Banking Dynamics and Capital Regulation

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WORK IN PROGRESS

Capital Buffers as a form of Regulation

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- Rationale is to Protect the Public Purse safe when there is Deposit Insurance in the presence of moral hazard on the part of the bank.

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  - How much extra banking loses?

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    - Nicely built on top of an infinitely lived RA business cycle model.
- Corbae et al. (2016) is quite similar except, single bank problem with market power, and constant interest borrowing and lending. Done to have structural models of stress testing.

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- Banks cannot issue new equity or sell assets (today).

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- Banks may take time to develop. They grow slowly in size due to exogenous loan productivity process and need for internal accummulation of funds.
- Useful also for Shadow Banking

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- New banks enter small ξ at cost $\overline{c}^e$

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- The state of the economy is a measure x of banks that evolves over time itself via banks decisions and shocks (an extension of Hopenhayn's classic)

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    - $\delta^*(z, \xi, \ell, n, b')$

The only relevant equilibrium condition is

1. Zero profit in the bonds markets:

$$q(z, \xi, \ell, n, b') = \frac{1 - \delta^*(z, \xi, \ell, n, b')}{1 + \bar{r}}$$

Model: Aggregate State, $\{z, x\}$

- The choices of the bank $\{n(z, \xi, a, \ell), b'(z, \xi, a, \ell), c(z, \xi, a, \ell)\}$ and the exogenous shocks $\{z', \xi', \delta'\}$ generate a transition for the state of each bank and in turn of the distribution of banks..

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Definition

A, equilibrium is a function $x' = G(z,x)$, a price of bonds q, and decisions for $\{n, b', c\}$ such that banks maximize profits, lenders get the market return, and the measure is updated consistently with decisions and shocks.

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- Describe properties of the stationary allocation in good times.
- Describe the transition when the economy switches to a recession.

Long Good Times Targets Capital Requirement: $\theta = .105$

- We have the following industry properties

	(Canadian) Data	Model
Bank failure rate	0.22%	0.23%
Capital ratio	14.4%	16.7%
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Normalized T-Account of Banking Industry

Canadian Data

New Loans	1.07	Deposits	3.31
Existing Loans	4.87	Wholesale Funding	1.63
		Own Capital	1.00

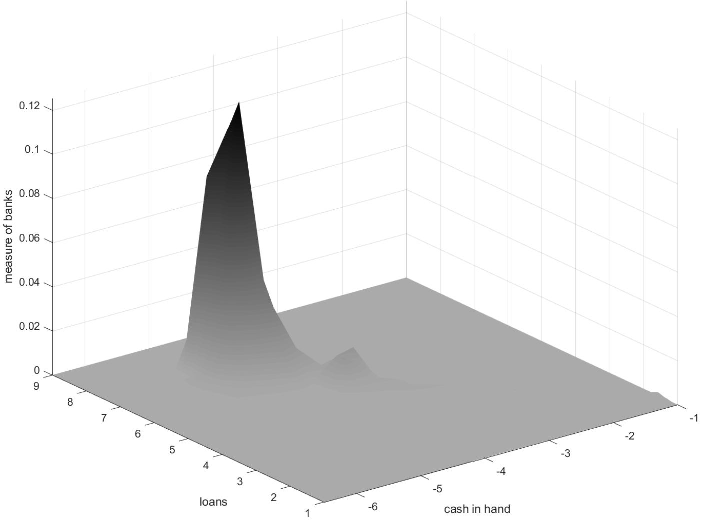
Model

New Loans	1.09	Deposits	3.80
Existing Loans	4.93	Wholesale Funding	1.22
		Own Capital	1.00

