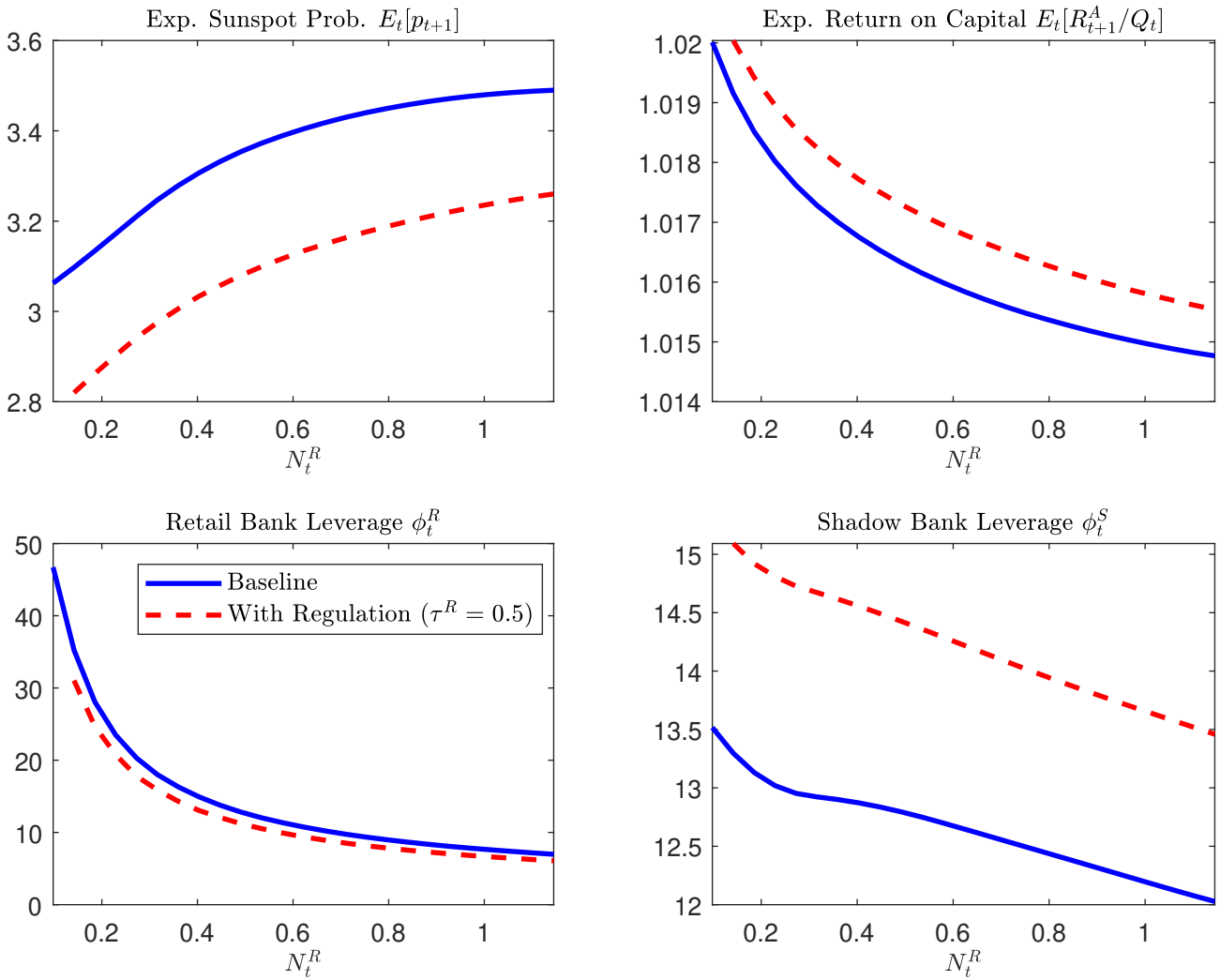
Eliminating shadow banking crises

	With Runs	No Runs	Only Exp.
Macroeconomic Aggregates			
Mean, Output (Y)	1.088	1.114	1.093
St. Dev., Output (Y)	3.181	3.275	3.192
Financial Sector			
Mean, Retail Bank Leverage (ϕ^R)	10.291	10.019	10.239
Mean, Shadow Bank Leverage (ϕ^S)	13.444	19.995	13.244
Bank Runs			
Runs per 100 Years	3.100	0.000	0.000
Recovery Rate ($x_t \vert Run_t$)	78.214	-	-
Welfare	0.850	0.865	0.853

