Financial Regulation in a Quantitative Model of the Modern Banking System

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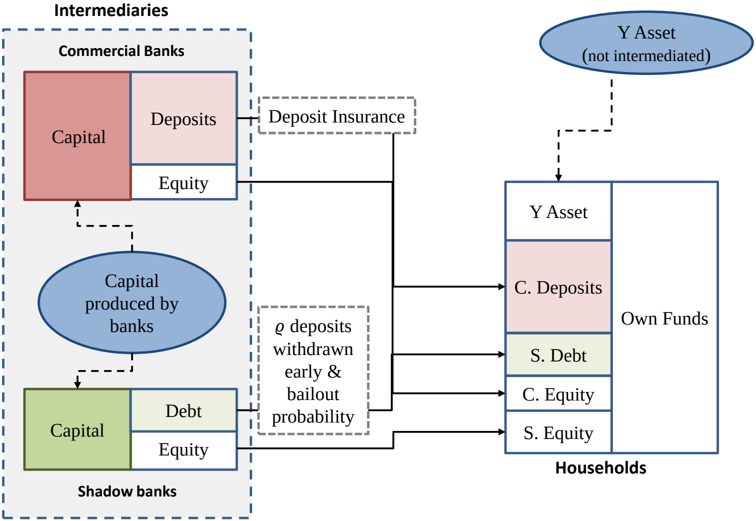
Motivation

- Financial System: regulated & unregulated banks
  - provide access to "intermediated" assets, e.g. long term credit
  - funded with liquidity services providing debt
  - both bank types compete with each other
- Effects of financial regulation on a subset of banks?
  - Does tighter regulation cause a shift to shadow banks?
  - Does this make the financial system riskier?
- Answers depend on determinants of the relative bank type size in equilibrium and banks' leverage choice
- Requires quantitative general equilibrium analysis
- Study effect of capital requirements

Model Overview



Mechanism behind effects of tighter capital requirement

- Liquidity demand for shadow (S-) & com. (C-) bank debt
- S- and C-banks compete in liquidity provision
- Deposit insurance gives C-banks a comp. advantage
- Two key equilibrium forces determine rel. size & leverage
  1. HH's liquidity demand implies that S-bank deposit rates fall when C-bank deposits fall - GE effect (*demand effect*)
  2. Endog. allocation of S- and C-bank equity (*competition effect*)

Effect of $\uparrow \theta$ (cap req) when C-bank leverage determined by $D^C/E^C = \theta$

1. Demand effect: Lower D^C reduces r^S and increases D^S
   $\Rightarrow$ Fixing E^S, higher S-bank leverage D^S/E^S & S-bank share

2. Competition effect: Higher θ reduces C-banks' competitive advantage ($\uparrow E^S/E^C$)
   $\Rightarrow$ Higher E^S reduces S-leverage & increases S-bank share

- Unambigiously positive effect on S-bank share
- Leverage: which effect dominates is a quantitative question

Calibration

Key: HH's liquidity demand parameters pinned down using

(1) aggregate liquidity premium (Van Binsbergen et al, 2019)

(2-3) S-& C-bank deposit spread sensitivity to S-&C-bank debt

(4) S-bank share based on Fed study (Gallin 2013)

- Model matches
  - Higher fragility of S-banks
  - Bank-dependent output and investment characteristics

Quantitative Effects: increase θ by 10pp

x 11% reduction in C-bank leverage

x S-bank deposit rate falls by 2%

x S-bank debt share increases by 7%

x S-bank leverage increases by only 80bps
$\Rightarrow$ Demand effect dominates but is counter-balanced by competition effect
$\Rightarrow$ Overall financial stability increases w/ θ

- Welfare maximized at $\theta = 16\%$: trades-off reduction in liquidity provision against incraese in consumption due to higher financial stability

Overview of this talk

1. 2-period model of the mechanism
2. Dynamic quantitative model
   - Differences to simple model
   - Calibration highlights
   - Quantitative results
3. Experiment: recovery after financial crisis

Setup

- Dates $t = 0$ and $t = 1$
  - Unit mass of HH endowed with 1 unit of capital at $t = 0$
  - C-banks and S-banks (unit mass) purchase capital financed with equity and deposit issuance to households