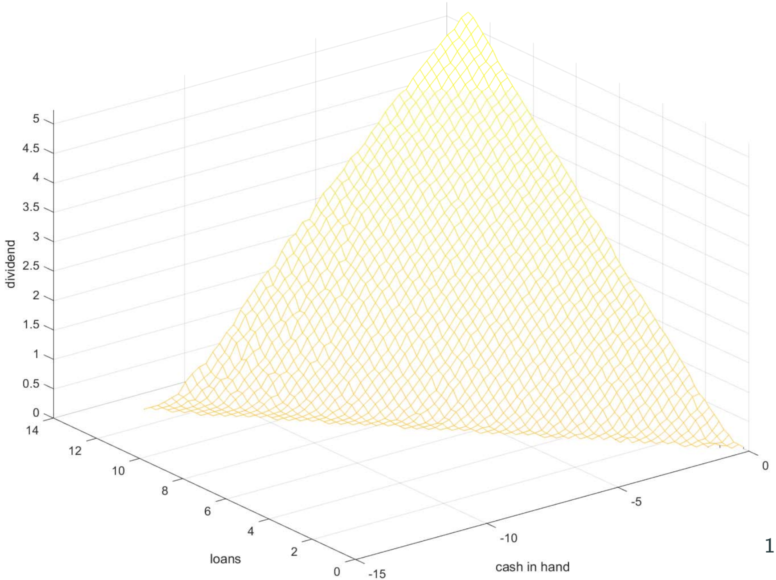
Model Parameters

Parameter	Value	Description
ξ_n	0.2	Loan issuance cost: $\chi(n, \xi_n) = 0.5\, \xi_n\, n^2$
ξ_d	5	Deposits
β	0.95	Subjective discount factor
λ	0.2	Maturity rate of long-term loans
r	0.1	Bank lending rate
r_f	0.005	Risk-free rate
σ	0.9	$u(c) = c^\sigma$
ω_r	1	Risk weight on risky loans
ω_s	0	Risk weight on safe assets
$\Gamma_{z=G,z'=G}$	0.99	$\Pr(z' = G \mid z = G)$
$\Gamma_{z=B,z'=B}$	0.80	$\Pr(z' = B \mid z = B)$
$E(\delta \mid z = G)$	0.025	$\Sigma_\delta\ \delta \cdot \pi(\delta \mid z = G)$
$V(\delta, Z = G)$	0.0017	$\alpha(Z = G) = 0.3334,\ \beta(Z = G) = 13.0015$
$E(\delta \mid z = B)$	0.040	$\Sigma_\delta\ \delta \cdot \pi(\delta \mid z = B)$

