Capital Requirements in a Quantitative Model of Banking Industry Dynamics

Dean Corbae Pablo D'Erasmo[1]

Wisconsin and NBER FRB Philadelphia

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(*Preliminary and Incomplete*)

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

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- "Optimal regulation may depend on the intensity of competition" (Vives (2010) "Competition and Stability in Banking")

- This paper is about how policy (e.g. capital requirements) affects bank lending by big and small banks, loan rates, exit, and market structure in the commercial banking industry.

Quantitative Question

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Answer

- A 50% ↑ capital requirements reduces exit rates of small banks by 40% but results in a more concentrated industry. Aggregate loan supply shrinks and interest rates are 50 basis points higher.

Outline

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   - Size dependent CR (add 2.5% to big banks)

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 0.72 and 0.22 respectively). Bigger banks have less volatile funding inflows (implications for buffers). ▸ Table

- High Concentration: Top 10 have 52% of loan share. ▸ Fig ▸ Table

- Signs of Noncompetitive Behavior: Large Net Interest Margins, Markups, Lerner Index, Rosse-Panzar $H < 100$. ▸ Table

- 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

Balance Sheet Data Key Components by Size

Fraction total assets (%)	2000		2010	
	Fringe	top 10	Fringe	top 10
Assets				
Liquid assets	9.88	14.19	9.77	15.95
Securities	17.20	11.49	18.15	15.15
Loans	72.91	74.32	72.07	68.91
Liabilities				
Deposits	74.55	75.46	79.94	81.34
fed funds/repos	19.04	18.42	13.84	13.66
equity	6.41	6.11	6.23	5.00
Bank capital (rw)	10.19	7.81	13.93	11.35

Note: Data corresponds to commercial banks in the US. Source: Consolidated Report of Condition and Income. Balance Sheet (Long) Definitions

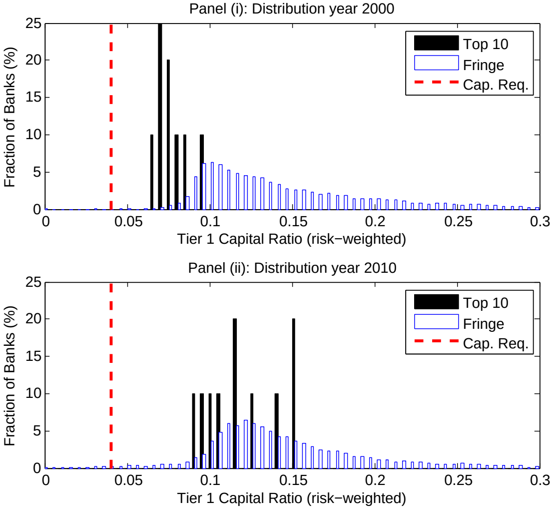
- While loans and deposits are the most important parts of the bank balance sheet, "precautionary holdings" of securities and liquid assets are an important buffer stock.

Capital Ratios by Bank Size from C-D (2014a)

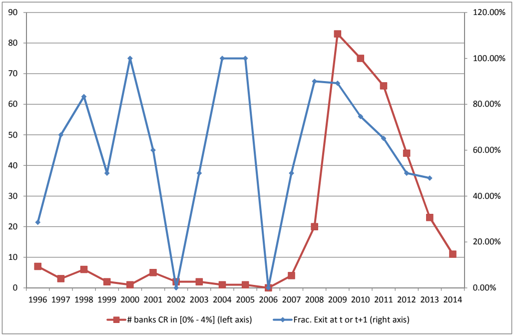
- Risk weighted capital ratios ((loans+net assets-deposits)/loans) are larger for small banks.
- On average, capital ratios are above what regulation defines as "Well Capitalized" ($\geq 6\%$) suggesting a precautionary motive.

Fig. non-rw Regulation Details

Distribution of Bank Capital Ratios

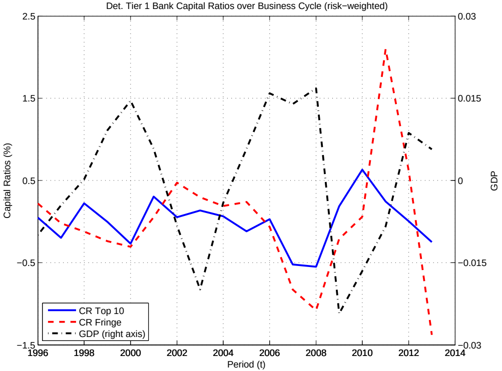


Undercapitalized bank exit



- Number of small U.S. banks below 4% capital requirement rose dramatically during crisis and most exited.