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- Household preferences: bank deposits provide liquidity services

$$U = C_0 + \beta(C_1 + \psi H(A_S, A_C))$$

with A_j, $j = S, C$, are deposits of banks held by households

S-banks

- Each bank solves

$$\max_{K_S \geq 0, B_S \geq 0} \underbrace{q_S(B_S, K_S)B_S - pK_S}_{\text{equity raised at } t=0} + \beta \underbrace{\max\{\rho_S K_S - B_S, 0\}}_{\text{dividend paid at } t=1}$$

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- Bank issues risky debt at price $q_S(B_S, K_S)$
  - Creditors price default risk
  - Bank internalizes effect of choice (B_S, K_S) on debt price

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- Bank-idiosyncratic payoff shock

C-banks

- Each bank solves

$$\max_{K_C \geq 0, B_C \geq 0} \quad \underbrace{q_C B_C - pK_C}_{\text{equity raised at } t=0} + \beta \underbrace{\max\{\rho_C K_C - B_C, 0\}}_{\text{dividend paid at } t=1}$$

subject to

$$B_C \leq (1-\theta)\mathrm{E}(\rho_C)K_C$$

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- Differences to S-bank problem
  - Government-insured debt is riskfree to creditors
  - Regulatory capital requirement θ

Households and Government

- HH choose purchases of debt and equity of each bank to max utility

$$\max_{\{A_j, S_j\}_{j=S,C}} \quad C_0 + \beta(C_1 + \psi H(A_S, A_C))$$

$$\text{s.t.} \quad C_0 = \underbrace{p}_{\text{sell cap.}} \underbrace{- q_S A_S - q_C A_C - p_S S_S - p_C S_C}_{\text{buy securities}}$$

$$C_1 = (1 - L_S) A_S + A_C - T$$
$$+ S_S \underbrace{\frac{1}{2} K_S (1 - L_S)^2}_{\text{div. from S-bank}} + S_C \underbrace{\frac{1}{2} K_C (1 - L_C)^2}_{\text{div. from C-bank}}$$

where

$$T = L_C B_C$$

lump-sum taxes to bail out failing C-banks

Equilibrium

- Market clearing

$$
\begin{aligned}
S_S &= 1 \\
S_C &= 1 \\
A_C &= B_C \\
A_S &= B_S \\
K_S + K_C &= 1.
\end{aligned}
$$

- Resource constraints: $C_0 = 0$ and

$$C_1 = \frac{1}{2}\left(1 - K_C L_C^2 - K_S L_S^2\right)$$

- Time-1 consumption clarifies fundamental trade-off
  - Bank leverage causes bankruptcies and deadweight losses
  - But some leverage necessary to produce liquidity services

Decentralized Equilibrium: HH's demand for S-bank and C-bank debt

- Define bank leverage $L_j = B_j/K_j$ and $F_S()$ is c.d.f. of ρ_S
- Household FOC for S-bank debt

$$q(L_S) = \beta(\underbrace{1 - F_S(L_S)}_{\text{payoff}} + \underbrace{\psi H_S(A_S, A_C)}_{\text{liq. premium}})$$

- Household FOC for C-bank debt

$$q_C = \beta(\underbrace{1}_{\text{payoff}} + \underbrace{\psi H_C(A_S, A_C)}_{\text{liq. premium}})$$

Decentralized Equilibrium: S-Bank Problem

$$\max_{K_S \geq 0, B_S \geq 0} \; q_S(B_S, K_S)B_S - pK_S + \beta \max\{\rho_S K_S - B_S, 0\}$$

- Define $\rho_S^+ = \mathrm{E}(\rho_S \,|\rho_S > L_S)$

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- Optimization regarding L^S and A^S leads to

1. Marginal default losses equal marginal liquidity benefit

$$L_S f_S(L_S) = \psi H_S(A_S, A_C).$$

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1. Marginal default losses equal marginal liquidity benefit

$$L_S f_S(L_S) = \psi H_S(A_S, A_C).$$

2. Constant returns implies S-banks earn zero expected profits

$$p = \beta\left((1 - F_S(L_S))\rho_S^+ + \psi L_S H_S(A_S, A_C)\right)$$

Decentralized Equilibrium: C-Bank Problem

- Similar to S-bank problem except for leverage constraint

$$L_C \leq \mathsf{E}(\rho_C)(1-\theta),$$

- As long as marginal benefit of C-bank liquidity positive, $\psi H_C(A_S, A_C) > 0$, the C-bank leverage constraint is always binding, implying $L_C = \mathsf{E}(\rho_C)(1-\theta)$, and C-banks' capital demand requires

$$p = \beta\left((1-F_C(L_C))\rho_C^+ + \psi L_C H_C(A_S, A_C) + F_C(L_C)L_C\right).$$

- Both banks value payout and collateral value of K_j
- Plus, C-bank value K_C due to deposit insurance $\rightarrow$ Leads to higher C-bank share
- To compete, S-banks must provide higher payoff or liq. prem.