Agenda

1. Introduction
2. Model
3. Equilibrium
4. Eliminating Shadow Banking Crises
5. Effects of Retail Bank Capital Requirements
6. Conclusion

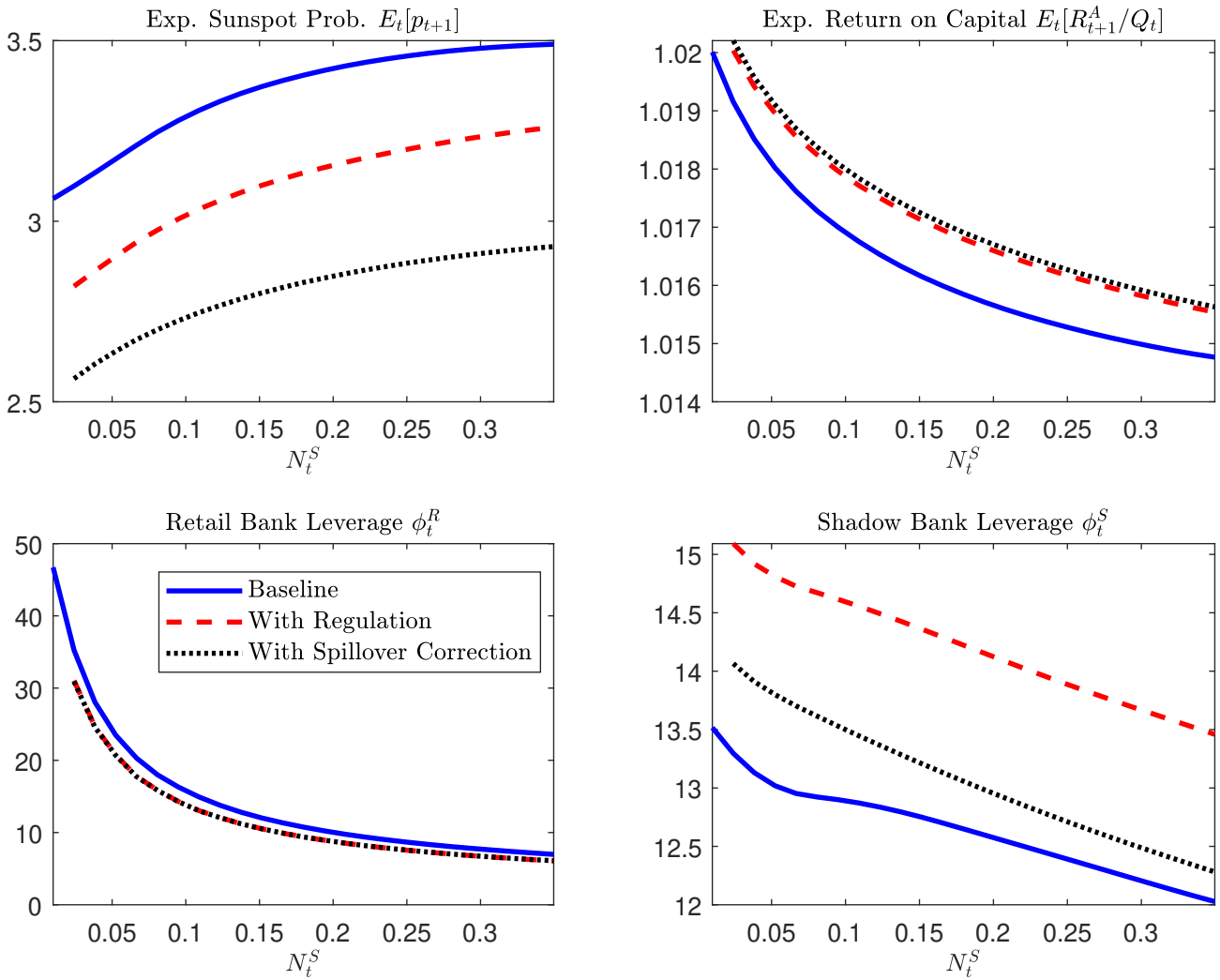
Retail CR push fire sale prices up



Effectiveness of retail bank capital requirements

	With Runs		No Runs	
	Baseline	$\tau^R = 0.5$	Baseline	$\tau^R = 0.5$
Macroeconomic Aggregates				
Mean, Output (Y)	1.088	1.082	1.114	1.101
St. Dev., Output (Y)	3.185	3.204	3.279	3.302
Financial Sector				
Mean, Retail Bank Leverage (ϕ^R)	10.291	8.057	10.019	7.571
Mean, Shadow Bank Leverage (ϕ^S)	13.444	14.847	19.993	20.820
Bank Runs				
Runs per 100 Years	3.096	2.899	0.000	0.000
Recovery Rate ($x_t \vert Run_t$)	78.212	78.725	-	-
Welfare	0.850	0.848	0.865	0.860

Correcting for the spillover increases the effectiveness of retail CR



Correcting for the spillover effect

	With Runs		
	Baseline	Regulation W Spillover	Regulation W/O Spillover
Macroeconomic Aggregates			
Mean, Output (Y)	1.088	1.082	1.079
St. Dev., Output (Y)	3.184	3.202	3.179
Financial Sector			
Mean, Retail Bank Leverage (ϕ^R)	10.291	8.057	8.033
Mean, Shadow Bank Leverage (ϕ^S)	13.444	14.847	13.436
Bank Runs			
Runs per 100 Years	3.105	2.909	2.630
Recovery Rate ($x_t \vert Run_t$)	78.213	78.728	79.427
Welfare	0.850	0.848	0.846

Conclusion

- Quantitative nonlinear DSGE model to evaluate effectivness of retail bank capital requirements to reduce shadow banking crises:
