Capital Requirements in a Quantitative Model of Banking Industry Dynamics

Dean Corbae Pablo D'Erasmo[1]

Wisconsin and NBER FRB Philadelphia

March 28, 2019

In loving memory of Enrique Kawamura

[1]The views expressed here do not necessarily reflect those of the FRB Philadelphia or The Federal Reserve System.

Introduction

- The banking industry is highly concentrated. During the last 30 years the number of banks has fallen in half and the Top 10 share of assets has doubled. Figure
- There is a large empirical literature on the relation between banking concentration and stability.
- The last financial crisis triggered several changes in banking regulation.
- We develop a quantitative model of banking industry dynamics with imperfect competition to study how policy (e.g. capital requirements) affects bank lending by big and small banks, loan rates, exit/entry, and market structure in the commercial banking industry.

Main Question

- How much does a rise in capital requirements (4%$\rightarrow$8.5% as proposed by Basel III) affect failure rates and market shares of large and small banks in the U.S.?

Main Question

- How much does a rise in capital requirements (4%→8.5% as proposed by Basel III) affect failure rates and market shares of large and small banks in the U.S.?

Answer

- We find that higher capital requirements can have an important impact on the banking industry market structure
  - Leads to higher concentration due to a reduction in lending by small banks
  - Higher failure rates for small banks (selection) increase the cost of credit but improve allocative efficiency
  - Large short-term losses and modest long-term welfare gains for hh's

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.
   - Test model against other moments: (1) business cycle correlations, (2) the bank lending channel, (3) competition-stability regressions.

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.
   - Test model against other moments: (1) business cycle correlations, (2) the bank lending channel, (3) competition-stability regressions.

3. Capital Requirement Policy Counterfactuals:

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.
   - Test model against other moments: (1) business cycle correlations, (2) the bank lending channel, (3) competition-stability regressions.

3. Capital Requirement Policy Counterfactuals:
   - Basel III CR rise from 4% to 8.5%

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.
   - Test model against other moments: (1) business cycle correlations, (2) the bank lending channel, (3) competition-stability regressions.

3. Capital Requirement Policy Counterfactuals:
   - Basel III CR rise from 4% to 8.5%
   - Size dependent CR (add 2% to big banks)

Outline

1. Data: Document U.S. Banking Facts from Balance sheet and Income Statement Panel Data.

2. Model:
   - Underlying static Cournot banking model with exogenous bank size distribution is from Allen & Gale (2004), Boyd & De Nicolo (2005)).
   - Endogenize bank size distribution by adding shocks and dynamic entry/exit decisions. Solve for industry equilibrium along the lines of Ericson & Pakes (1995) and Gowrisankaran & Holmes (2004).
   - Calibrate parameters to match long-run industry averages.
   - Test model against other moments: (1) business cycle correlations, (2) the bank lending channel, (3) competition-stability regressions.

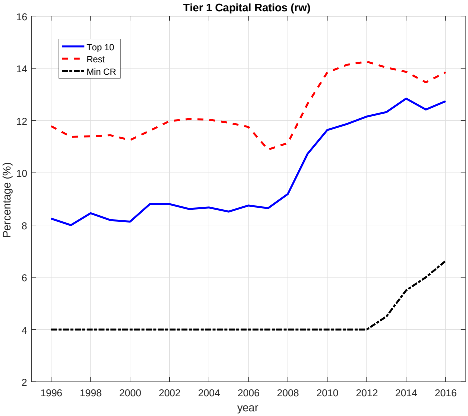
3. Capital Requirement Policy Counterfactuals:
   - Basel III CR rise from 4% to 8.5%
   - Size dependent CR (add 2% to big banks)
   - Countercyclical CR (add 2.5% in good states for big banks)

4. Liquidity Requirement Policy Counterfactual

U.S. Data Summary from C-D (2013)

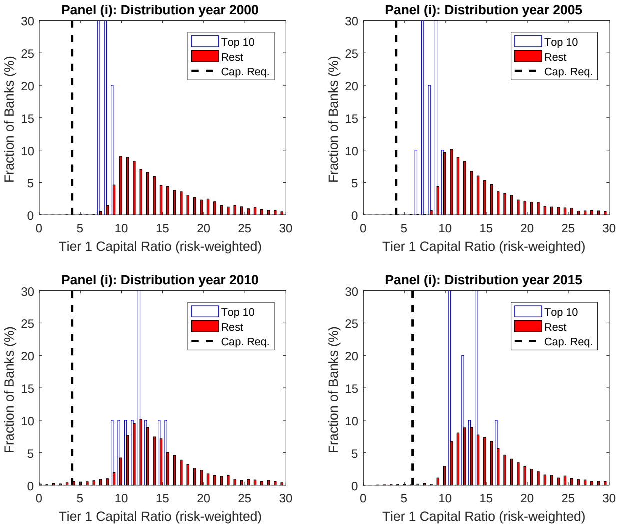
- Entry is procyclical and Exit by Failure is countercyclical. ▸ Fig Almost all Entry and Exit is by small banks. ▸ Table
- Loans and Deposits are procyclical (correl. with GDP equal to 0.41 and 0.07 respectively). Bigger banks have less volatile funding inflows (implications for buffers). ▸ Table
- High Concentration: Top 10 have 52% of loan share.
- Signs of Noncompetitive Behavior: Large Net Interest Margins, Markups, Lerner Index, Rosse-Panzar $H < 100$. ▸ Table
- Signs of Geographic Diversification: Loan returns are decreasing in bank size but volatility is increasing.
- Net marginal expenses increase, Fixed operating costs (normalized) decrease, Average costs decrease with bank size (IRS). ▸ Table
- Loan Returns, Margins, Markups, Delinquency Rates and Charge-offs are countercyclical. ▸ Table

Capital Ratios by Bank Size

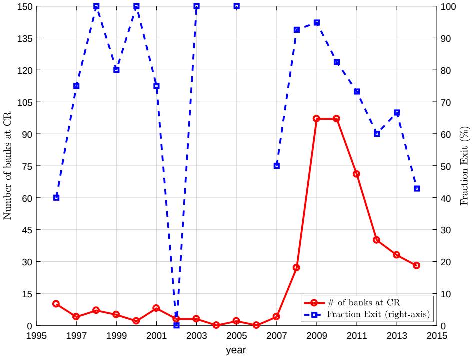


- Risk weighted capital ratios ((loans+net assets-deposits)/loans) are larger for small banks. Balance Sheet (by size)
- On average, capital ratios are above what regulation defines as "Well Capitalized" ($\geq 6\%$) suggesting a precautionary motive.

Distribution of Bank Capital Ratios



Undercapitalized bank exit



- Number of small U.S. banks below minimum capital requirement rose dramatically during crisis and most exited.

Model Essentials

- Banks intermediate between

Model Essentials

- Banks intermediate between
  - Measure $N > 1$ mass of identical risk neutral households who are offered insured bank deposit contracts or outside storage technology (Deposit supply). Insurance funded by lump sum transfers. hh problem

Model Essentials

- Banks intermediate between
  - Measure $N > 1$ mass of identical risk neutral households who are offered insured bank deposit contracts or outside storage technology (Deposit supply). Insurance funded by lump sum transfers. ▸ hh problem
  - Unit mass of identical risk neutral borrowers who demand funds to undertake i.i.d. risky projects (Loan demand). ▸ Borrowers

Model Essentials

- Banks intermediate between
  - Measure $N > 1$ mass of identical risk neutral households who are offered insured bank deposit contracts or outside storage technology (Deposit supply). Insurance funded by lump sum transfers. ▸ hh problem
  - Unit mass of identical risk neutral borrowers who demand funds to undertake i.i.d. risky projects (Loan demand). ▸ Borrowers
  - Banks diversify failure risk and can more efficiently minimize costly monitoring along the lines of Diamond (1984). Households hold bank shares.

Model Essentials

- Banks intermediate between
  - Measure $N > 1$ mass of identical risk neutral households who are offered insured bank deposit contracts or outside storage technology (Deposit supply). Insurance funded by lump sum transfers. hh problem
  - Unit mass of identical risk neutral borrowers who demand funds to undertake i.i.d. risky projects (Loan demand). Borrowers
  - Banks diversify failure risk and can more efficiently minimize costly monitoring along the lines of Diamond (1984). Households hold bank shares.
  - Loan market clearing determines interest rate $r_t^L(\mu_t, z_t)$ where μ_t is the cross-sectional distribution of banks and z_t are beginning of period t shocks.