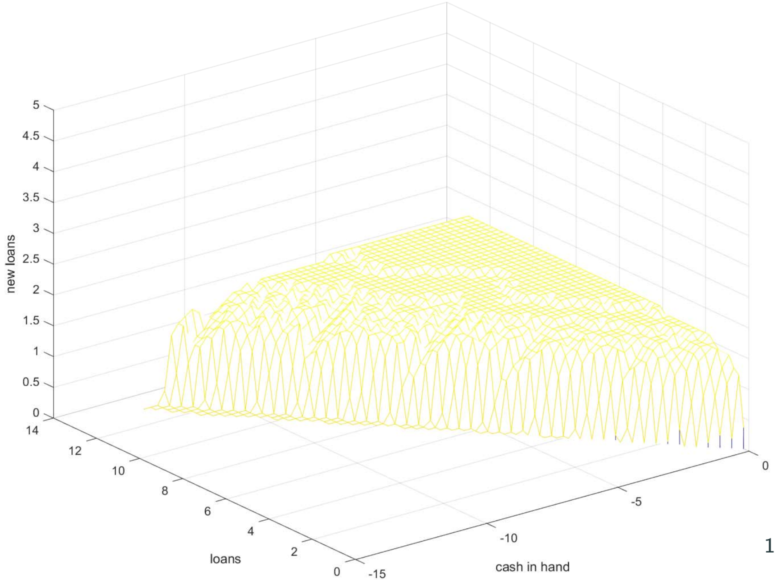
Distribution of Banks



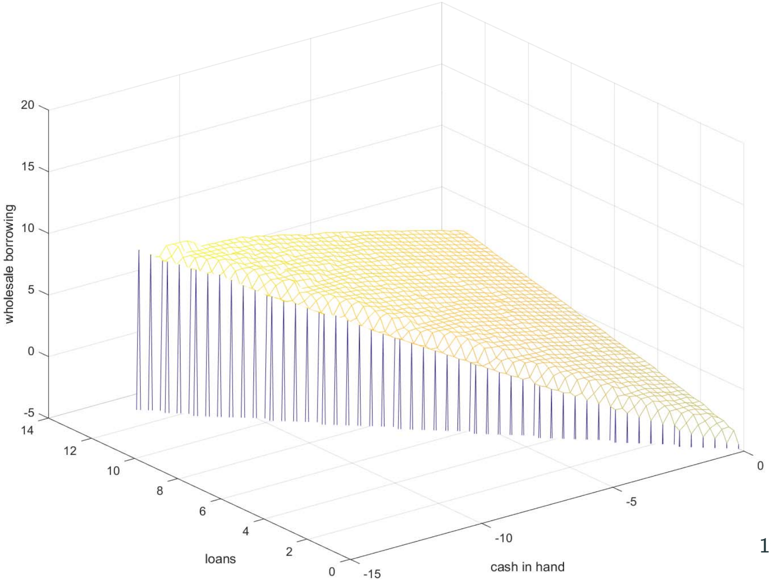
Banks Dividends



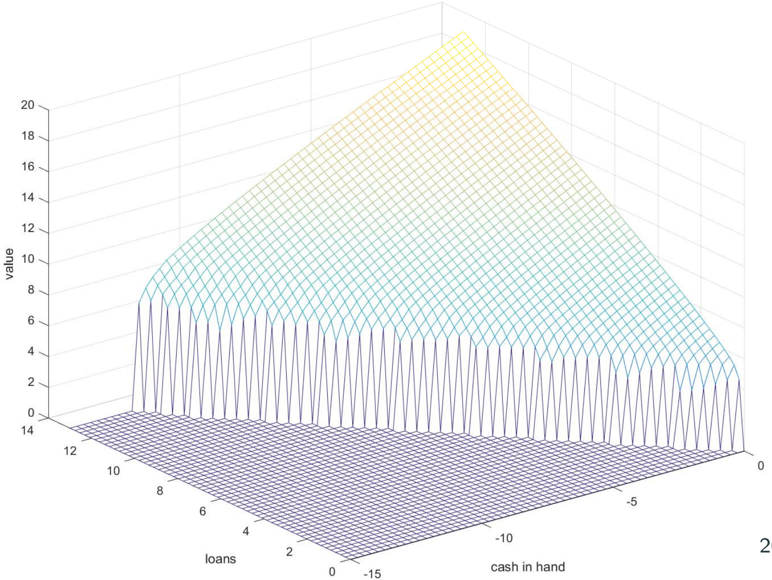
Banks New Loans Issue



Banks Wholesale Funding (Deposits plus Bonds)



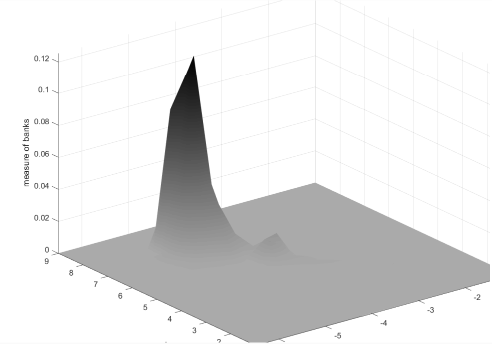
Banks Value Function

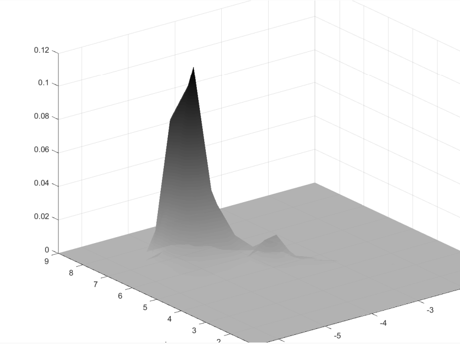


A Nasty Crisis with and without CCyB

- Imagine the shock $\triangle(\delta) = 0.015$ (from .025 to .04) hits all banks, which happens with a very small probability, 0.01. The crisis continues for two periods and ends to go back to the good aggregate state thereafter.
- Some banks are in better financial shape than others.
- We explore the recovery of the Banking sector under the four scenarios.
- What happens upon

A Nasty Crisis with and without CCyB





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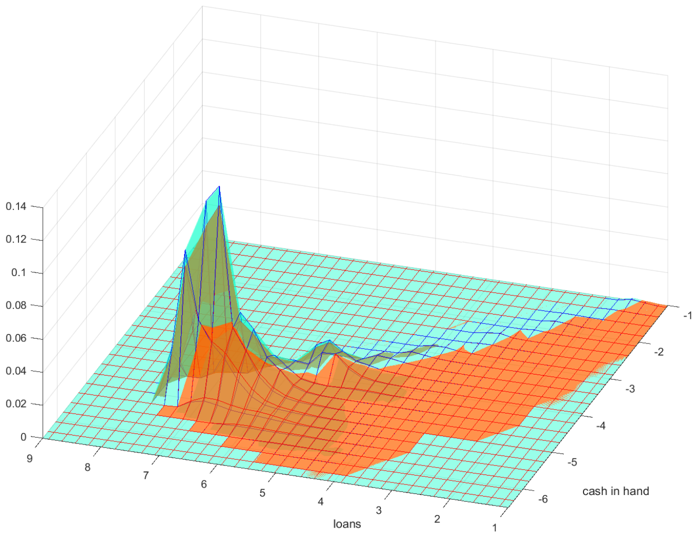
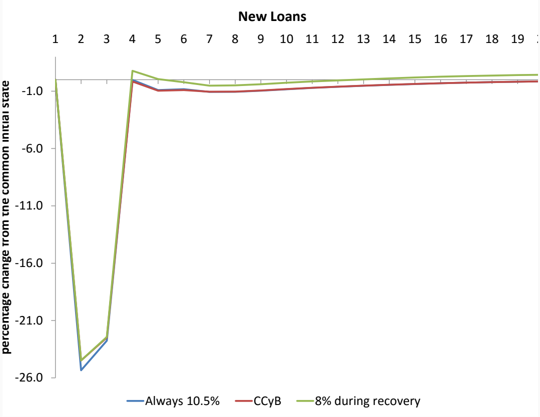