Efficiency Properties of Equilibrium

Assume liquidity preferences are

$$H(A_S, A_C) = \frac{\left(\alpha A_S^{\epsilon} + (1-\alpha)A_C^{\epsilon}\right)^{\frac{1-\gamma_H}{\epsilon}}}{1-\gamma_H},$$

with $\gamma_H \geq 0$, $\epsilon \in (0, \infty)$

- Planner maximizes household utility under $\rho_S \sim \text{Uniform}[0,1]$

$$\frac{A_S}{A_C} = \frac{K_S}{K_C} = \left(\frac{\alpha}{1-\alpha}\right)^{\frac{1}{1-\epsilon}}$$

  Relative size pinned down by liquidity preference
- Optimal leverage is equalized across bank types $L_S = L_C = L^*$ as banks have identical technology to produce liquidity, where L^* is a function of parameters

Implications for Decentralized equilibrium

- Factor *m* is a wedge b/w
  - Social marginal benefit of C-bank liquidity $\psi \mathcal{H}_C(A_S, A_C)$
  - Cost to society of producing this liquidity L_C
- In competitive equilibrium, C-banks overproduce liquidity, too much equity allocated to C-banks
- Competition effect means share of shadow banks in liquidity provision too small $\Rightarrow$ not fixed by capital requirement
- Competition effect induced via
  - Equity investors need to be indifferent b/w S- & C-banks
  - C-bank distortion extends to S-banks

The effect of a higher C-bank capital requirement

Proposition

1. *Holding constant all other parameters, an increase in the capital requirement* θ
   (i) *reduces C-bank leverage,*
   (ii) *causes an expansion in the S-bank share:* $\frac{d(A_S/A_C)}{d\theta} > 0$ *and* $\frac{d(K_S/K_C)}{d\theta} > 0$*,*
   (iii) *can either raise or lower optimal S-bank leverage, depending on model parameters,*
2. *For* $m \geq 0$*, a marginal increase in the capital requirement improves aggregate welfare.*

Ambigious response of S-bank leverage

- Raising θ in the model two effects

  1. Competition Effect
     - Lowering C-bank leverage reduces equity return
     - Lowers competitive pressure on S-banks
     - c.p. *lowers* S-bank's optimal leverage
  2. Demand Effect
     - Decreasing returns to liquidity production, lower C-bank liquidity production increases marginal utility of liquidity
     - c.p. reduces q_S
     - c.p. *increases* S-bank's optimal leverage

- Which effect dominates depends on parameters!
  - E.g. higher decreasing returns of liquidity serices γ_H, stronger demand effect

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2. Dynamic quantitative model
   - Differences to simple model
   - Calibration highlights
   - Quantitative results
3. Experiment: recovery after financial crisis

Dynamic Model: Key Differences

1. Infinite horizon model with bank-independent sector (endowment) and bank-dependent sector (production)
   - Banks have investment tech. w/ convex adj. costs
   - Convex capital adjustment costs
2. Riskier S-banks: runs and implicit bail-out guarantees
   - S-banks subject to stochastic deposit redemption shocks ϱ_t
     ▸ More Details
   - Introduces additional losses through fire-sale
   - Government bails out S-bank *liabilities* with probability π_B

Dynamic Model: Key Differences ctd

3. Risk averse households with preferences

$$U\left(C_t, H\left(A_t^S, A_t^C\right)\right) = \frac{C_t^{1-\gamma}}{1-\gamma} + \psi \frac{\left(\left[\alpha (A_t^S)^\epsilon + (1-\alpha)(A_t^C)^\epsilon\right]^{\frac{1}{\epsilon}}\right)^{1-\gamma_H}}{1-\gamma_H}$$