  - Endogenous wholesale lending market
  - Endogenous and anticipated shadow bank runs
- Main findings:
  - Shadow bank runs have a large welfare cost, mostly through anticipation effects
  - Retail bank capital requirements can reduce the frequency and severity of shadow bank runs
  - Retail bank CR create a spillover due to a relaxed shadow bank leverage constraint, which mitigates their effectiveness substantially

Appendix

Households

$$\max_{\{k_{t+1}^H, d_{t+1}^H, c_t^H\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_t^H) \right]$$

s.t.

$$c_t^H = n_t^H - Q_t k_{t+1}^H - d_{t+1}^H - \frac{\eta_H}{2} \left(\frac{k_{t+1}^H}{K_t} \right)^2 K_t + \left(f_t^R - \frac{\eta_R}{2} \frac{k_{t+1}^R}{K_t} \right) k_{t+1}^R$$

$$n_t^H = \left[r_t^K + (1-\delta) Q_t \right] k_t^H + (1 + r_t^D) d_t^H + W_t + \Pi_t^Q$$

Back

Retail Banks

- Define the value function of a banker as: $V_t^R = \sigma n_t^{R,C} + (1-\sigma) V_t^{R,C}$
- The value function of a continuing banker is given by:

$$V_t^{R,C} = \max_{k_{t+1}^R, d_{t+1}, b_{t+1}} \beta \mathbb{E}_t \left[V_{t+1}^R \right]$$

s.t.

$$n_t^{R,C} + d_{t+1} = (Q_t + f_t^R) k_{t+1}^R + b_{t+1} \qquad \text{(Balance Sheet Constraint)}$$

$$\psi((Q_t + f_t^R) k_{t+1}^R + \gamma b_{t+1}) \leq \beta \mathbb{E}_t \left[V_{t+1}^R \right] \qquad \text{(Incentive Constraint)}$$

$$n_t^{R,C} \geq \Gamma((Q_t + f_t^R) k_{t+1}^R + \gamma b_{t+1}) \qquad \text{(Bank Capital Requirement)}$$