Capital Ratios Over the Business Cycle



- Risk-Weighted capital ratio is countercyclical for small and big banks (corr. -0.40 and -0.64 respectively).

Fig Ratio to Total Assets

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  - Loan market clearing determines interest rate $r_t^L(\eta_t, z_t)$ where η_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
- Noncontingent loan contracts
- Market power by a subset of banks

Stochastic Processes

- Aggregate Technology Shocks $z_{t+1} \in \{z_b, z_g\}$ follow a Markov Process $F(z_{t+1}, z_t)$ with $z_b < z_g$ (business cycle).

- Conditional on z_{t+1}, project success shocks which are iid across borrowers are drawn from $p(R_t, z_{t+1})$ (non-performing loans).

- "Liquidity shocks" (capacity constraint on deposits) which are iid across banks given by $\delta_t \in \{\underline{\delta}, \ldots, \overline{\delta}\} \subseteq \mathbb{R}_{++}$ follow a Markov Process $G^{\theta}(\delta_{t+1}, \delta_t)$ (buffer stock).

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

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

- 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 $\Upsilon(\omega_t)$.

Borrower Decision Making

- If a borrower chooses to demand a loan, then given limited liability his problem is to solve:

$$v(r_t^L, z_t) = \max_{R_t} E_{z_{t+1}|z_t} p(R_t, z_{t+1}) \left(z_{t+1} R_t - r_t^L \right). \tag{2}$$

- The borrower chooses to demand a loan if

$$v(\overset{-}{r_t^L}, \overset{+}{z_t}) \geq \omega_t. \tag{3}$$

- Aggregate demand for loans is given by

$$L^d(r_t^L, z_t) = N \cdot \int_{\underline{\omega}}^{\overline{\omega}} 1_{\{\omega_t \leq v(r_t^L, z_t)\}} d\Upsilon(\omega_t). \tag{4}$$

Loan Market Outcomes

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

Banks - Cash Flow

For a bank of type θ which

- makes loans ℓ_t^θ at rate r_t^L
- accepts deposits d_t^θ at rate r_t^D,
- holds net securities A_t^θ at rate r_t^a,

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Its end-of-period profits are given by Current Profit Trade-offs

$$\pi_{t+1}^\theta = \left\{ p(R_t, z_{t+1})(1 + r_t^L) + (1 - p(R_t, z_{t+1}))(1 - \lambda) - c^\theta \right\} \ell_t^\theta + r^a A_t^\theta - (1 + r^D) d_t^\theta - \kappa^\theta.$$

where

- $p(R_t, z_{t+1})$ are the fraction of performing loans which depends on borrower choice R_t and shocks z_{t+1},
- Charge-off rate λ,
- $(c^\theta, \kappa^\theta)$ are net proportional and fixed costs.

Banks - Capital Ratios and Borrowing Constraints

- After loan, deposit, and security decisions have been made, we can define bank equity capital $\tilde{e}_t^\theta$ as

$$e_t^\theta \equiv \underbrace{A_t^\theta + \ell_t^\theta}_{\text{assets}} - \underbrace{d_t^\theta}_{\text{liabilities}} .$$

- Banks face a Capital Requirement:

$$e_t^\theta \geq \varphi^\theta(\ell_t^\theta + w \cdot A_t^\theta) \tag{CR}$$

where w is the "risk weighting" (i.e. $w = 0$ imposes a risk-weighted capital ratio).

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- Banks face an end-of-period Borrowing Constraint:

$$a_{t+1}^\theta = A_t - (1 + r^B)B_{t+1} \geq 0 \qquad \text{(BBC)}$$

Banks - Optimization

- When $\pi^{\theta}_{t+1} < 0$ (negative cash flow), bank can issue equity (at unit cost $\zeta^{\theta}(\cdot)$) or borrow ($B^{\theta}_{t+1} > 0$) against net securities (e.g. repos) to avoid exit but beginning-of-next-period's assets fall.