- Portfolio choice of equity and debt of both types of banks
- Inelastic labor supply

State Variables and Solution Method

- Exogenous states

$$\log(Y_{t+1}) = (1-\rho_Y)\log(\mu_Y) + \rho_Y \log(Y_t) + \epsilon_{t+1}^Y$$
$$Z_t = \phi^Z Y_t \exp(\epsilon_t^Z)$$

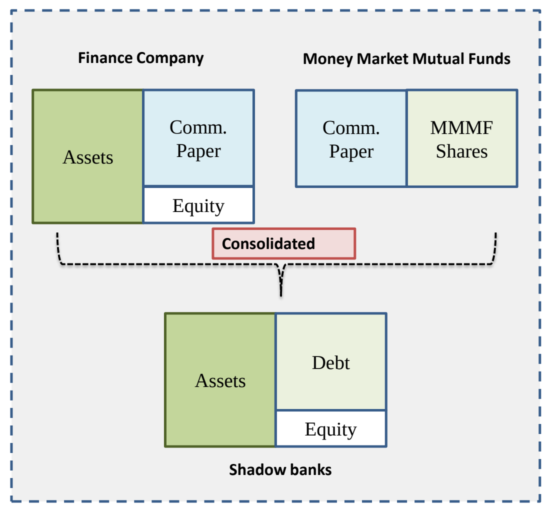
  and ϱ_t follows a two-state Markov-process

- Endogenous states
  1. Capital stock

  2., 3. C-bank and S-bank debt

  4. S-bank capital share
- Solve using non-linear projection methods
  - Probability of default bounded in $[0,1]$
  - Nonlinear dynamics because of bankruptcy option
- Report results for simulated model

Calibration: Consolidated View of Shadow Banks



Key Parameters: Quarterly data 1999 – 2019

	Value	Description	Target	Data	Model
β	0.993	Discount rate	C-bank debt rate	0.36%	0.39%
α	0.33	CES weight S-bank debt	Shadow banking share Gallin (2015)	34.0%	33.7%
ψ	0.0072	Liq. preference weight	Liq. premium BDG2019	0.21%	0.17%
γ_H	1.6	Liq. preference curvature	Reg. coefficient on AS	-0.19%	-0.14%
ϵ	0.2	Liq. type elasticity	Reg. coefficient on AC	0.50%	0.68%

Liquidity Preference Parameters (1/2)

- How are key liquidity preference parameters disciplined by data?
- ψ: level of liquidity premium
  - Van Binsbergen, Diamond, and Grotteria (2019) provide estimate of "risk-free rate w/o liquidity premium" based on option spreads
  - ψ directly scales marginal liquidity benefit in model

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- α: market share of S-banks
  - Higher α raises S-bank relative to C-bank premium
  - Lowers funding cost, increases demand for capital of S-banks

Liquidity Preference Parameters (2/2)

$\underline{\gamma_H \text{ \& } \epsilon}$: curvature & elasticity of subs. b/w S- and C-banks

- Determined by regression coefficients of spread on quantities

$$q_t^C - q_t^S = \mathrm{E}_t \left[M_{t,t+1} \left(\mathrm{MRS}_{t+1}^C - \mathrm{MRS}_{t+1}^S + F_{\rho,t+1}^S \right) \right]$$

  - Log-linear approximation of spread
  - If $\epsilon = 1$ (perfect substitutes) and $\gamma_H = 0$ (CRS in liquidity), *quantities* of debt (A_S, A_C) do not matter for spread
  - Regression of spread b/w deposit price and 3month AA CP price on S-bank and C-bank money-like liabilities and controls, leads to coefficients of -0.19% on A_S and 0.50% on A_C
  - Matched in model with $\epsilon = 0.20$ (net substitutes) and $\gamma_H = 1.60$

Other important parameters: Quarterly data 1999 – 2019

	Values	Target	Data	Model
	Bank leverage and default			
δ_S	0.390	Corp. bond default rate	0.28%	0.30%
δ_C	0.204	Net loan charge-offs	0.23%	0.23%
ξ_C	0.352	Secured recov. rate Moody's	48.1%	48.1%
ξ_S	0.205	Unsecured recov. rate Moody's	38.1%	38.2%
π_B	0.85	Shadow bank leverage	87.0%	83.2%
	Runs			
$\underline{\delta}_K$	2.5%	Avg. haircut (GM 2009)	15.1%	15.2%