Ulterior Path of the Economies after the shock

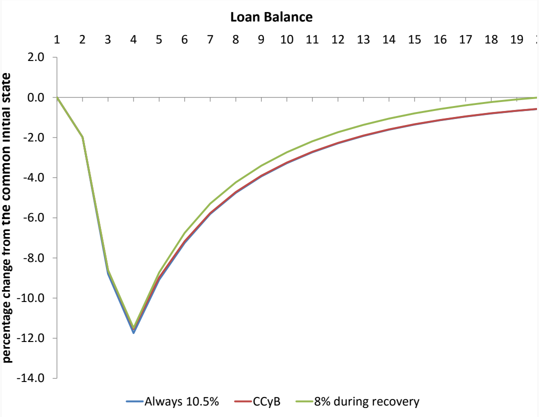
- Recall that it is a recession for two periods and then we have a recovery.
- We compare Countercyclical Capital Requirement with a constant weight to risk assests (left)and with a variable weight (right)
- We look at impulse responses

New Lending

Small difference between non-contingent policy and CCyB during the downturn. CCyB (if low capital requirement extends for a longer period) provides some help during the recovery.

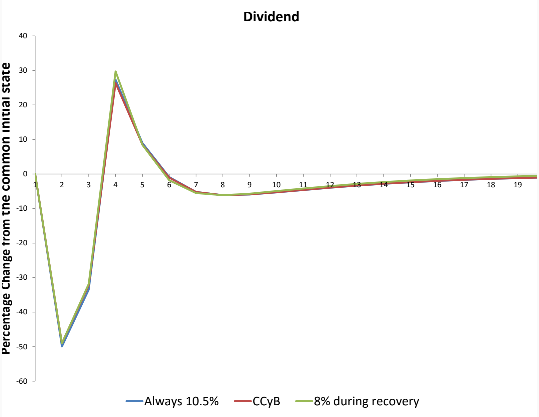


Stock of Loans



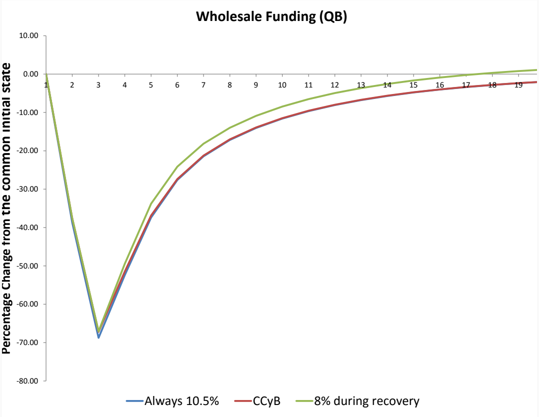
- Almost no difference between non-contingent policy and CCyB