- where net worth of continuing bank is $n_t^{R,C} = (r_t^K + (1-\delta) Q_t) k_t^R + R_{t+1}^B b_t - R_t^D d_t$.
- Net worth of all banks: $N_t^B = (1-\sigma) n_t^{R,C} + \sigma \omega K_t$

▸ Back

Shadow Banks

- Define the value function of a banker as: $V_t^S = \sigma n_t^{S,C} + (1-\sigma) V_t^{S,C}$
- The value function of a continuing banker is given by:

$$V_t^{S,C} = \max_{k_{t+1}^S, b_{t+1}} \beta \mathbb{E}_t \left[V_{t+1}^S \right]$$

s.t.

$$n_t^{S,C} + b_{t+1} = Q_t k_{t+1}^S \qquad \text{(Balance Sheet Constraint)}$$

$$\psi(\omega b_{t+1} + n_t^{S,C}) \leq \beta \mathbb{E}_t \left[V_{t+1}^S \right] \qquad \text{(Incentive Constraint)}$$

- where net worth of continuing bank is $n_t^{S,C} = (r_t^K + (1-\delta)Q_t)k_t^R + R_{t+1}^B b_t - R_t^D d_t$.
- Net worth of all banks: $N_t^B = (1-\sigma) n_t^{S,C} + \sigma \omega K_t$

Back

Production

Final Goods Producers:

$$\max_{K_t, L_t} \left\{ Z_t K_t^{\alpha} L_t^{1-\alpha} - W_t L_t - r_t^K K_t \right\}$$

Capital Goods Producers:

$$\max_{i_t} \left\{ Q_t i_t - i_t - \frac{\theta}{2} \left(\frac{i_t}{K_t} - \delta \right)^2 K_t \right\}$$

FOC:

$$Q_t = 1 + \theta \left(\frac{i_t}{K_t} - \delta \right)$$

▸ Back

Adrian, T. and H. S. Shin (2011). Chapter 12 - Financial Intermediaries and Monetary Economics. In *Handbook of Monetary Economics*, Volume 3, Chapter 12, pp. 601–650. Elsevier Ltd.

Begenau, J. and T. Landvoigt (2017). Financial Regulation in a Quantitative Model of the Modern Banking System. *Working Paper, Harvard*, 1–53.

Boissay, F., F. Collard, and F. Smets (2016). Booms and Banking Crises. *Journal of Political Economy 124*(2), 489–538.

Farhi, E. and J. Tirole (2017). Shadow Banking and the Four Pillars of Traditional Financial Intermediation. *Unpublished Manuscript*.

Ferrante, F. (2018). A Model of Endogenous Loan Quality and the Collapse of the Shadow Banking System. *American Economic Journal: Macroeconomics 10*(4), 152–201.

Garcia-Macia, D. and A. Villacorta (2016). Macroprudential Policy with Liquidity Panics. Technical report.

Gennaioli, N., A. Shleifer, and R. W. Vishny (2013, aug). A Model of Shadow Banking. *The Journal of Finance 68*(4), 1331–1363.

Gertler, M. and N. Kiyotaki (2013). Banking, Liquidity and Bank Runs in an Infinite-Horizon Economy. *Working Paper*.

Gertler, M., N. Kiyotaki, and A. Prestipino (2016). *Wholesale Banking and Bank Runs in Macroeconomic Modelling of Financial Crises* (1 ed.), Volume No. 21892. Elsevier B.V.

Gertler, M., N. Kiyotaki, and A. Prestipino (2017). A Macroeconomic Model with Financial Panics. *Unpublished Manuscript*.

Huang, J. (2018). Banking and Shadow Banking. *Journal of Economic Theory 178*, 124–152.

Meeks, R., B. Nelson, and P. Alessandri (2017). Shadow Banks and Macroeconomic Instability. *Journal of Money, Credit and Banking 49*(7), 1483–1516.

Moreira, A. and A. Savov (2017). The Macroeconomics of Shadow Banking. *The Journal of Finance 72*(6), 2381–2432.

Paul, P. (2018). A Macroeconomic Model with Occasional Financial Crises. *Federal Reserve Bank of San Francisco Working Paper*.

Plantin, G. (2014). Shadow Banking and Bank Capital Regulation. *Review of Financial Studies*.