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- Bank dividends at the end of the period are

$$\mathcal{D}^{\theta}_{i,t+1} = \begin{cases} \pi^{\theta}_{i,t+1} + B^{\theta}_{i,t+1} & \text{if } \pi^{\theta}_{i,t+1} + B^{\theta}_{i,t+1} \geq 0 \\ \pi^{\theta}_{i,t+1} + B^{\theta}_{i,t+1} - \zeta^{\theta}(\pi^{\theta}_{i,t+1} + B^{\theta}_{i,t+1}, z_{t+1}) & \text{if } \pi^{\theta}_{i,t+1} + B^{\theta}_{i,t+1} < 0 \end{cases}$$

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- Bank type θ chooses loans, deposits, net securities, non-negative dividend payouts, exit policy to maximize the future discounted stream of dividends Problem

$$E\left[\sum_{t=0}^{\infty} \beta^t \mathcal{D}^{\theta}_{t+1}\right]$$

Banks - Entry & Exit

At the end of the period,

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- Entry: Banks which choose to enter incur cost Υ^{θ}. Entry

Bank Size Distribution and Loan Market Clearing

- The industry state is given by the cross-sectional distribution of active banks $\eta_t^\theta(a, \delta)$ of a given type θ (a measure over beginning-of-period deposits δ_t and net securities a_t). ▸ Distn

- The cross-sectional distribution is necessary to calculate loan market clearing:

$$\sum_{\theta \in \{b,f\}} \left[\int \ell_t^\theta(a_t, \delta_t, z_t) d\eta_t^\theta(a_t, \delta_t) \right] = L^d(r_t^L, z_t) \tag{5}$$

Defn. Markov Perfect Industry EQ

Given policy parameters:

- Capital requirements,φ^{θ}, and risk weights, w.
- Borrowing rates, r^B, and securities rates, r^a,

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. At r^D, households choose to deposit at a bank.
3. Bank loan, deposit, net security holding, borrowing, exit, and dividend payment functions are consistent with bank optimization. ▸ Decision Rules
4. The law of motion for cross-sectional distribution of banks η is consistent with bank entry and exit decision rules. ▸ Dist
5. The interest rate $r^L(\eta, z)$ is such that the loan market clears.
6. Across all states, taxes cover deposit insurance.

▸ timing ▸ Solution Approach/Computation

Long-run Model vs Data Moments

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

Moment (%)	Data	Model
Std. dev. Output	1.46	1.97
Std. dev. net-int. margin	0.89	0.34
Borrower Return	12.94	12.33
Std. deviation default frequency	1.49	1.13
Net Interest Margin	4.70	5.69
Default freq.	2.33	2.69
Elasticity Loan Demand	-1.40	-1.01
Loans to asset ratio Top 10	55.52	83.48
Loans to asset ratio fringe	60.63	96.32
Deposit mkt share fringe	74.44	29.25
Fixed cost over loans Top 10	1.41	0.95
Fixed cost over loans Fringe	2.08	2.29
Bank entry rate	1.55	1.60
Bank exit rate	0.71	1.55
Freq. Top 10 bank exit	3.03	6.00
Capital Ratio Top 10 (rwa)	9.09	4.23
Capital Ratio Fringe (rwa)	12.65	13.10
Equity Issuance over Assets Top 10 (%)	0.02	0.05
Equity Issuance over Assets Fringe (%)	0.17	0.40
Sec. to asset ratio Top 10	25.34	3.68
Sec. to asset ratio Fringe	30.04	6.52
Avg Loan Markup	102.73	119.19
Loan Market Share Fringe	66.61	53.93

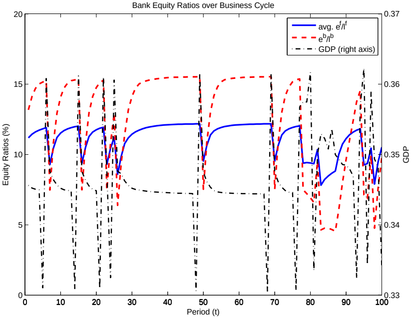
Parameterization, AR1 · Defn Moments · Param Values

Untargeted Business Cycle Correlations

Variable Correlated with GDP	Data	Model
Loan Interest rate	-0.18	-0.90
Exit rate	-0.33	-0.67
Entry rate	0.21	0.46
Loan Supply	0.55	0.98
Deposit Demand	0.16	0.70
Default Frequency	-0.66	-0.32
Loan return	-0.27	-0.05
Charge-off rate	-0.35	-0.32
Price Cost Margin	-0.39	-0.59
Capital Ratio Top 10 (rwa)	-0.64	-0.14
Capital Ratio Fringe (rwa)	-0.18	-0.17

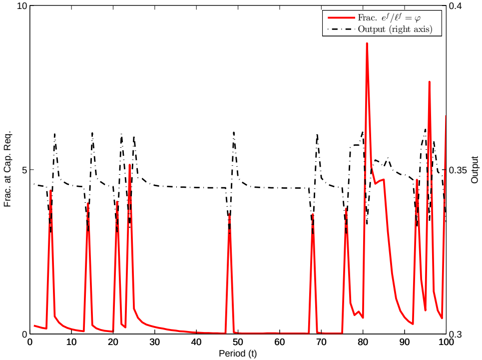
- The model does a good qualitative job with the business cycle correlations. Kashyap-Stein

Capital Ratios over the Business Cycle



- Capital Ratios are countercyclical because loans are more procyclical than "precautionary" asset choices.