Model Essentials

- Banks intermediate between
  - Measure $N > 1$ mass of identical risk neutral households who are offered insured bank deposit contracts or outside storage technology (Deposit supply). Insurance funded by lump sum transfers. ▸ hh problem
  - Unit mass of identical risk neutral borrowers who demand funds to undertake i.i.d. risky projects (Loan demand). ▸ Borrowers
  - Banks diversify failure risk and can more efficiently minimize costly monitoring along the lines of Diamond (1984). Households hold bank shares.
  - Loan market clearing determines interest rate $r_t^L(\mu_t, z_t)$ where μ_t is the cross-sectional distribution of banks and z_t are beginning of period t shocks.
- Shocks to loan performance and bank financing along with entry and exit induce an endogenous distribution of banks of different sizes.

Model Essentials - cont.

Deviations from Modigliani-Miller for Banks (influence costly exit):

- Limited liability and deposit insurance (moral hazard)
- Equity finance and bankruptcy costs
- Bank agency costs
- Noncontingent loan contracts
- Market power by a subset of banks

Stochastic Processes

- Aggregate Technology Shocks $z_{t+1} \in Z = \{z_C, z_B, z_M, z_G\}$ follow a Markov Process $F(z_{t+1}, z_t)$ with $z_C < z_B < z_M < z_G$ (business cycle).
- Conditional on z_{t+1}, project success shocks are iid across borrowers drawn from $p(R_t, z_{t+1})$ (non-performing loans).
- "Funding shocks" (capacity constraint on deposits) which are iid across banks given by $\delta_{\theta,t} \in \{\underline{\delta}, \ldots, \overline{\delta}\} \subseteq \mathbb{R}_{++}$ follow a Markov Process $G_\theta(\delta_{\theta,t+1}, \delta_{\theta,t})$ (buffer stock).

Banks

- There are two types of banks: $\theta \in \{b, f\}$, a representative big bank and small banks that we call "fringe" (as in G-H (2004)).
- The big bank is a Stackelberg leader in the loan market, each period choosing a level of loans before fringe banks make their choice of loan supply.
- At the beginning of each period, after the realization of z_t; the cash flows $\pi^i_{\theta,t}$ for bank i of type θ are realized from
  - its previous lending $\ell^i_{\theta,t}$ at rate r^L_t (fraction $p(R_{t-1}, z_t)$)
  - liquid assets (cash and securities) $A^i_{\theta,t}$ at rate r^a_t
  - and deposits $d^i_{\theta,t}$ at rate r^D_t,

$$\pi^i_{\theta,t+1} = \Big\{p(R_t, z_{t+1})r^L_t - (1 - p(R_t, z_{t+1}))\lambda\Big\}\ell^i_{\theta,t+1} + r^a_t A^i_{\theta,t+1} - r^D_t d^i_{\theta,t+1}.$$

- The incumbent is randomly matched with a set of potential depositors $\delta^i_{\theta,t+1}$ and the bank chooses $d^i_{\theta,t+1} \leq \delta^i_{\theta,t+1}$

Banks (cont.)

- Along with possible equity injections ($e^i_{\theta,t} \in \mathbb{R}_+$), an incumbent bank allocates its net worth $n^i_{\theta,t}$ and deposits to its asset portfolio and pays dividends ($\mathcal{D}^i_{\theta,t} \in \mathbb{R}_+$).

$$n^i_{\theta,t}+d^i_{\theta,t+1}+e^i_{\theta,t} \geq \ell^i_{\theta,t+1}+A^i_{\theta,t+1}+\mathcal{D}^i_{\theta,t}+\zeta_\theta(e^i_{\theta,t}, z_t)+\kappa^i_\theta+c^i_\theta\left(\ell^i_{\theta,t+1}\right)$$

Banks (cont.)

- Along with possible equity injections ($e^i_{\theta,t} \in \mathbb{R}_+$), an incumbent bank allocates its net worth $n^i_{\theta,t}$ and deposits to its asset portfolio and pays dividends ($\mathcal{D}^i_{\theta,t} \in \mathbb{R}_+$).

$$n^i_{\theta,t}+d^i_{\theta,t+1}+e^i_{\theta,t} \geq \ell^i_{\theta,t+1}+A^i_{\theta,t+1}+\mathcal{D}^i_{\theta,t}+\zeta_\theta(e^i_{\theta,t}, z_t)+\kappa^i_\theta+c^i_\theta\left(\ell^i_{\theta,t+1}\right)$$

- Beginning-of-next-period equity/net worth is given by

$$\begin{aligned} n^i_{\theta,t+1} &= \underbrace{\pi^i_{\theta,t+1}+\ell^i_{\theta,t+1}+A^i_{\theta,t+1}}_{Assets} - \underbrace{d^i_{\theta,t+1}}_{Liabilities} \\ &= n^i_{\theta,t} + \underbrace{\pi^i_{\theta,t+1} - \mathcal{D}^i_{\theta,t} + e^i_{\theta,t} - \zeta_\theta(e^i_{\theta,t}, z_t) - \kappa^i_\theta - c^i_\theta\left(\ell^i_{\theta,t+1}\right)}_{\text{ret. earnings+equity injection}} \end{aligned}$$

Banks - Policy Constraints

- When making loans, buying securities and accepting deposits at the beginning of period t, banks face a capital requirement that they expect to have sufficient equity in the following period:

$$
\begin{aligned}
E_t[n^i_{\theta,t+1}] = \quad & \ell^i_{\theta,t+1} + A^i_{\theta,t+1} + E_t[\pi^i_{\theta,t+1}] - d^i_{\theta,t+1} \\
& \geq \varphi_{\theta,t}(w^{\ell}_{\theta,t}\ell^i_{\theta,t+1} + w^A_{\theta,t}(A^A_{\theta,t+1} + E_t[\pi^i_{\theta,t+1}]))
\end{aligned}
$$

- Liquidity requirement[2]:

$$
\varrho_{\theta,t} d^i_{\theta,t+1} \leq A^i_{\theta,t+1} + \pi^i_{\theta,t+1}(z_C),
$$

[2] Liquid assets to meet banks' 100% outflow needs (deposits/funding) for a 30 calendar day under a stress scenario

Banks (cont.)

- Banks can choose to exit any period. There is limited liability on the part of banks.

$$V_\theta^x(n^i_{\theta,t+1}, \ell^i_{\theta,t+1}) = \max\left\{ n^i_{\theta,t+1} - \xi \ell^i_{\theta,t+1}, 0 \right\},$$

- The objective of the bank is ▸ Bank Problem

$$E_t\left[\sum_{s=0}^{\infty} (\gamma\beta)^s \left(\mathcal{D}^i_{\theta,t+s} - e^i_{\theta,t+s}\right)\right]$$

  where manager's discount factor can depart from the households' discount factor β by the factor $\gamma \in (0,1]$

- Entry costs for the creation of banks are denoted by $\Upsilon_b > \Upsilon_f$ ▸ Entrant's Problem

▸ Bank Size Distribution

Defn. Markov Perfect Industry EQ

Given policy parameters $(r^a, \varphi_{\theta,z}, w^{\ell}_{\theta,z}, w^{A}_{\theta,z}, \varrho_{\theta,z})$, a pure strategy Markov Perfect Industry Equilibrium (MPIE) is:

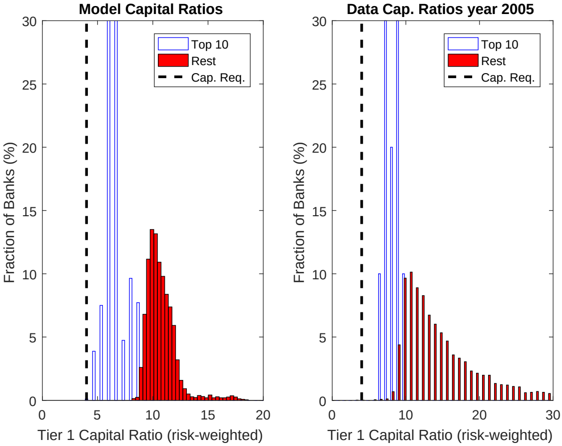
1. Given r^L, loan demand $L^d(r^L, z)$ is consistent with borrower optimization.
2. Given $r^D = \overline{r}$ and P_θ, $\{a'_h, d'_h, S'_\theta\}$ are consistent with household optimization
3. Bank loan, deposit, net security holding, exit, and dividend payment functions are consistent with bank optimization.
4. The law of motion for the cross-sectional distribution of banks $\mu' = H(z, \mu, z', M'_e)$ is consistent with bank entry and exit decision rules.
5. The interest rate $r^L(\mu, z)$ is such that the loan market clears.
6. Across all states, taxes cover deposit insurance.

▸ timing ▸ Computation ▸ Decision Rules

▸ Calibration

Tests of the Model

Distribution of Capital Ratios



- As in the previous data Figures, model is consistent with capital buffer decreasing in bank size. ▸ Dist n'_{θ}

Test I: Untargeted Business Cycle Correlations

Variable Correlated with Output	Data	Model
Loan Interest Rate	-0.23	-10.83
Exit Rate	-0.12	-22.51
Entry Rate	0.70	0.18
Loan Supply	0.54	0.88
Deposits	0.29	0.46
Default Frequency	-0.65	-0.49
Charge Off Rate	-0.72	-0.49
Price Cost Margin Rate	-0.36	-0.31
Markup	-0.31	-0.31

- The model does a good qualitative job with the business cycle correlations.