Dividends

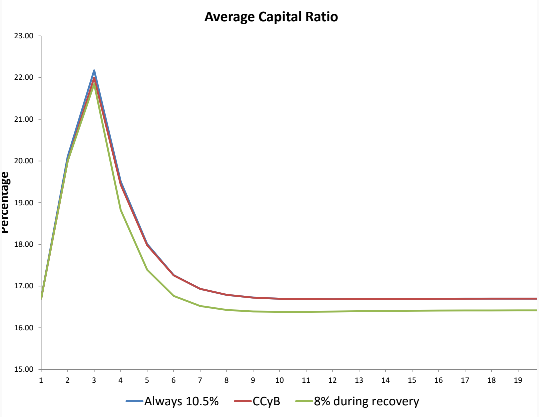


- Again almost no difference

Wholesale Funding

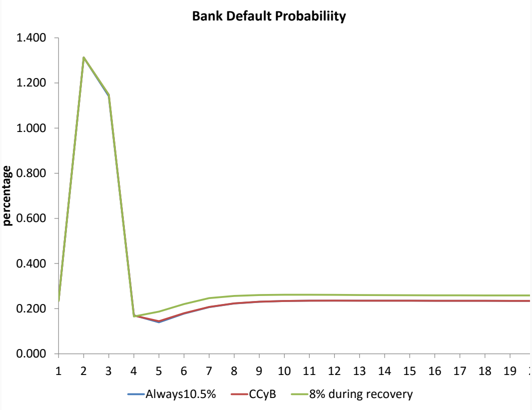


Capital Ratio

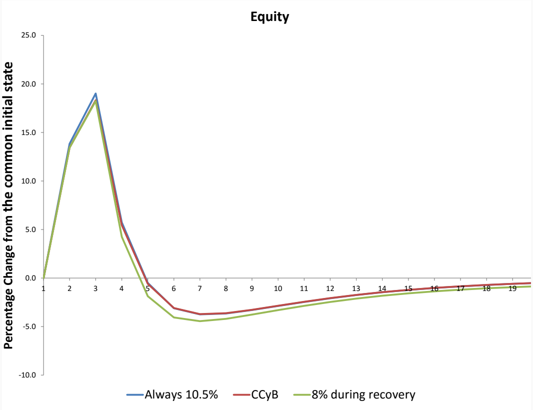


- Almost no difference, the capital ratios go up under both non-contingent and CCyB.

Bank Failure Rates

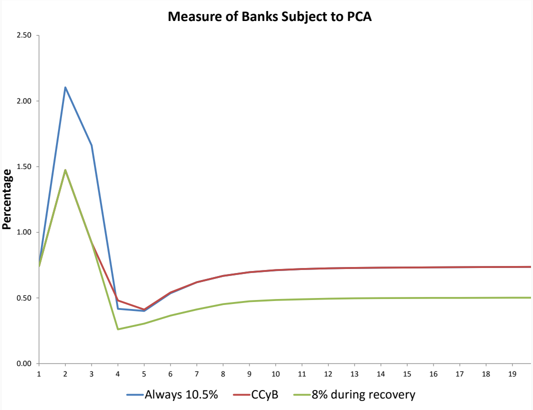


Bank Equity



- Own capital is somewhat affected.

Fraction of Capital Requirement Violation



- This is what the Counter Cyclical Capital Requirement directly does.

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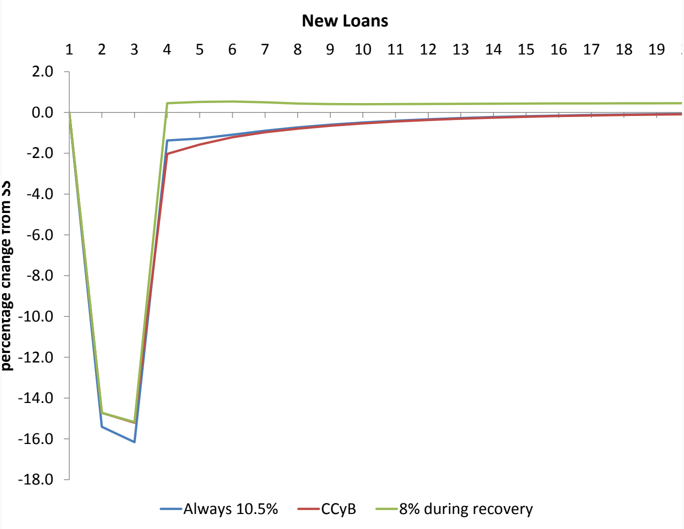
New Lending by Banks: with 8% Capital Requirement during Recovery



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- Households own shares of a mutual fund

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Representative Bank-Representative Household version of Dynamics and Capital Regulation

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Bank of Canada

May 25, 2017

1 Linear Costs for Banks

General Equilibrium Model

- There is a household sector with indivisible labor (many workers in a household).
- There is a banking sector that produces deposits' services and make loans with CRS.
- There is a productive sector with a putty clay technology.
- Otherwise it is a growth model.
- There may be shocks to TFP, to the destruction of new and old firms, and to the banking management losses.
- But we start lookng at a steady state

- Period utililty $u(c, n, d)$, where n is the fraction employed and d stands for deposits' services. Discount rate β.

- Deposits are created via matches with banks. We can think of a matching function with banks.

- A household has a measure one of workers that may or may not have a job. Employment in loan firms is n^{ℓ} while employment in equity firms is n^e, $n^{\ell} + N^e \leq 1$. A household member that does not work gets $\overline{c}$ units of utility consumption.

$$u(c, n, d) = \log c + (1 - n)b + v(d)$$

Investment and firms: Putty-Clay

- Firms create plants with one worker using loans in a putty-clay fashion $y = A\,k^{\alpha}$.
- There is free entry of these firms. Upon entry, firms (which are worth zero) join a mutual fund with their liabilities.
- With prob λ loans are paid off.
- All firms get destroyed with probability $\delta \sim \gamma_{\delta}$.
- Extensive margin: There are N^n new firms each period.
- Intensive margin: Each period firms invest k units.
- Total amount of new loans is $L^n = k * N^n$.
- The whole distribution of firms can be summarized by two aggregates (as in Choi and Ríos-Rull (2010) and others)
- Employment or the number of plants is

$$N' = (1 - \delta)N + N^n.$$

- Output is

$$Y' = (1 - \delta')Y + N^n\,A\,k^{\alpha}.$$

- Firms borrow at rate r^ℓ.