Increasing Capital Requirement

Larger shadow banking share, C-banks "exit", S-bank "enter"
Demand effect dominates competition effect: higher S-bank leverage

	Benchmark	13%	16%	20%	30%
	mean	mean	mean	mean	mean
		Capital and Debt			
1. Capital	3.15	+0.2%	+0.4%	+.7%	+1.6%
2. Debt share S	32%	+2.7%	+4.6%	+6.9%	+13.8%
3. Leverage S	0.831	+0.2%	+0.4%	+0.8%	+1.8%
4. Leverage C	0.899	-3.3%	-6.7%	-11.2%	-22.2%
5. Early Liquidation (runs)	0.004	+0.3%	+0.6%	+1.1%	+2.5%
		Prices			
6. Deposit rate S	0.45%	-0.7%	-1.6%	-3.1%	-6.8%
7. Deposit rate C	0.39%	-3.7%	-7.2%	-12.0%	-26.8%
8. Conv. Yield S	0.28%	+1.4%	+3.3%	+6.3%	+14.3%
9. Conv. Yield C	0.31%	+4.7%	+9.1%	+15.2%	+34.0%

Increasing Capital Requirement

C-banks become safer, but S-banks riskier

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Increasing Capital Requirement

Interest rates fall as liquidity premia rise ⇒ more investment

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Increasing Capital Requirement

Defaults from C-banks decline, from S-banks rise

	BM	13%	16%	20%	30%
	mean	mean	mean	mean	mean
		Welfare			
10. Default Rate S	0.30%	+3.1%	+7.4%	+14.1%	+34.1%
11. Default Rate C	0.23%	-65.1%	-89.4%	-98.3%	-100.0%
12. GDP	1.29	+0.0%	+0.1%	+0.1%	+0.2%
13. Liquidity Services	1.48	-2.2%	-4.22%	-7.0%	-14.1%
14. Consumption	1.21	+0.1%	+0.1%	+0.1%	+0.1%
15. HH Welfare		+0.04%	+0.05%	+0.4%	+0.04%

Increasing Capital Requirement

More consumption and lower liquidity provision

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Increasing Capital Requirement

Welfare maximized at 16%

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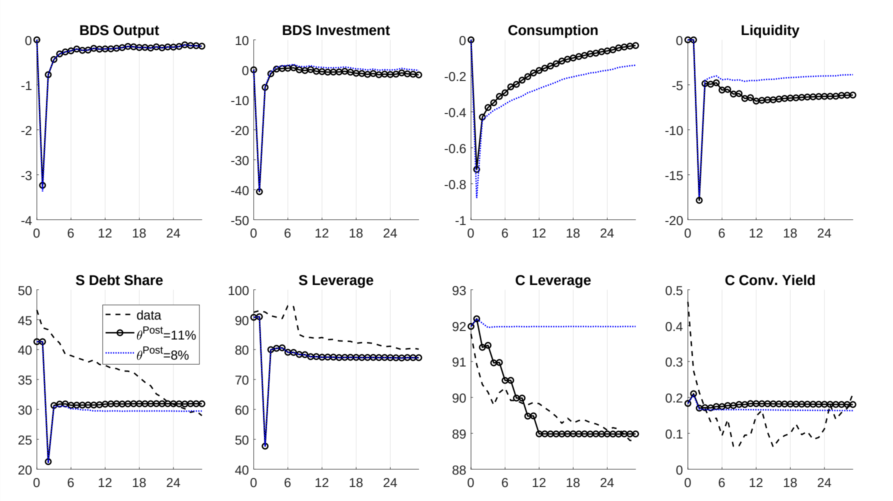
Experiment: Recovery from the Financial Crisis

- Effects of a Basel III shift in capital req in our model?
- Simulate 2008/2009 crisis and subsequent increase in cap req
- Pre 2008/2008 features: lax capital requirements & agents underestimate risk of run on shadow banking system (Moreira and Savov, 2017)
- Relative to bncmk calibration: pre-crisis has a lower capital requirement and higher S-bank bailout prob. and zero perceived prob. of S-bank run.
- Shock: run on S-banks and bad productivity shock
- Regulators increase cap req to 11% over 3 years and reduce S-bank bailout prob.