Frac Banks constrained by Min Cap. Req.



- Fraction of capital requirement constrained banks rises during downturns (correlation of constrained banks and output is -0.85).

Counterfactuals

Higher Capital Requirements

Question: How much does a 50% increase of capital requirements (from 4% to 6% as in Basel III) affect outcomes?

- Higher cap. req. $\rightarrow$ banks substitute away from loans to securities $\rightarrow$ lower profitability. Figure Decision Rules
- Lower loan supply (-8%) $\rightarrow$ higher interest rates (+50 basis points), more chargeoffs (+12%), lower intermediated output (-9%).
- Entry/Exit drops (-45%) $\rightarrow$ lower taxes (-60%), more concentrated industry (less small banks (-14%)).

Table CR Competition Cyclical CR

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- Stackelberg game allows us to examine how policy changes which affect big banks spill over to the rest of the industry.

other

Related Research

C-D (2013) "A Quantitative Model of Banking Industry Dynamics"

- A quantitative segmented markets model where "big" national geographically diversified banks coexist in equilibrium with "smaller" regional and fringe banks that are restricted to a geographical area.
- Counterfactuals:
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  - Too-big-to-fail induces biggest banks to increase loan exposure which substitutes for small bank lending leading to lower profitability and entry.

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C-D (2015) "Foreign Competition and Banking Industry Dynamics"

- A General Equilibrium version of our model calibrated to the Mexican Economy to quantitatively assess how restrictions on foreign bank entry affect domestic loan rates and welfare.
- Foreign entry leads to lower interest rates but higher volatility due to exposure to foreign bank funding shocks.

Related Research - cont.

C-D-G-I-S (2017) "Structural Stress Tests"

- A structural model to conduct stress tests with endogenous "hurdle" (exit decision) which can be used to assess regulatory changes without Lucas critique concerns of reduced form statistical models (e.g. CLASS model)
- Adds borrower heterogeneity (commercial vs residential) and maturity transformation to the framework.

Appendix

Test III: Empirical Studies of Banking Crises, Default and Concentration

Model Dependent Variable	Logit Crisis_t	Linear Default Freq._t
Concentration_t	-3.77	0.0294
	$(0.86)^{***}$	$(0.001)^{***}$
GDP growth in t	0.81	-1.423
	$(0.09)^{***}$	$(0.021)^{***}$
Loan Supply Growth_t	-3.38	1.398
	$(1.39)^{**}$	$(0.0289)^{***}$
R^2	0.76	0.53

Note: SE in parenthesis.

- As in Beck, et. al. (2003), banking system concentration (market share of top 1%) 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). Return

Open Questions

- Why is market structure so different across countries?
    - In 2011, this is evident in the asset market share of the top 3 banks in the following countries (1/N with symmetric banks):
        - Germany: 78%
        - Japan: 44%
        - Mexico: 57%
        - Portugal: 89%
        - Spain: 68%
        - UK: 58%
        - US: 35%

Open Questions

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    - Spain: 68%
    - UK: 58%
    - US: 35%
- Does competition matter for crises?

Stress Tests - Reduced Form Approach

Hirtle, et. al. (2014) CLASS (Capital and Loss Assessment under Stress Scenarios) model:

1. Reduced form regressions:

$$y_{i,t} = \beta_0 + \beta_1 \cdot y_{i,t-1} + \beta_2 \cdot macro_t + \beta_3 \cdot x_{i,t} + \varepsilon_{i,t} \qquad (6)$$

   where $y_{i,t}$ is an N vector of key income or expense ratios across loan classes (e.g. net interest margin, net charge-offs), $x_{i,t}$ are firm specific characteristics such as shares of different types of loans in bank $i's$ portfolio, etc. NIMAR1

2. To translate the above ratios into dollar values to calculate net income position etc, the CLASS model assumes each bank's total assets (liabilities) grow at a fixed percentage rate of 1.25% per quarter over the stress test horizon and evaluates their capital buffer in response to shock.