Test II: Monetary Transmission Mechanism

- Kashyap and Stein ((95) and (01)) studied whether the impact of Fed policy on lending behavior is stronger for big or small banks.
- The idea is consistent with a failure of the MM theorem:
  - Banks with lower costs of external funding or more liquid balance sheets should be better able to buffer their lending activity against adverse shocks (e.g. rises in the Fed Funds rate).
- They find strong evidence that small banks cut lending more than big banks in the presence of contractionary shocks.
- Our model is largely consistent with this evidence Table Elasticities Table Moments

Test III: Empirical Studies
Competition-Stability Tradeoff

Model	Logit	Linear
Dependent Variable	Crisis_{t+1}	$\text{Default Freq.}_{t+1}$
Concentration_t	-9.436	0.057
	(0.223)***	(0.001)***
GDP growth in t	-16.098	0.013
	(3.425)***	(0.006)***
$\text{Loan Supply Growth}_t$	-13.381	0.010
	(2.528)***	(0.009)
R^2	0.72	0.58

Note: SE in parenthesis. R^2 refers to Pseudo R^2 in the logit model. *** Statistically significant at 1%, ** at 5% and * at 10%.

- As in Beck, et. al. (2003), banking system concentration (market share of top 10) is negatively related to the probability of a banking crisis (e.g. 2xhigher exit rate) (consistent with A-G).
- As in Berger et. al. (2008) we find that concentration is positively related to default frequency (consistent with B-D).

Counterfactuals

Higher Capital Requirements

Question: How much does an increase of capital requirements (from 4% to 8.5% as in Basel III) affect short and long run outcomes?

▸ Table CR

- Higher cap. req. $\rightarrow$ big banks raise equity issuance and lower dividends in order to fund lending while small banks lower lending and unprofitable ones exit (leads to selection effects).
- Exit/Entry increases $\rightarrow$ more concentrated industry (fringe bank market share falls (SR:-9%, LR:-5%)).
- Lower loan supply (SR:-9%, LR: -3%) $\rightarrow$
  - higher interest rates (SR:+75 BP, LR:+28 BP),
  - higher markups (SR: $+47\%$, LR:$+33\%$),
  - more chargeoffs (SR: $+1\%$, LR: $+4\%$)
- Despite lower intermediated output, lower taxes per output in long run(SR: $+80\%$, LR: -25%).

▸ Table Zero CR

Size Dependent Capital Requirements

Question: What if capital requirements are higher for big banks than for small banks (i.e. $\varphi_\theta = 0.04) \rightarrow (\varphi_b = 0.11, \varphi_f = 0.085)$)? Table

- Unlike other cases, big bank decreases loan supply in the short run as well as small banks.
- As in other cases, exit by poorly funded small banks (selection) and similar rise in loan interest rates.
- A 1% increase in small bank market share (due to higher capital req. on big banks).

Countercyclical Capital Requirements

Question: What if capital requirements are higher in good times (i.e. $\varphi = 0.04) \rightarrow (\varphi_{f,z} = 0.085,\ \varphi_{b,z} \in [0.085, 0.11]))$? ▸ Table CCR

- Unlike the previous case, big banks increase their lending
- As in baseline, we observe an increase in exit by poorly funded small banks (selection) that leads to lower loan supply and higher interest rates (SR: +100 BP, LR: +55 BP).
- More concentration: (SR: -14%, LR: -13%) decline in small bank market share.
- Despite drop in intermediated output, long run taxes/output drop 62%.

Liquidity Requirements

Question: What are the aggregate and industry consequences of imposing liquidity requirements (i.e. $\varrho_\theta = 0) \rightarrow (\varrho_\theta = 0.08)$)? ▸ Table

- Bank exit decreases and the loan interest rate increases slightly (SR: 34 BP, LR: 26 BP).
- Taxes/output decline 32%.
- Larger increase in concentration (7.3% drop in small bank market share) than in capital requirement counterfactual.

Conclusion

- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.

Conclusion

- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.
- Countercyclical interest margins provide a new amplification mechanism; in a downturn, exit weakens competition $\rightarrow$ higher loan rates, amplifying the downturn.

Conclusion

- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.
- Countercyclical interest margins provide a new amplification mechanism; in a downturn, exit weakens competition $\rightarrow$ higher loan rates, amplifying the downturn.
- We find that a rise in capital requirements from 4% to 8.5% leads to a significant long run reduction in the costs of bank failure, but a more concentrated industry and higher interest rates

Conclusion

- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.
- Countercyclical interest margins provide a new amplification mechanism; in a downturn, exit weakens competition $\rightarrow$ higher loan rates, amplifying the downturn.
- We find that a rise in capital requirements from 4% to 8.5% leads to a significant long run reduction in the costs of bank failure, but a more concentrated industry and higher interest rates
- Strategic interaction between big and small banks generates lower volatility than a perfectly competitive model.

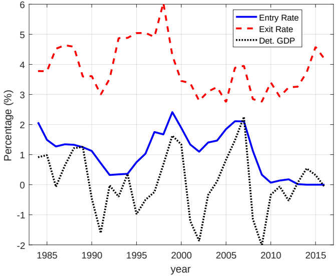
Conclusion

- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.
- Countercyclical interest margins provide a new amplification mechanism; in a downturn, exit weakens competition $\rightarrow$ higher loan rates, amplifying the downturn.
- We find that a rise in capital requirements from 4% to 8.5% leads to a significant long run reduction in the costs of bank failure, but a more concentrated industry and higher interest rates
- Strategic interaction between big and small banks generates lower volatility than a perfectly competitive model.
- Policy changes that lead to an increase in concentration also improve allocative efficiency table

Conclusion

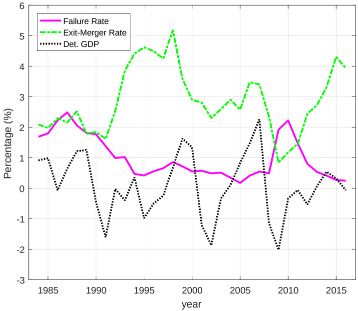
- First paper to pose a structural dynamic model with imperfect competition in the loan market and an endogenous bank size distribution to assess the quantitative significance of capital and liquidity requirements.
- Countercyclical interest margins provide a new amplification mechanism; in a downturn, exit weakens competition $\rightarrow$ higher loan rates, amplifying the downturn.
- We find that a rise in capital requirements from 4% to 8.5% leads to a significant long run reduction in the costs of bank failure, but a more concentrated industry and higher interest rates
- Strategic interaction between big and small banks generates lower volatility than a perfectly competitive model.
- Policy changes that lead to an increase in concentration also improve allocative efficiency table
- Increasing capital requirements lead to sizable welfare losses (CE) in the short run and a moderate increase in the long table

Entry and Exit Over the Business Cycle



- Trend in exit rate prior to mid 90's due to deregulation
- Correlation of GDP with (Entry,Exit) =(0.69,0.43); with (Failure, Troubled, Mergers) =(-0.16, -0.72, 0.49) ▸ Exit Rate Decomposed ▸ Return

Exit Rate Decomposed



- Correlation of GDP with (Failure, Troubled, Mergers) =(-0.16, -0.72, 0.49)

Return

Entry and Exit by Bank Size

Fraction of Total x, Accounted by (%):	x Entry (denovo)	Exit (merger)	Exit (failure)
Top 10 Banks	0.00	0.05	0.00
Top 35 Banks	0.04	0.42	0.02
Top 36-236	2.95	4.28	2.78
Rest	97.01	95.29	97.20

Fraction of Assets of Banks in x, Accounted by (%):	x Entry (denovo)	Exit (merger)	Exit (failure)
Top 10 Banks	0.00	4.41	0.00
Top 35 Banks	6.61	23.88	1.77
Top 36-236	20.29	39.01	20.88
Rest	73.11	37.11	77.34

- Most entry and failure accounted by small banks
- Several medium/large size banks involved in exit via merger

Return

Borrowers - Loan Demand

- Risk neutral borrowers demand bank loans in order to fund a project/buy a house.
- Project requires one unit of investment at start of t and returns

$$\begin{cases} 1 + z_{t+1} R_t & \text{with prob } p(R_t, z_{t+1}) \\ 1 - \lambda & \text{with prob } 1 - p(R_t, z_{t+1}) \end{cases} .$$

- Borrowers choose R_t (return-risk tradeoff, i.e. higher return R, lower success probability p).
- Borrowers have limited liability.
- Borrowers have an unobservable outside option (reservation utility) $\omega_t \in [\underline{\omega}, \overline{\omega}]$ drawn at start of t from distribution $\Upsilon(\omega_t)$.