- The value a newly opened firm with capital k using the effective household interest rate r^b is

$$\frac{\Pi^f(k)}{1+r^b} = \frac{\left[Ak^\alpha - w(k) + \frac{1-\delta'}{1+r^b}\Pi^f(k)\right]}{1+r^b}$$

where $w(k)$ are wages and r^b is the market discount rate. So

$$\Pi^f(k) = \frac{1+r^b}{r^b+\delta}\left[Ak^\alpha - w(k)\right].$$

- The cost of a loan of size k is

$$\sum_{t=1}^{\infty} k\left[r^\ell + \frac{\lambda}{1-\lambda}\right]\left(\frac{1-\lambda}{1+r^b}\right)^t = k\left[r^\ell + \frac{\lambda}{1-\lambda}\right]\frac{1-\lambda}{r^b+\lambda}.$$

Investment decision

- So the optimal size satisfies

$$\max_k \quad \frac{Ak^\alpha - w(k)}{r^b + \delta} - k\left[r^\ell + \frac{\lambda}{1-\lambda}\right]\frac{1-\lambda}{r^b+\lambda}.$$

- With FOC

$$A\,\alpha\,k^{\alpha-1} - w_k(k) = \left[(1-\lambda)r^\ell + \lambda\right]\frac{r^b+\delta}{r^b+\lambda}.$$

- Firms enter until there are zero profits from doing so

$$\frac{Ak^\alpha - w(k)}{r^b + \delta} = k\left[r^\ell + \frac{\lambda}{1-\lambda}\right]\frac{1-\lambda}{r^b+\lambda}.$$

Firms Profits and loses

- Because upon creation firms are worth zero there is no need to worry about their value.
- Once created, firm's profits or loses go to the households who do not buy and sell firms and take those profits as given.
- Profits of all firms are

$$\pi^f = Y - W\ N - L[(1-\lambda)r^\ell + \lambda]$$

Wage Determination

- A bargaining process between the firm and the worker. V: (We may change this to get more wage rigidity and avoid the Shymer puzzle)

- The bargaining process is repeated every period and if unsuccesfull neither firm nor worker can partner with anybody else within a period. Let μ be the bargaining weight of the worker. Then, because of log utility, we have

$$w(k) = \mu\, A\, k^{\alpha} + (1-\mu)\frac{b}{c}$$

- Total (per capita) Labor Income paid in the Economy are

$$W\ N = N\left[\mu\, A\, k^{\alpha} + (1-\mu)\frac{b}{C}\right] = \mu Y + (1-\mu)\frac{Nb}{C}$$

Banking Industry I

- A CRS banking industry uses output to produce deposits and to make loans
- Loans are long term and decay at rate λ. Deposits are short term.
- It borrows and lends short term bonds B' at interest rate r^b.
- A fraction δ^ℓ of the loans are destroyed V: (Still have to discuss the relation between δ and δ^ℓ

$$
\begin{aligned}
D' &= \kappa_d Y^d \\
L^n &= \kappa_\ell Y^\ell \\
L' &= (1 - \delta'^\ell)(1 - \lambda)L + L^n
\end{aligned}
$$

- Banks cash position

$$A' = (\lambda + r^\ell(1 - \lambda))(1 - \delta'^\ell)L + r^\ell L^n - D'(1 + r^d) - B'(1 + r)$$

Banking Industry II

- Bank's Budget Constraint (π^B are dividends)

$$\pi^B + L^n \left(1 + \frac{1}{\kappa_\ell}\right) = A + B' + D' \left(1 - \frac{1}{\kappa_d}\right)$$

- Due to linearity of technology banks have zero steady state profits. $\pi^B = 0$.

- This is not the case outside steady state.

- Let $r^\ell(r^b)$ and $r^b(r^b)$ be the interest rates of bonds and deposits when the Capital Requirement constraint is not binding.

$$
\begin{aligned}
1+\frac{1}{\kappa_\ell} &= \sum_{t=1}^{\infty}\left[\frac{(1-\lambda)(1-\delta)}{1+r^b}\right]^{t-1}\left[(1-\lambda)r^\ell+\lambda\right] \\
r^d &= r^b-\kappa_d \\
r^\ell &= \left[\left(1+\frac{1}{\kappa_\ell}\right)\frac{r^b+\lambda+\delta-\lambda\delta}{(1+r^b)}-\lambda\right]\frac{1}{1-\lambda}
\end{aligned}
$$

- Households lend funds to banks at rate r^b. We call them bonds, B.