Stress Tests - Structural Approach

After solving for optimal lending, capital buffer, dividend, and exit decision rules as a function of bank specific (e.g. a, δ) and macro (e.g. z, ζ) state variables, we can simply compute

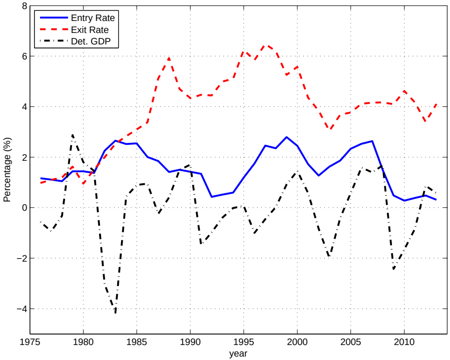
$$\mathbb{P}(x = 1|a, \delta, z, \zeta) = \mathbb{P}\left(W^{x=1}(\ell, d, A, \delta, \zeta, z') > W^{x=0}(\ell, d, A, \delta, \zeta, z')|a, \delta, z, \zeta\right) \quad (7)$$

where $W^{x=1}$ and $W^{x=0}$ are the charter values of the bank under exit and no-exit options.

- Evolution of the state variables (asset position a and bank size distribution ζ) and exit decision are endogenously determined.
- RW Capital ratios at which failure arises are higher than in CLASS model. Hurdle

Return

Entry and Exit Over the Business Cycle



- Trend in exit rate prior to early 90's due to deregulation
- Correlation of GDP with (Entry,Exit) =(0.25,0.22); with (Failure, Troubled, Mergers) =(-0.47, -0.72, 0.58) after 1990 (deregulation)

Exit Rate Decomposed   Return

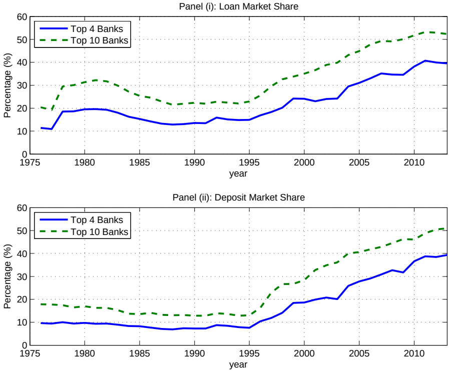
Entry and Exit by Bank Size

Fraction of Total x, accounted by:	Entry	Exit	Exit/Merger	Exit/Failure
	x			
Top 10 Banks	0.00	0.09	0.16	0.00
Top 1% Banks	0.33	1.07	1.61	1.97
Top 10% Banks	4.91	14.26	16.17	15.76
Bottom 99% Banks	99.67	98.93	98.39	98.03
Total Rate	1.71	3.92	4.57	1.35

Note: Big banks that exited by merger: 1996 Chase Manhattan acquired by Chemical Banking Corp. 1999 First American National Bank acquired by AmSouth Bancorp.

Definitions Frac. of Loans Return

Increase in Loan and Deposit Market Concentration



Return

Measures of Concentration in 2010

Measure	Deposits	Loans
Percentage of Total in top 4 Banks (C_4)	38.2	38.2
Percentage of Total in top 10 Banks	46.1	51.7
Percentage of Total in top 1% Banks	71.4	76.1
Percentage of Total in top 10% Banks	87.1	89.6
Ratio Mean to Median	11.1	10.2
Ratio Total Top 10% to Top 50%	91.8	91.0
Gini Coefficient	.91	.90
HHI : Herfindahl Index (National) (%)	5.6	4.3
HHI : Herfindahl Index (by MSA) (%)	19.6	20.7

Note: Total Number of Banks 7,092. Top 4 banks are: Bank of America, Citibank, JP Morgan Chase, Wells Fargo.

- High degree of imperfect competition $HHI \geq 15$
- National measure is a lower bound since it does not consider regional market shares (Bergstresser (2004)).