Return

Loan Market Outcomes

Borrower chooses R	Receive	Pay	Probability
Success	$1 + z_{t+1} R_t$	$1 + r^L(\mu_t, z_t)$	$p\left(\overset{-}{R_t}, \overset{+}{z_{t+1}}\right)$
Failure	$1 - \lambda$	$1 - \lambda$	$1 - p\left(R_t, z_{t+1}\right)$

- Aggregate demand for loans Borrower Prob.

$$L^d(r_t^L, z_t) = \int_0^{\overline{\omega}} \mathbf{1}_{\{\omega_t \leq E_{z_{t+1}|z_t} \pi_E(0, R_t, z_{t+1})\}} d\Omega(\omega_t),$$

Return

Borrower Decision Making

- Borrowers choose whether to operate the technology (ι_t), the type of technology (R_t), and whether to use retained earnings (I_{t+1}) and/or save ($a_{E,t+1}$):

$$\max_{\{C_{E,t}, a_{E,t+1}, I_{t+1}, \iota_t \in \{0,1\}, R_t\}_{t=0}^{\infty}} E_0 \left[\sum_{t=0}^{\infty} \beta_E^t C_{E,t} \right]$$

subject to

$$C_{E,t} + a_{E,t+1} + I_{t+1} = \iota_t(\omega_t + I_t) + (1 - \iota_t)\pi_E(I_t, R_t, z_{t+1}) + (1 + \overline{r})a_{E,t}$$

where

$$\pi_E(I_t, R_t, z_{t+1}) = \begin{cases} \max\{0, z_{t+1}R_t - r_t^L + (1 + r^L)I_t\} & \text{w prob } p(R_t, z_{t+1}) \\ \max\{0, -\lambda - r^L + (1 + r^L)I_t\} & \text{w prob } 1 - p(\cdot) \end{cases}$$

return

Borrower Decision Making (cont.)

- If $\beta_E(1+r^L) < 1$, the entrepreneur neither uses retained earnings nor saves.

- If the entrepreneur undertakes the project, then an application of the envelope theorem implies

$$\frac{\partial E_{z_{t+1}|z_t}\pi_E(I_t, R_t, z_{t+1})}{\partial r_t^L} = -E_{z_{t+1}|z_t}[p(R_t, z_{t+1})] < 0.$$

- Aggregate demand for loans is given by

$$L^d(r_t^L, z_t) = \int_0^{\overline{\omega}} \mathbf{1}_{\{\omega_t \leq E_{z_{t+1}|z_t}\pi_E(0,R_t,z_{t+1})\}} d\Omega(\omega_t),$$

return

Household Problem

- The problem of a representative household is

$$\max_{\{C_t, a_{h,t+1}, d_{h,t+1}, \{S^i_{\theta,t+1}\}_{\forall i}\}_{t=0}^{\infty}} E_0 \left[\sum_{t=0}^{\infty} \beta^t C_t \right]$$

subject to

$$C_t + a_{h,t+1} + d_{h,t+1} + \sum_{\theta} \int [P^i_{\theta,t} + \mathbf{1}_{\{e^i_{\theta,t}=1\}}(\Upsilon_\theta + n^i_{\theta,t})] S^i_{\theta,t+1} di$$

$$= \frac{1}{N} + \sum_{\theta} \int (\mathcal{D}^i_{\theta,t} - e^i_{\theta,t} + P^i_{\theta,t}) S^i_{\theta,t} di + (1+\overline{r}) a_{h,t} + (1 + r^d_t) d_{h,t} - \tau_t.$$

- The FOC for $S^i_{\theta,t+1}$ is:

$$P^i_{\theta,t} = \beta E_{z_{t+1}|z_t} \left[\mathcal{D}^i_{\theta,t+1} - e^i_{\theta,t+1} + P^i_{\theta,t+1} \right], \forall i.$$

return

Bank's Problem

- The value of an incumbent bank consistent with the manager's choice over $\{\{\ell'_\theta, A'_\theta, \mathcal{D}_\theta, e_\theta\} \geq 0, d_\theta \in [0, \delta_\theta], x'_\theta \in \{0,1\}\}$ is:

$$V_\theta(n_\theta, \delta_\theta; z, \mu, \cdot) = \max \Big\{ \mathcal{D}_\theta - e_\theta$$

$$+\gamma\beta E_{z'|z}\Big[\max_{x'_\theta \in \{0,1\}} \Big\{ (1-x'_\theta) E_{\delta'_\theta|\delta_\theta} V_\theta(n'_\theta, \delta'_\theta; z', \mu', \cdot) + x'_\theta V^x_\theta(n'_\theta, \ell'_\theta) \Big\} \Big] \Big\}$$

s.t.

$$\begin{aligned}
n_\theta + d'_\theta + e_\theta &\geq \ell'_\theta + A'_\theta + \mathcal{D}_\theta + \zeta_\theta(e_\theta, z) + [\kappa_\theta + c_\theta(\ell'_\theta)] \\
E[n'_\theta] &\geq \varphi_{\theta,z}(w^\ell_\theta \ell'_\theta + w^A_{\theta,z}(A'_\theta + E[\pi'_\theta])) \\
\varrho_{\theta,z} d'_\theta &\leq A'_\theta + \pi'_\theta(z' = z_C) \\
n'_\theta &= \pi'_\theta + \ell'_\theta + A'_\theta - d'_\theta \\
L^d(r^L, z) &= \ell'_\theta + L_f(z, \mu, \ell'_b) \\
\mu' &= H(z, \mu, z', M'_e),
\end{aligned}$$

return

Entrants' Problem

- Each period, there is a large number of potential type θ entrants.
- The value of entry (net of costs) is given by

$$V_\theta^e(z,\mu,z',M'_{e,\theta}) \equiv \max_{n'_{e,\theta}} \Big\{ -(n'_{e,\theta}+\Upsilon_\theta)(1+\zeta_\theta(n'_{e,\theta}+\Upsilon_\theta,z')) + E_{\delta'|\theta} V_\theta(n'_{e,\theta},\delta'_\theta,z',H(z,\mu,z',M'_{e,\theta}))\Big\}.$$

- Entry occurs as long as $V_\theta^e(z,\mu,z',M'_{e,\theta}) \geq 0$.
- Free entry implies that

$$V_\theta^e(z,\mu,z',M'_{e,\theta}) \times M'_{e,\theta} = 0$$

where $M'_{e,\theta}$ denotes the mass of entrants.

return

Timing

At the beginning of period t,

1. z_t is realized which induces $n^i_{\theta,t}$ for incumbent banks and project returns for entrepreneurs.
2. Incumbents decide whether to exit and potential entrants decide whether to enter which requires an initial equity injection in stage 3.
3. Funding shocks $\delta_{\theta,t+1}$ - the mass of potential depositors the bank is matched with - are realized and borrowers draw ω_t.
   - The dominant bank chooses $(\ell^i_{b,t+1}, d^i_{b,t+1}, A^i_{b,t+1}, \mathcal{D}^i_{b,t}, e^i_{b,t})$.
   - Each fringe bank observes the total loan supply of the dominant bank $(\ell^i_{b,t+1})$ and all other fringe banks (that jointly determine the loan interest rate r^L_t) and simultaneously decide $(\ell^i_{f,t+1}, d^i_{f,t+1}, A^i_{f,t+1}, \mathcal{D}^i_{f,t}, e^i_{f,t})$.
   - Borrowers choose whether or not to undertake a project requiring bank funding and, if so, a level of technology R_t.
   - Households pay taxes τ_t to fund deposit insurance, choose to store or deposit at a bank, how many stocks to hold, equity injections, and consume. ▸ τ

▸ DMPIE

Deposit Process Estimation

- Let $x^i_{\theta,t}$ be the sum of deposits and other borrowings for bank type θ.
- Regress $\log(x^i_{\theta,t})$ on firm and year fixed effects and a linear trend:

$$\log(x^i_{\theta,t}) = b^\theta_i + b^\theta_{2,t} + b^\theta_3 t + e^i_{\theta,t}$$

- Let $\log(\delta^i_{\theta,t}) = e^i_{\theta,t}$ and use Arellano and Bond to estimate the AR(1) for deposit shocks:

$$\log(\delta^i_{\theta,t}) = (1-\rho^d_\theta)k^\theta_0 + \rho^d_\theta \log(\delta^i_{\theta,t-1}) + u^i_{\theta,t}, \quad (1)$$

where $u^i_{\theta,t}$ is iid, distributed $N(0, \sigma_{u,\theta})$ and $\sigma_{d,\theta} = \frac{\sigma_{\theta,u}}{(1-(\rho^d_\theta)^2)^{1/2}}$.