- Budget constraint of households

$$c + d' + b' = b(1 + r^b) + d(1 + r^d) + W\,n + \pi^f + \pi^b$$

Definition of a Steady-State Equilibrium

- Stocks: Y, N, $\Pi, A, B, L, D,$
- Choices: K, C, A', B', D', L^N, N^n, s.t.
- Prices $r^\ell, r^b, r^d, W, w(k)$
- Profits π^f, π^B

1. Plant sizes are optimal
2. Entry yields zero profits
3. Households solve their problem $r^b = \beta^{-1}$, $u_c = u_d \frac{1}{\kappa_d}$
4. Wages are determined by Nash bargaining
5. The choices imply that the stocks repeat themselves

Non-Steady-State Equilibrium: Shocks for $\eta = \{z, \delta, \delta^\ell\}$

- As is standard in putty-clay models, there is no need to keep track of the whole distribution of firms. Only of output and number of plants/workers. The aggregate state vector S consists of
  - The shocks η
  - Y Output
  - N Employment or number of plants
  - A Banks Cash
  - B Bonds
  - D Deposits
  - L Loans
- Households also have an idiosyncratic state vector $s = \{b, d, n\}$.

Household Problem

$$v(S,s) = \max_{c,b',d'} \quad u(c,d,n) + \beta E\left\{v(S',s')|S,s\right\} \qquad \text{s.t.}$$

$$\begin{aligned}
c + d' + b' &= b[1+r^b(S)] + d[1+r^d(S)] + W(S)\,n + \pi^f(S) + \pi^b(S) \\
N'(S) &= (1-\delta')N + N^n(S) \\
n'(S,s) &= (1-\delta')n(S,s) + N^n(S) \\
Y'(S) &= (1-\delta')Y + N^n(S)\; z\; A\; k(S)^\alpha \\
L'(S) &= (1-\delta'^{\ell})(1-\lambda)L + L^n(S) \\
A'(S) &= A'(S) \\
B'(S) &= B'(S) \\
D'(S) &= D'(S)
\end{aligned}$$

- With solution $d'(S,s)$ and $b'(S,s)$, as well as $v(S,s)$

- The value of firms with loans Π^ℓ and of firms without loans Π^e is

$$\begin{aligned}\Pi^\ell(S,k) &= zAk^\alpha - w(S,k) - kr^\ell(S) + \\ &\qquad \mathrm{E}\left\{(1-\delta')\frac{(1-\lambda)\Pi^\ell(S',k)+\lambda\left[\Pi^e(S',k)-k\right]}{1+r^b(S')} \;\middle|\; S\right\} \\ \Pi^e(S,k) &= zAk^\alpha - w(S,k) + \mathrm{E}\left\{(1-\delta')\frac{\Pi^e(S',k)}{1+r^b(S')} \;\middle|\; S\right\}\end{aligned}$$

- The cost of a loan of size k is $\mathrm{E}\left\{\frac{kr^\ell(S')+\frac{\Phi(S'',k)}{1+r^b(S'')}}{1+r^b(S')} \;\middle|\; S\right\}$

$$\Phi(S,k) = k[(1-\lambda)r^\ell + \lambda] + (1-\lambda)\,\mathrm{E}\left\{\frac{(1-\delta'^\ell)\Phi(S',k)}{1+r^b(S')} \;\middle|\; S\right\}$$

Firms' Problem II

- So the optimal size satisfies

$$\max_k \ \mathrm{E}\left\{ \frac{\Pi^\ell(S', k)}{1 + r^b(S')} - \frac{kr^\ell(S') + \frac{\Phi(S'', k)}{1+r^b(S'')}}{1 + r^b(S')} \;\middle|\; S \right\}$$

- V: COMPUTE THE FOC

- Firms enter until there are zero profits from doing so

$$\mathrm{E}\left\{ \frac{\Pi^\ell(S', k)}{1 + r^b(S')} \;\middle|\; S \right\} = \mathrm{E}\left\{ \frac{kr^\ell(S') + \frac{\Phi(S'', k)}{1+r^b(S'')}}{1 + r^b(S')} \;\middle|\; S \right\}$$

Recursive Competitive Equilibrium

- Laws of motion $N'(S), Y'(S), L'(S), B'(S), D'(S)$,
- Decision rules and value functions for households $d'(S,s)$, $b'(S,s)$, and $v(S,s)$, and firms $k(S), N^n(S), \Pi^\ell(S), \Pi^e(S)$.
- Prices $r^b(S), r^\ell(S), r^d(S), w(S,k), W(S)$, and Profits $\pi^f(S)$, $\pi^B(S)$