Return

Measures of Banking Competition

Moment	Value (%)	Std. Error (%)	Corr w/ GDP
Interest margin	4.56	0.30	-0.309
Markup	102.73	4.3	-0.203
Lerner Index	49.24	1.38	-0.259
Rosse-Panzar H	51.97	0.87	-

- 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 Figures Return

Costs by Bank Size

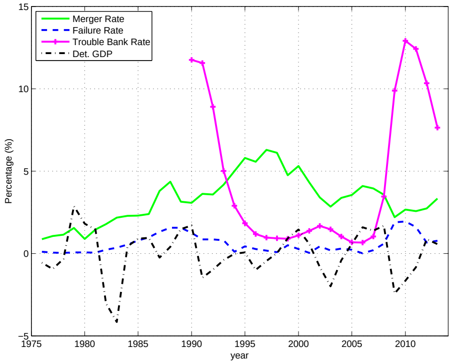
Table : Period 1984 - 2015

Moment (%)	Non-Int Inc.	Non-Int Exp.	Net Exp. (c^θ)	Fixed Cost ($\kappa^\theta/\ell^\theta$)	Avg Cost
Top 10	$3.45^\dagger$	$3.82^\dagger$	$0.37^\dagger$	$0.87^\dagger$	$1.25^\dagger$
Fringe	1.69	3.09	1.39	0.70	2.09

- Marginal Non-Int. Income, Non-Int. Expenses (estimated from trans-log cost function) and Net Expenses increase with size.
- Fixed Costs (normalized by loans) decrease in size.
- Average Costs decrease in size (consistent with evidence (e.g. Mester) for IRS in banking).
- Selection of only low cost banks in the competitive fringe may drive the Net Expense pattern.

Definitions Return

Exit Rate Decomposed



- Correlation of GDP with (Failure, Troubled, Mergers) =(-0.47, -0.72, 0.58) after 1990

Return

Definitions Entry and Exit by Bank Size

- Let $y \in \{\text{Top 4}, \text{Top 1\%}, \text{Top 10\%}, \text{Bottom 99\%}\}$
- let $x \in \{\text{Enter}, \text{Exit}, \text{Exit by Merger}, \text{Exit by Failure}\}$
- Each value in the table is constructed as the time average of "y banks that x in period t" over "total number of banks that x in period t".
- For example, Top $y = 1\%$ banks that "$x =$enter" in period t over total number of banks that "$x =$enter" in period t.

Return

Entry and Exit by Bank Size

Fraction of Loans of Banks in x, accounted by:	x Entry	Exit	Exit/Merger	Exit/Failure
Top 10 Banks	0.00	9.23	9.47	0.00
Top 1% Banks	21.09	35.98	28.97	15.83
Top 10% Banks	66.38	73.72	47.04	59.54
Bottom 99% Banks	75.88	60.99	25.57	81.14

Note: Big banks that exited by merger: 1996 Chase Manhattan acquired by Chemical Banking Corp. 1999 First American National Bank acquired by AmSouth Bancorp.

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:

$$\text{Markup}_{tj} = \frac{p_{\ell_{tj}}}{mc_{\ell_{tj}}} - 1 \tag{8}$$

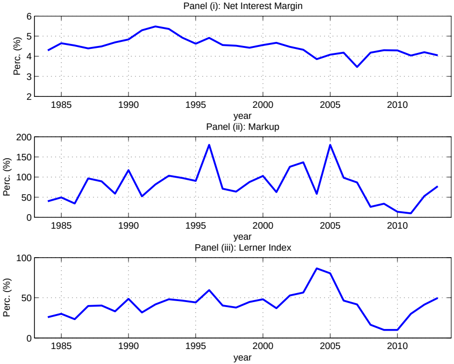
where $p_{\ell_{tj}}$ is the price of loans or marginal revenue for bank j in period t and $mc_{\ell_{tj}}$ is the marginal cost of loans for bank j in period t

- The Lerner index is defined as follows:

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

Return

Cyclical Properties



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

Balance Sheet: all variables

	Fraction Total Assets (%)	2000		2010	
		Small	Top 10	Small	Top 10
1	cash	5.52	6.23	7.61	7.73
2	fed funds sold	3.72	5.47	1.19	5.83
3	securities	20.73	12.39	19.10	19.86
4	safe	16.01	8.18	16.18	12.05
5	risky	4.72	4.21	2.92	7.80
6	trading assets	0.94	11.38	1.31	9.75
7	safe	0.07	1.29	0.17	0.83
8	risky	0.87	10.09	1.14	8.93
9	loans	62.88	55.52	61.45	45.75
10	fixed assets and other real estate	1.33	1.15	1.82	1.01
11	intangibles	1.30	2.22	2.79	3.50
12	other assets	3.58	5.64	4.73	6.57
13	deposits	69.69	62.22	71.99	69.17
14	insured	58.63	56.51	68.23	67.27
15	fed funds/repos	7.49	7.67	3.41	5.13
16	other borrowed money	10.31	7.52	9.05	6.49
17	trading liabilities	0.31	8.54	0.60	3.88
18	subordinated debt	0.87	2.18	0.72	1.55
19	other liabilities	2.30	4.16	2.05	3.46
20	equity	9.03	7.71	12.18	10.32
21	Tier 1 capital (rw)	10.19	7.81	13.93	11.35
22	Total capital (rw)	12.71	11.33	16.56	14.57