- Discretize using Tauchen (1986) method with 5 states.
- Results:
  - Fringe: $\sigma_{u,f} = 0.156$, $\rho^d_f = 0.876 \Rightarrow \sigma_{d,f} = 0.325$
  - Top 10: $\sigma_{u,b} = 0.070$, $\rho^d_b = 0.405 \Rightarrow \sigma_{d,b} = 0.077$
- Bigger banks have less volatile funding inflows (implications for buffers).

Return Data Return Targets

Measures of Banking Competition

Moment	Value (%)	Std. Error (%)	Corr w/ GDP
Interest margin	4.69	0.34	-0.36
Markup	46.26	16.2	-0.31
Lerner Index	30.31	7.32	-0.25
Rosse-Panzar H	40.13	0.43	-

- All the measures provide evidence for imperfect competition (H< 100 implies MR insensitive to changes in MC).
- Estimates are in line with those found by Berger et.al (2008),Bikker and Haaf (2002), and Koetter, Kolari, and Spierdijk (2012).
- Countercyclical interest margins imply amplification of shocks to real side of the economy.

Definitions Return

Definition of Competition Measures

- The Interest Margin is defined as:

$$pr^{L}_{it} - r^{D}_{it}$$

where r^L realized real interest income on loans and r^D the real cost of loanable funds

- The markup for bank is defined as:

$$\text{Markup}_{tj} = \frac{p_{\ell_{tj}}}{mc_{\ell_{tj}}} - 1 \quad (2)$$

where $p_{\ell_{tj}}$ is the price of loans or marginal revenue for bank j in period t and $mc_{\ell_{tj}}$ is the marginal cost of loans for bank j in period t

- The Lerner index is defined as follows:

$$\text{Lerner}_{it} = 1 - \frac{mc_{\ell_{it}}}{p_{\ell_{it}}}$$

Return

Costs by Bank Size

Table: Period 1984 - 2007

Moment (%)	Mg Non Int Inc. $c_\theta^{inc}(\ell'_\theta)$	Mg Non Int Exp. $c_\theta^{exp}(\ell'_\theta)$	Mg Net Exp. $c_\theta(\ell'_\theta)$	Fixed Cost $\kappa_\theta/\ell_\theta$	Avg. Cost
Top 10 Banks	$4.07^\dagger$	$4.72^\dagger$	$0.65^\dagger$	0.84	$1.49^\dagger$
Fringe Banks	2.12	3.69	1.57	0.75	2.32

- Marginal Non-Int. Income, Non-Int. Expenses (estimated from trans-log cost function) and Net Expenses increase with size.
- Fixed Costs (normalized by loans) increase in size.
- Average Costs decrease in size (consistent with evidence (e.g. Mester) for IRS in banking).

Definitions Return

Definitions Net Costs by Bank Size

Non Interest Income:

i. Income from fiduciary activities.
ii. Service charges on deposit accounts.
iii. Trading and venture capital revenue.
iv. Fees and commissions from securities brokerage, investment banking and insurance activities.
v. Net servicing fees and securitization income.
vi. Net gains (losses) on sales of loans and leases, other real estate and other assets (excluding securities).
vii. Other noninterest income.

Non Interest Expense:

i. Salaries and employee benefits.
ii. Goodwill impairment losses, amortization expense and impairment losses for other intangible assets.
iii. Other noninterest expense.

Fixed Costs:

i. Expenses of premises and fixed assets (net of rental income). (excluding salaries and employee benefits and mortgage interest).

Return

Business Cycle Correlations

	Data	
Variable correlated with output	1984-2007	1984-2016
Loan Interest Rate	-0.23	-0.25
Exit Rate	-0.12	-0.16
Entry Rate	0.70	0.70
Loan Supply	0.54	0.41
Deposits	0.29	0.07
Default Frequency	-0.65	-0.65
Loan Return	-0.06	-0.02
Charge Off Rate	-0.72	-0.58
Price Cost Margin Rate	-0.36	-0.25
Markup	-0.31	-0.16

Return

Balance Sheet Data Key Components by Size

Assets	Top 10	Fringe
Cash/Safe Securities	13.43	24.04
Loans/Risky Securities	86.57	75.96
Liabilities		
Deposits/Other Borrowings	92.37	90.20
Equity	7.63	9.80
Capital Ratio (risk-weighted)	8.81	12.90

Note: Avg. 1984 - 2007. Data corresponds to bank holding co in the US.
Source: Consolidated Report of Condition and Income. ▸ Balance Sheet (Long)
▸ Definitions

- While loans and deposits are the most important parts of the bank balance sheet, "precautionary holdings" of liquid assets are an important buffer stock. ▸ return

Balance Sheet: all variables (avg 1984-2007)

Fraction Total Assets (%)	Top 10	Fringe
Assets		
Liquid Assets	13.53	10.30
Securities	10.09	20.92
Loans	62.28	62.70
Trad Assets	5.92	0.23
Other Assets	8.18	5.85
Liabilities		
Deposits	66.66	79.59
Other Borrowed Money	8.11	4.35
ST Liab (ff & Repo)	8.90	5.68
Trading Liab	4.89	0.02
Sub Debt	1.50	0.27
Other Liab	2.44	1.50
Equity	7.49	8.58
Tier 1 Capital	6.86	8.70
Risk Weighted Assets	78.87	71.64
Tier 1 Capital (rw)	8.81	12.90
Total Capital (rw)	11.96	14.34

Def. Short BS Return

Balance Sheet Short Definitions

- Normalized Assets= total assets - short term liab. (fed funds/repos)
- Loans: risk-weighted assets
- Cash/Securities: 1 - loans = 1- risk-weighted assets (net of short term liab) = cash + fed funds sold + Safe securities + safe trading assets - short term liab. (fed funds/repos)
- Tier 1 capital Ratio (rw): tier 1 capital over risk-weighted assets
- Equity: Tier 1 capital Ratio (rw) $\times$ loans
- Deposits: 1 - equity = deposits + other borrowed money + other liab

▸ Balance Sheet (Long) ▸ Return

Incumbent Bank Decision Making

- Differentiating end-of period profits with respect to ℓ^{θ} we obtain

$$\frac{d\pi'_{\theta}}{d\ell'_{\theta}} = \Big[\underbrace{pr^L - (1-p)\lambda}_{(+)\text{ or }(-)}\Big] + \ell'_{\theta}\Big[\underbrace{p}_{(+)} + \underbrace{\frac{\partial p}{\partial R}\frac{\partial R}{\partial r^L}(r^L + \lambda)}_{(-)}\Big]\underbrace{\frac{dr^L}{d\ell'_{\theta}}}_{(-)}.$$

- $\frac{dr^L}{d\ell'_f} = 0$ for competitive fringe.

Return

Bank Entry

- Entry costs for the creation of banks are denoted by $\Upsilon_b > \Upsilon_f$
- Every period a large number of potential entrants make the decision of whether or not to enter the market after the realization of z_t but before the realization of $\delta_{\theta,t}$
- Entry costs and the initial injection of equity are subject to equity finance costs $\zeta_\theta(\Upsilon_\theta + n^i_{e_\theta,t}, z_t)$ is the entrant's initial equity injection.

Entrant's Problem
return

Bank Size Distribution & Loan Mkt Clearing

- We denote the cross-sectional distribution of banks or "industry state" by
$$\mu = \{\mu_b(n,\delta), \mu_f(n,\delta)\},$$
where each element of μ is a measure $\mu_\theta(n,\delta)$ corresponding to *active* banks of type θ over matched deposits δ and net worth n

- The law of motion for the industry state is denoted $\mu' = H(z,\mu,z',M_e')$ where $M_e' = \{M_{e,b}', M_{e,f}'\}$ denotes the vector of entrants of each type and H is a transition function Distn

- The cross-sectional dist. is necessary to calculate loan market clearing:
$$L^d(r^L, z) = \sum_{\theta \in \{b,f\}} \left[\int \ell_\theta'(n,\delta; z,\mu,\cdot) d\mu_\theta(n,\delta) \right]$$

return

Evolution of Cross-sectional Bank Size Distribution

- The distribution of banks evolves according to $\mu' = H(z, \mu, z', M_e')$:

$$\mu_\theta'(n_\theta', \delta_\theta') = \int \sum_{\delta_\theta} (1 - x_\theta'(n_\theta, \delta_\theta; z, \mu, \cdot, z')) \mathbf{1}_{\{n_\theta' = n_\theta'(n_\theta, \delta_\theta, z, \mu, \cdot, z'))\}} G_\theta(\delta_\theta', \delta_\theta) d\mu_\theta(n_\theta, \delta_\theta)$$

$$+ M_{e,\theta}' \mathbf{1}_{\{n_\theta' = n_{e,\theta}'(z, \mu, z', M_{e,\theta}'))\}} G_{e,\theta}(\delta_\theta)$$

- This equation makes clear how the law of motion for the distribution of banks is affected by entry and exit decisions.