1. Households and Firms solve their problems
   1.1 Euler equation of Households $u_c(S) = \mathrm{E}\{\beta(1+r^b(S'))u_c(S') \mid S\}$.
   1.2 Marginal utility of deposits equals $\mathrm{E}\left\{\frac{r^b(S')-r^d(S')}{1+r^b(S')} \;\middle|\; S\right\}$
   1.3 Optimal choice of k
2. Rep Agent: $B'(S) = b'(S, s(S))$, $D'(S) = D'(S, s(S))$, $n'(S, s(S)) = N'(S)$.
3. Interest rates yield zero expected profits to banks
4. Realized profits are

$$\begin{aligned} \pi^f(S) &= zY - N\,W - L[(1-\lambda)r^b + \lambda L] \\ \pi^B(S) &= A - (1-\lambda)(1-\delta)L \end{aligned}$$

5. Wages are set by Nash bargaining.

2 Non-linear Costs for Banks

Banking Industry I

- Banks use output to produce deposits and to make loans, $d' = \kappa_d y^d$ and $\ell^n = \kappa_\ell y^\ell$.
- Loans are long term and decay at rate λ. Deposits are short term.
- It borrows and lends short term bonds B' at interest rate r^b.
- A random fraction δ^ℓ of the loans are destroyed. There are increasing costs with that destruction: $\ell' = (1 - \delta'^\ell)(1 - \lambda)\ell + \ell^n$
- Banks cash position

$$a' = (\lambda + r^\ell(1 - \lambda))(1 - \delta^\ell)\ell + r^\ell \ell^n - d'(1 + r^d) - b'(1 + r^b) - \xi(\delta^\ell)\ell$$

- There is a capital requirement

$$\frac{\ell + \ell^n - d' - b'}{\ell + \ell^n} \geq \theta$$

- There is curvature in the bank's dividends $\Phi(m)$

$$\Omega(S, a, \ell) = \max_{d', b', \ell^n} \Phi \left[a - \ell^n \left(1 + \frac{1}{\chi_\ell} \right) + d' \left(1 - \frac{1}{\chi_\ell} \right) + b' \right] + \\ + \mathrm{E} \left\{ \frac{\Omega[S', a'(S'), \ell'(S')]}{1 + r^b(S')} \;\middle|\; S \right\} \qquad \text{s.t.}$$

$$\begin{aligned} a'(S') &= (\lambda + r^\ell(S')(1-\lambda))(1-\delta^\ell)\ell + r^\ell(S')\ell^n - \\ &\qquad d'[1 + r^d(S')] - b'[1 + r^b(S')] - \xi(\delta^\ell)\ell \end{aligned}$$

$$\ell'(S') = \left(1 - \delta'^\ell\right)(1-\lambda)\ell + \ell^n$$

$$\theta \leq \frac{\ell + \ell^n - d' - b'}{\ell + \ell^n}$$

First order conditions

- Dividends and bonds interest rates are linked mechanically as they are perfect substitutes for banks. Wrt new loans ℓ^n we have

$$-\Phi_m\left(1+\frac{1}{\chi_\ell}\right)+\mathrm{E}\left\{\frac{r^\ell\Omega_2'+\Omega_3'}{1+r^b(S')}\right\}+\mu(KREQ)=0$$

- WRT bonds we have

$$\Phi_m-\mathrm{E}\{\Omega_2'\}-\mu(KREQ)=0$$

- The envelope conditions tell us that

$$\begin{aligned}\Omega_2 &= \phi_m+\frac{\partial\ell^n}{\partial a}\left[\phi_m\left(1+\frac{1}{\chi_\ell}\right)+\mathrm{E}\left\{\frac{r^\ell\Omega_2'+\Omega_3'}{1+r^b(S')}\right\}+\mu(KREQ)\right]\\ \Omega_3 &= \mathrm{E}\big\{(\lambda+r^\ell(S')(1-\lambda))(1-\delta^\ell)-\xi(\delta^\ell)\big\}+\mathrm{E}\big\{(1-\delta'^\ell)(1-\lambda)\Omega_3'\big\}\end{aligned}$$

- Let $r^\ell(r^b)$ and $r^b(r^b)$ be the interest rates of bonds and deposits when the Capital Requirement constraint is not binding.

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\end{aligned}
$$

Model: An Extension Shadow Banking

- Brought to center stage by the troubles of Home Capital in Canada

Return

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- No deposits ($\xi_d = 0$), just bonds, but particularly good at issuing high risk loans.

◂ Return

Model: An Extension Shadow Banking

- Brought to center stage by the troubles of Home Capital in Canada
- No deposits ($\xi_d = 0$), just bonds, but particularly good at issuing high risk loans.
- The only thing to add is a distinction between low and high risk loans.

Return

Model: An Extension Shadow Banking

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◂ Return

Model: An Extension Shadow Banking

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◂ Return