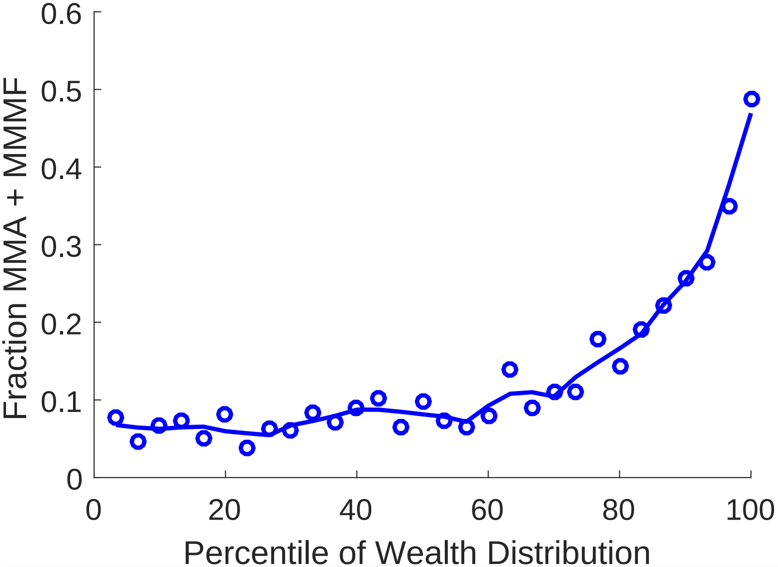
Recovery from the Financial Crisis



Conclusion

- Tractable quantitative GE model with two types of banks
- Increasing capital requirement on commercial banks
  - makes C-banks less, S-banks more profitable
  - leads to larger and riskier S-bank sector
  - less liquidity provision
  - no negative effects on production and investment in total
- Welfare trade-off: greater consumption (fewer bank failures) versus reduced liquidity provision
- Key Model Lessons
  - Quantitative force of either demand or competition effect depends on semi-well understood parameters governing
    - Liquidity preference of HH
    - Competition between S-bank & C-bank
  - Slight increase in S-bank risk does not undermine intended benefits of tighter capital regulation

Fraction of Liquid Wealth in MMA at Household Level



Source: 2013 SCF ▸ Back

S-bank problem ▸ Back

$$v^S(Z_t) = \max_{b^S_{t+1}\geq 0, k^S_{t+1}\geq 0} \; k^S_{t+1}\left(q_S(b^S_{t+1})b^S_{t+1} - p_t\right) - \frac{\phi_K}{2}\left(k^S_{t+1}-1\right)^2 + k^S_{t+1}\mathrm{E}_t\left[M_{t,t+1}\,\Pi^S_{t+1}\Omega^S(L^S_{t+1})\right],$$

with

$$\Omega^S(L^S_t) = (1-F^S_{\rho,t})\left(\rho^{S,+}_t\left(1-\ell^S_t\left(1-x^S_t\right)\right) - L^S_t + (1-\ell^S_t)\frac{v^S(Z_t)}{\Pi^S_t}\right) - F^S_{\rho,t}\delta_S$$

- Endogenous liquidation (fraction of assets)

$$\ell^S_t = \frac{\varrho^S_t B^S_t}{K^S_t \Pi^H_t}$$

- Probability of default $F^S_{\rho,t} = F^S_\rho(\hat{\rho}^S_t)$ with threshold

Bankruptcy & Deposit Insurance

- C-bank default
  - Government bails out liabilities of failing C-banks
  - Recovers

$$r^C(L_t^C) = (1 - \xi^C)\frac{\rho_t^{C,-}}{L_t^C}$$

per bond issued by C-banks

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    per bond issued by C-banks
- S-banks default
  - Benchmark: government does not bailout failing S-banks bails out liabilities of failing S-bank with probability π_B
  - Recovery value per bond
    $$r^S(L_t^S) = (1-\xi^S)(1-\ell_t^S(1-x_t))\frac{\rho_t^{S,-}}{L_t^S}$$

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$$r^S(L_t^S) = (1-\xi^S)(1-\ell_t^S(1-x_t))\frac{\rho_t^{S,-}}{L_t^S}$$
- Required taxes in addition to deposit insurance revenue

[illegible]