Return BSD

Funding deposit insurance

- Let post-liquidation net transfers be given by

$$\Delta'_\theta(n_\theta, \delta_\theta, z, \mu, z') = (1 + r^D) d'_\theta$$
$$-\Big\{p(R, z')(1 + r^L) + (1 - p(R, z'))(1 - \lambda) - \xi_\theta\Big\}\ell'_\theta - (1 + r^a)A'_\theta$$

where $\xi \leq 1$ is the post-liquidation value of the bank's loan portfolio.

- Then aggregate taxes are given by

$$\tau'(z, \mu, z') \cdot N = \sum_\theta \left[\int \sum_\delta x'_\theta \max\{0, \Delta'_\theta(n_\theta, \delta_\theta, z, \mu, z')\} d\mu_\theta(n_\theta, \delta_\theta)\right].$$

▸ Return Timing

Solution Approach

▸ Return Def. Eq.

- Solve the model using a variant of Krusell and Smith (1998) and Ifrach and Weintraub (2017).

- Main difficulty arises in approximating the distribution of fringe banks and computing the reaction function from the fringe sector to clear the loan market:

$$\ell_b(n,\delta,z,\mu) + \underbrace{\int_{\mathbf{N}\times\mathbf{D}} \ell_f(n,\delta,z,n_b,\delta_b,\mu,\ell_b)d\mu(n,\delta)}_{=L^s_f(z,n_b,\delta_b,\mu,\ell_b)} = L^d(r^L,z)$$

- Approximate the cross-sectional distn of fringe banks using a finite set of moments:
  - the cross-sectional avg of net-worth plus deposits (denoted $\mathcal{N}$) since that determines feasible loan and asset choices at the beginning of the period and
  - the mass of incumbent fringe banks (denoted $\mathcal{M}$) where

$$\mathcal{N} = \int_{\mathbf{N}\times\mathbf{D}} (n+\delta)d\mu(n,\delta), \quad \mathcal{M} = \int_{\mathbf{N}\times\mathbf{D}} d\mu(n,\delta)$$

Solution Approach (cont.)

▸ Return Def. Eq.

- The evolution of these moments is approximated using a log-linear function that has $\{n_b, \delta_b, z, \mathcal{N}, \mathcal{M}, z'\}$ as states.

- The mass of entrants M_e' and incumbents $\mathcal{M}$ are linked since

$$\mu'(n', \delta') = T^*(\mu(n, \delta)) + M_e' \int_{\mathbf{D}} I_{n'=n_e} G^e(\delta)$$

where $T^*(\cdot)$ is the transition operator.

- For each combination of state variables $\{n_b, \delta_b, z, \mathcal{N}, \mathcal{M}\}$ we iterate on $\ell_b(\cdot)$ and $L_f^s(\cdot)$ until we find a fixed point (i.e. the equilibrium in the Stackelberg game).

$$\ell_b^*(n_b, \delta_b, z, \mathcal{N}, \mathcal{M}) + L_f^s(n_b, \delta_b, z, \mathcal{N}, \mathcal{M}, \ell_b^*(\cdot)) = L^d(r^L, z)$$

Computational Algorithm

1. Guess **aggregate functions**. Make an initial guess of $L_f^s(n_b, \delta_b, z, \mathcal{N}, \mathcal{M})$ and the law of motion for $\mathcal{N}'$ and $\mathcal{M}'_x$ where $\mathcal{M}'_x$ is the mass of survivors after exit decisions (note that $\mathcal{M}' = \max\{\mathcal{M}'_x, \mathcal{M} + \mathcal{M}'_e\}$) .

$$L_f^s = H^{\mathcal{L}}(n_b, \delta_b, z, \mathcal{N}, \mathcal{M}).$$
$$\log(\mathcal{N}') = H^{\mathcal{N}}(n_b, \delta_b, z, \mathcal{N}, \mathcal{M}, z').$$
$$\log(\mathcal{M}'_x) = H^{\mathcal{M}_x}(n_b, \delta_b, z, \mathcal{N}, \mathcal{M}, z').$$

2. Solve the **dominant bank** problem.

3. Solve the problem of **fringe banks**.

4. Solve the **entry problem** of the fringe bank and big bank to obtain the number of entrants as a function of the state space.

5. **Simulate** to obtain a sequence $\{n_{b,t}, \mathcal{N}_t, \mathcal{M}_t\}_{t=1}^T$ and update aggregate functions. If convergence achieved stop. If not, return to (2).

▸ Return Parametrization ▸ Return Def. Eq.

Parameterization

Parameter		Value	Target
Autocorrel. z	ρ_z	0.256	TFP US (Fernald)
Std. Dev. Error (%)	σ_{u^z}	0.87	TFP US (Fernald)
Crisis state	z_C	0.976	TFP US (Fernald)
Deposit interest rate (%)	$\bar{r} = r^d$	0.659	Int. expense
Securities Return (%)	r^a	1.28	Return Securities
Charge-off rate	λ	0.41	Charge off rate
Autocorrel. Deposits	ρ_b^d	0.410	Deposit Process Big
Std. dev. error b bank	$\sigma_{b,u}^d$	0.070	Deposit Process Big
Autocorrel. Deposits	ρ_f^d	0.876	Deposit Process Fringe
Std. dev. error f bank	$\sigma_{f,u}^d$	0.156	Deposit Process Fringe
Salvage value	ξ	0.1965	Recovery Failures (FDIC)
Capital requirement b bank	$\{\varphi_b^\ell, \varphi_b^A\}$	$\{0.04, 0\}$	Basel II Capital Reg.
Capital requirement f bank	$\{\varphi_f^\ell, \varphi_f^A\}$	$\{0.04, 0\}$	Basel II Capital Reg.
Liquidity requirement	ϱ_θ	0	Basel II Capital Reg.

Return Mom

Parameters Chosen within Model

Parameter		Value	Target
Disc. Factor Manager	γ	0.957	Loans to asset ratio fringe
Avg. dep f banks	μ_f^d	0.062	Deposits to output ratio
Avg. dep b bank	μ_b^d	0.092	Deposit mkt share fringe (%)
Mg. Cost b bank	$c_{b,0}$	0.000	Net non-int exp. Top 10 (%)
Mg. Cost b bank	$c_{b,1}$	0.003	Capital ratio (risk-weighted) top 10
Mg. Cost f bank	$c_{f,0}$	0.001	Net non-int exp. Fringe (%)
Mg. Cost f bank	$c_{f,1}$	0.260	Capital ratio (risk-weighted) fringe
Fixed cost b bank	κ_b	0.0010	Fixed cost over loans top 10 (%)
Fixed cost f banks	κ_f	0.0022	Fixed cost over loans fringe (%)
EI Cost b bank	$\zeta_{b,0}$	0.025	Dividends to asset ratio fringe (%)
EI Cost b bank	$\zeta_{b,1}$	0.100	Dividends to asset ratio Top 10 (%)
EI Cost f bank	$\zeta_{f,0}$	3.629	Frequency of Div payment Top 10 (%)
EI Cost f bank	$\zeta_{f,1}$	26.38	Frequency of Div payment Fringe (%)
EI Cost	ζ_z	4.00	Loans to asset ratio Top 10
Entry Cost f banks	Υ_f	0.017	Bank failure rate (%)
Entry Cost b bank	Υ_b	0.025	Bank entry rate (%)

Note: Functional Forms Return Mom

Functional Forms

- Borrower outside option is distributed uniform $[0, \overline{\omega}]$.
- For each borrower, let $y = \alpha z' + (1-\alpha)\varepsilon - bR^{\psi}$ where ε is drawn from $N(\mu_\varepsilon, \sigma^2_\varepsilon)$.
- Define success to be the event that $y > 0$, so in states with higher z or higher ε_e success is more likely. Then

$$p(R, z')1 - \Phi\left(\frac{-\alpha z' + bR^{\psi}}{(1-\alpha)}\right) \quad (4)$$

where $\Phi(x)$ is a normal cumulative distribution function with mean (μ_ε) and variance σ^2_ε.