Def. Short BS Return

Balance Sheet Short Definitions

- Liquid Assets = 1+ 2
  (=cash + fed funds sold)
- Securities= 4 + 7
  (=Safe securities + safe trading assets)
- Loans = 5 + 8 + 9 - 17
  (=risky securities + risky trading assets + loans - trading liabilities)
- Other assets= 10+11+12- 18-19
  (=fixed assets + int. + other assets- sub. debt - other liabilities)
- fed funds/repos =15+16 (fed funds/repos + other borrowed money)
- Normalized Assets= 1+ 2 +4 + 7 +5 + 8 + 9 - 17
  (=Total Assets - Other assets)
- Capital Ratio (rw) = 21 (= Tier 1 capital (rw))

Balance Sheet (Long) Return

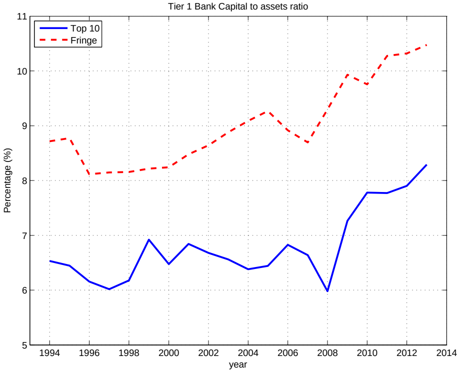
Regulation Capital Ratios

	Tier 1 to Total Assets	Tier 1 to Risk w/ Assets	Total Capital to Risk w/ Assets
Well Capitalized	$\geq 5\%$	$\geq 6\%$	$\geq 10\%$
Adequately Capitalized	$\geq 4\%$	$\geq 4\%$	$\geq 8\%$
Undercapitalized	$< 4\%$	$< 4\%$	$< 8\%$
Signif. Undercapitalized	$< 3\%$	$< 3\%$	$< 6\%$
Critically Undercapitalized	$< 2\%$	$< 2\%$	$< 2\%$

Source: DSC Risk Management of Examination Policies (FDIC). Capital (12-04).

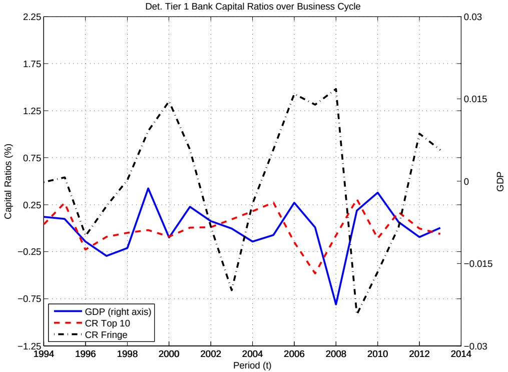
Return

Capital Ratios by Bank Size



- Capital Ratios (equity capital to assets) are larger for small banks.
- On average, capital ratios are above what regulation defines as "Well Capitalized" ($\geq 6\%$) further suggesting a precautionary motive. Return

Capital Ratio Over the Business Cycle



- Capital Ratio (over total assets) is countercyclical for small banks (corr. -0.42) and big banks (corr. -0.25).

Return

Business Cycle Correlations

Variable Correlated with GDP	Data
Loan Interest Rate r^L	-0.18
Exit Rate	-0.47
Entry Rate	0.25
Loan Supply	0.72
Deposits	0.22
Default Frequency	-0.61
Loan Return	-0.26
Charge Off Rate	-0.56
Interest Margin	-0.31
Lerner Index	-0.26
Markup	-0.20

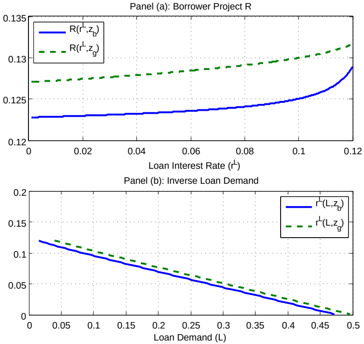
Return

Depositors

- Each hh is endowed with 1 unit of a good and is risk averse with preferences $u(c_t)$.
- HH's can invest their good in a riskless storage technology yielding exogenous net return $\overline{r}$.
- If they deposit with a bank they receive r_t^D even if the bank fails due to deposit insurance (funded by lump sum taxes on the population of households).
- If they match with an individual borrower, they are subject to the random process in (1).