Return

Definition Model Moments

Aggregate loan supply	$L^s(z,\mu) = \ell_b' + L^f(z,\mu,\ell_b')$
Aggregate Output	$L^s(z,\mu)\Big\{p(z,\mu,z')(1+z'R) + (1-p(z,\mu,z'))(1-\lambda)\Big\}$
Entry Rate	$\sum_\theta M'_{e,\theta} / \sum_\theta \int d\mu_\theta(n_\theta,\delta_\theta)$
Default Frequency	$1 - p(R^*, z')$
Borrower Return	$p(R^*, z')(z' R^*)$
Loan Return	$p(R^*, z') r^L(z,\mu) - (1 - p(R^*, z'))\lambda$
Loan Charge-off Rate	$(1 - p(R^*, z'))\lambda$
Interest Margin	$p(R^*, z') r^L(z,\mu) - r^d$
Loan market share fringe banks	$L^f(z,\mu,\ell_b')/L^s(z,\mu)$
Deposit market share fringe banks	$\int d_f' d\mu_f(n_f,\delta_f)/[\sum_\theta \int d_\theta' d\mu_\theta(n_\theta,\delta_\theta)]$
Risk- Weighted Capital Ratio	$(\ell_\theta' + A_\theta' + \pi_\theta' - d_\theta')/\ell_\theta'$
Loans to Asset Ratio	$\ell_\theta'/(\ell_\theta' + A_\theta' + \pi_\theta')$
Equity to Asset Ratio	$(\ell_\theta' + A_\theta' + \pi_\theta' - d_\theta')/(\ell_\theta' + A_\theta' + \pi_\theta')$
Securities/Cash to Assets Ratio	$(A_\theta' + \pi_\theta')/(\ell_\theta' + A_\theta' + \pi_\theta')$
Markup	$\Big[p(R^*(\mu,z),z') r^L(\mu,z) + c_\theta^{inc}(\ell_\theta')\Big] \,/\, \Big[r^d + c_\theta^{exp}(\ell_\theta')\Big] - 1$

▸ Return

Long-run Model vs Data Moments

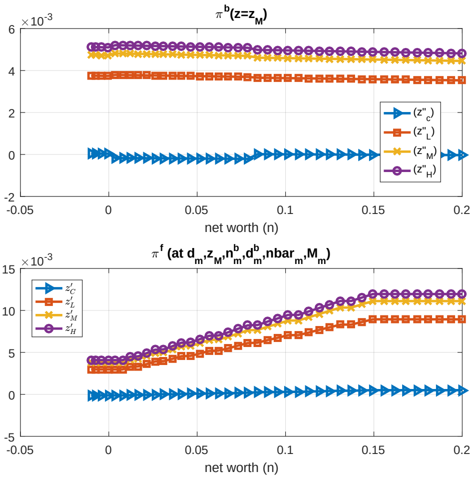
Table: Non-Targeted Moments

Moment (%)	Data	Model
Equity Issuance over Assets Top 10	0.02	0.01
Frequency of Equity Issuance Top 10	9.86	0.00
Equity Issuance over Assets Fringe	0.11	3.18
Frequency of Equity Issuance Fringe	9.59	61.54
Securities to Asset Ratio Top 10	21.75	34.93
Securities to Asset Ratio fringe	24.90	23.65
Dep/Asset ratio Top 10	93.05	95.60
Dep/Asset ratio fringe	90.76	91.91
Avg Markup	46.27	73.89
Avg Lerner Index	30.32	42.49
Avg Loan Return	4.53	4.73
Equity to Asset Ratio Top 10	6.64	4.40
Equity to Asset Ratio fringe	8.73	8.09

Note: † implied by target.

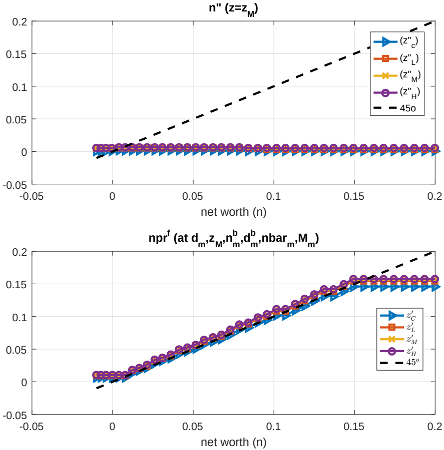
return

PROFITABILITY



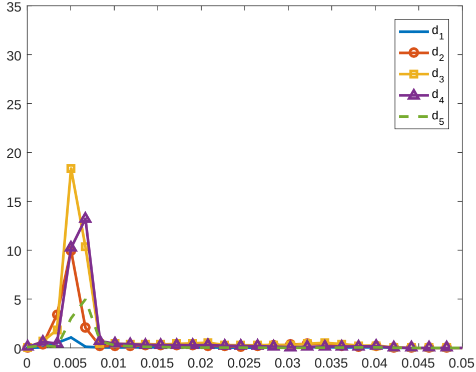
▸ return ℓ, A, Div

Equity/Net Worth



▸ return Cap. Ratios

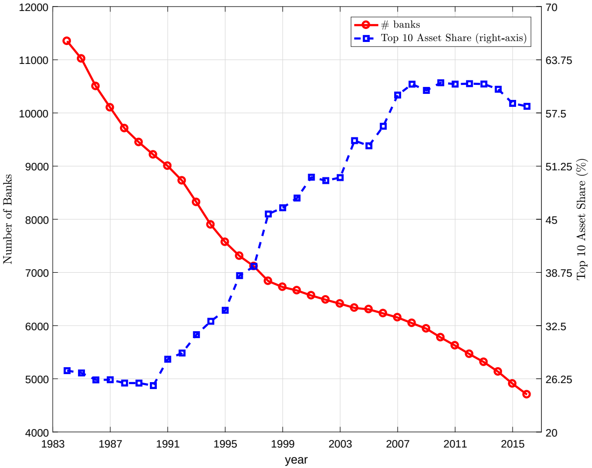
Distribution of Equity/Net-Worth



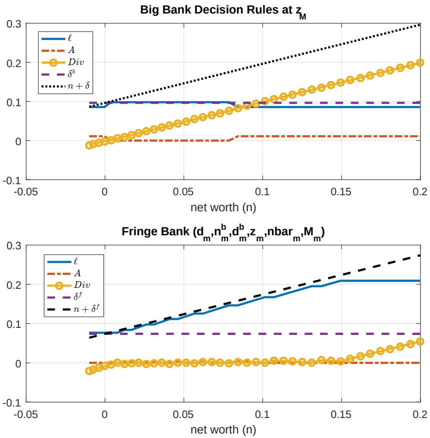
return

Banking Industry Concentration

Return



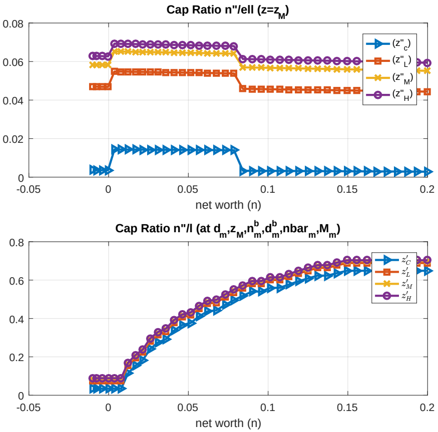
Loans, Securities & Dividends



- Big banks optimal level of loans driven by market power, fringe banks invest all their resources in loans (price takers)

Fig π Return

Capital Ratios



- Capital Ratios are countercyclical consistent with buffer stock story
- Big bank's charter value is large enough that chooses to recapitalize when $z' = z_C$ (an unlikely event) Fig. n'_θ

Return

Long-run Model vs Data Moments: Targets

Param. chosen to minimize the diff. between data and model moments.

Moment (%)	Data	Model
Borrower Return	12.94	13.75
Default freq.	1.84	1.57
Net Interest Margin	4.69	4.49
Elasticity loan demand	-1.10	-0.60
Deposits to output ratio	56.20	56.20
Deposit mkt share fringe	60.99	61.32
Std. dev. net-int. margin	0.34	0.11
Dividends to asset ratio Top 10	0.66	1.66
Dividends to asset ratio fringe	0.62	0.82
Loans to asset ratio Top 10	78.25	63.88
Loans to asset ratio fringe	75.10	78.18
Capital ratio (risk-weighted) top 10	8.48	6.61
Capital ratio (risk-weighted) fringe	11.62	10.55
Net non-int exp. Top 10	0.65	0.04
Net non-int exp. Fringe	1.57	2.58
Fixed cost over loans Top 10	0.84	1.05
Fixed cost over loans fringe	0.75	2.88
Equity Issuance over Assets Top 10	0.02	0.01
Equity Issuance over Assets Fringe	0.11	0.60
Bank failure rate	1.02	2.11

▸ Parameterization, AR1 ▸ Defn Moments ▸ Param Values ▸ Non Targeted Moments ▸ return Eq. Def.

Test II: Monetary Transmission - cont.

Moment (%)	Benchmark ($r^D = 0.0065$)	Monetary Policy ($r^D = 0.021$)	
		Short Run	Long Run
Capital Ratio Top 10	6.12	6.35	7.65
Capital Ratio Fringe	10.38	23.75	13.13
Loan mkt sh. Fringe	66.31	41.59	26.15
Loan Interest Rate	5.49	6.20	7.93
Exit Rate	2.31	44.69	34.51
Entry Rate	2.31	21.88	34.51
Additional Moments		Δ (%)	
Measure Banks Fringe		0.00	-60.67
Loan Supply		-8.39	-28.83
ℓ^f		-16.35	-44.07
ℓ^b		58.66	55.34
π^f		-62.42	-58.91
π^b		-31.43	12.39

↑ in external debt (deposit) finance costs of 145 BP → short run ↑ in loan rates of 71 BP and a long run ↑ of 244 BP and big ↓ of small bank market share. return

Test II: Monetary Transmission - cont.

Table: Kashyap and Stein ('95) Regressions (Model Pseudo-Panel)

	Dependent Variable $\Delta\ell_{it}$
Specification	Coeff. on Monetary Impulse (Δr^D)
Small 98%	-0.3541 0.003***
Small 92%	-0.3765 0.004***
Small 68%	-0.4023 0.004***

Note: All specifications include one lag of the dep. variable, and growth rate of GDP.
*** significant at 1% level, ** significant at 5% level, * significant at 10% level.

return

Capital Requirement Counterfactual

Moment (%)	Benchmark ($\varphi = 0.04$)	Higher Cap Req. ($\varphi = 0.085$)	
		Short Run	Long Run
Capital Ratio Top 10	6.12	10.74	10.90
Capital Ratio Fringe	10.38	17.16	19.60
Exit Rate	2.31	33.76	5.48
Entry Rate	2.31	22.54	5.55
Loan mkt sh. Fringe	66.31	51.29	62.81
Loan Interest Rate	5.49	6.91	5.55
Default Frequency	1.867	2.30	1.954
Avg. Markup	73.62	102.63	74.95
Dividends over Assets Top 10	2.38	0.00	1.91
Dividends over Assets Fringe	0.74	0.86	1.46
Additional Moments		Δ (%)	
Measure Banks Fringe		0.00	-3.34
Loan Supply		-16.78	-0.83
Int. Output		-16.92	-0.89
Taxes/Output		592.66	-12.84
ℓ^f		-15.86	-0.20
ℓ^b		20.34	9.36

Important selection effects (only well funded small banks remain). Return

Zero Capital Requirement

Question: What are the effects of removing capital requirements?

Moment (%)	Benchmark ($\varphi = 0.04$)	Zero Cap Req. ($\varphi = 0$)	
		Short Run	Long Run
Capital Ratio Top 10	6.12	5.21	2.31
Capital Ratio Fringe	10.38	10.58	8.70
Exit Rate	2.31	8.80	2.89
Entry Rate	2.31	0.00	2.95
Loan mkt sh. Fringe	66.31	69.48	58.41
Deposit mkt sh. Fringe	60.70	61.88	54.94
Loan Interest Rate	5.49	5.44	5.81
Default Frequency	1.867	1.86	2.025
Avg. Markup	73.62	72.61	80.49
Div. to Assets Top 10	2.38	2.67	2.25
Div. to Assets Fringe	0.74	1.05	0.88
Additional Moments		Δ (%)	
Measure Banks Fringe		0.00	-20.48
Loan Supply		0.50	-3.94
Int. Output		0.49	-4.03
Taxes/Output		284.97	80.03
ℓ^f		4.76	6.66
ℓ^b		-8.95	18.42

Return

Countercyclical Capital Requirements

Moment (%)	Benchmark ($\varphi = 0.04$)	Countercyclical Cap Req. ($\varphi(z_C) = 0.085$, $\varphi(z_G) = 0.11$)	
		Short Run	Long Run
Capital Ratio Top 10	6.12	16.65	12.30
Capital Ratio Fringe	10.38	19.58	20.54
Exit Rate	2.31	36.39	5.13
Entry Rate	2.31	23.21	5.17
Loan mkt sh. Fringe	66.31	55.06	60.15
Loan Interest Rate	5.49	7.55	5.83
Default Frequency	1.867	2.65	2.027
Avg. Markup	73.62	115.31	80.69
Div. to Assets Top 10	2.38	0.00	2.10
Div. to Assets Fringe	0.74	0.83	1.44
Additional Moments		Δ (%)	
Measure Banks Fringe		0.00	-9.45
Loan Supply		-24.28	-4.06
Int. Output		-24.55	-4.13
Taxes/Output		444.30	-52.52
ℓ^f		-19.27	-1.47
ℓ^b		1.02	13.44

Return

Size Dependent Capital Requirements

Moment (%)	Benchmark ($\varphi = 0.04$)	Size Dep. Cap Req. ($\varphi_b = 0.105, \varphi_f = 0.085$)	
		Short Run	Long Run
Capital Ratio Top 10	6.12	16.91	15.16
Capital Ratio Fringe	10.38	19.07	19.04
Exit Rate	2.31	36.23	4.92
Entry Rate	2.31	21.20	4.97
Loan mkt sh. Fringe	66.31	56.20	64.33
Loan Interest Rate	5.49	7.45	5.87
Default Frequency	1.867	2.52	2.045
Avg. Markup	73.62	113.56	81.58
Div. to Assets Top 10	2.38	0.00	1.97
Div. to Assets Fringe	0.74	0.87	1.40
Additional Moments	Δ (%)		
Measure Banks Fringe		0.00	-6.26
Loan Supply		-23.11	-4.67
Int. Output		-23.32	-4.72
Taxes/Output		605.72	-31.35
ℓ^f		-16.16	1.12
ℓ^b		-0.04	0.63

Return

Liquidity Requirements

Moment (%)	Benchmark ($\varphi = 0.04$)	Liq Req. ($\varphi_\theta = 0.04$, $\varrho_\theta = 0.08$)	
	$\gamma_\theta = 0$	Short Run	Long Run
Capital Ratio Top 10	6.12	8.13	6.92
Capital Ratio Fringe	10.38	12.52	13.18
Exit Rate	2.31	6.77	2.20
Entry Rate	2.31	0.00	2.28
Loan mkt sh. Fringe	66.31	66.75	57.12
Loan Interest Rate	5.49	5.69	6.21
Default Frequency	1.867	1.99	2.145
Avg. Markup	73.62	77.75	88.51
Div. to Assets Top 10	2.38	0.92	2.44
Div. to Assets Fringe	0.74	0.64	0.80
Additional Moments		Δ (%)	
Measure Banks Fringe		0.00	-19.66
Loan Supply		-2.39	-8.56
Int. Output		-2.46	-8.71
Taxes/Output		164.12	-43.91
ℓ^f		-3.54	-2.15
ℓ^b		-3.68	16.61

Return

Allocative Efficiency

We use the following decomposition of weighted average bank-level marginal cost (proposed originally by Olley and Pakes [?] to measure productivity):

$$\hat{c} \equiv \sum_{\theta} \int \sum_{\delta_\theta} c_\theta(\ell'_\theta)\omega(\ell'_\theta) d\mu_\theta = \overline{c} + cov(c(\ell'_\theta), \omega(\ell'_\theta)),$$

Moment (%)	Baseline $\varphi_{\theta,z} = 0.04$	Higher Cap. Req. $\varphi_{\theta,z} = 0.085$	Size Dep. Cap. Req. $\varphi_{b,z} = 0.105$ $\varphi_{f,z} = 0.085$	Countercyclical Cap. Req. $\varphi_{f,z} = 0.085$ $\varphi_{b,z} \in [0.085, 0.11]$	High Cap. Req. & Liq. Req. $\varphi_{\theta,z} = 0.085$ $\varrho_\theta = 0.08$
$\hat{c}$	1.755	1.640	1.754	1.525	1.662
$\overline{c}$	1.766	1.695	1.736	1.642	1.708
$Cov(c, \omega)$	-0.011	-0.055	0.018	-0.117	-0.047
Fringe Loan Mkt Sh.	66.94	64.34	68.28	58.65	64.91

return

Welfare

	Higher Cap. Req. $\varphi_{\theta,z} = 0.085$		Size Dep. Cap. Req. $\varphi_{b,z} = 0.105$ $\varphi_{f,z} = 0.085$		Countercyclical Cap. Req. $\varphi_{f,z} = \varphi_{b,z_C} = 0.085$ $\varphi_{b,z_G} = 0.11$		High Cap. Req. & Liq. Req. $\varphi_{\theta,z} = 0.085$ $\gamma_{\theta} = 0.08$	
	short-run	long-run	short-run	long-run	short-run	long-run	short-run	long-run
α_H	-1.063	0.220	-0.988	0.275	-1.343	0.315	-0.779	0.187
$\Delta\sigma_{C_H}$	19.38		-1.80		15.48		29.31	
α_E	-0.591	-0.167	-0.799	-0.345	-0.592	-0.333	-0.453	-0.087
$\Delta\sigma_{C_E}$	63.88		7.52		45.09		60.33	
$\overline{\alpha}$	-0.983	0.154	-0.956	0.170	-1.216	0.205	-0.724	0.140
$\overline{\Delta}\sigma_C$	26.95		-0.22		20.51		34.59	

Note: Positive values correspond to a welfare gain from the reform and a negative value corresponds to a welfare loss.

return