Return

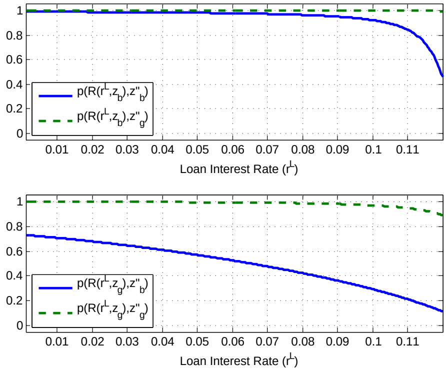
Borrower Project Choice & Inverse Loan Demand



- "Risk shifting" effect that higher interest rates lead borrowers to choose more risky projects as in Boyd and De Nicolo. Borrower Problem
- Thus higher loan rates can induce higher default frequencies. Fig.
- Loan demand is pro-cyclical.

Return Mkt Essentials Return Timing

Loan rates and default risk



- Higher loan rates induce higher default risk

Return

Big Bank Problem

The value function of a "big" incumbent bank at the beginning of the period is then given by

$$V^b(a,\delta,z,\zeta) = \max_{\ell,d\in[0,\delta],A\geq 0} \left\{\beta E_{z'|z} W^b(\ell,d,A,\zeta,\delta,z')\right\}, \tag{9}$$

s.t.

$$\begin{aligned} a+d &\geq A+\ell & (10)\\ e=\ell+A-d &\geq \varphi^b \ell & (11)\\ \ell + L^{s,f}(z,\zeta,\ell) &= L^d(r^L,z) & (12) \end{aligned}$$

where $L^{s,f}(z,\zeta,\ell) = \int \ell_i^f(a,\delta,z,\zeta,\ell^b)\zeta^f(da,d\delta)$.

- Market clearing (12) defines a "reaction function" where the dominant bank takes into account how fringe banks' loan supply reacts to its own loan supply.

▸ Fringe Decision Making ▸ Return OPT

Big Bank Problem - Cont. Return OPT

The end of period function is given by

$$W^b(\ell, d, A, \eta, \delta, z') = \max_{x\in\{0,1\}} \left\{W^{b,x=0}(\ell, d, A, \eta, \delta, z'), W^{b,x=1}(\ell, d, A, \eta, \delta, z')\right\}$$

$$W^{b,x=0}(\ell, d, A, \eta, \delta, z') = \max_{B' \le \frac{A}{(1+r^B)}} \left\{\mathcal{D}^b + E^b_{\delta'|\delta} V^b(a', \delta', z', \eta')\right\}$$

$$\begin{array}{lrcl} \text{s.t.} & \mathcal{D}^b & = & \begin{cases} \pi^b(\ell, d, a', \eta, z') + B' & \text{if } \pi^b(\cdot) + B' \ge 0 \\ \pi^b(\ell, d, a', \eta, z') + B' - \zeta^b(\pi^b(\cdot) + B', z') & \text{if } \pi^b(\cdot) + B' < 0 \end{cases} \\ & a' & = & A - (1 + r^B)B' \ge 0 \\ & \eta' & = & H(z, \eta, z') \end{array}$$

$$W^{b,x=1}(\ell, d, A, \eta, \delta, z') = \max\Big\{\xi\big[\{p(R, z')(1 + r^L) + (1 - p(R, z'))(1 - \lambda) - c^b\}\ell\big] + (1 + r^a)A - d(1 + r^D) - \kappa^b, 0\Big\}.$$

Bank Entry

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

$$V^{\theta,e}(z,\eta,z') \equiv \max_{a'} \Big\{ -(a'+\Upsilon^{\theta}) - \zeta^{\theta}(a'+\Upsilon^{\theta}) + E_{\delta'} V^{\theta}(a',\delta',z',H(z,\eta,z')) \Big\} \quad (13)$$

- Entry occurs as long as $V^{\theta,e}(z,\eta,z') \geq 0$.
- The argmax of (13) defines the initial equity distribution of banks which enter.
- Free entry implies that

$$V^{\theta,e}(z,\zeta,z') \times E^{\theta} = 0 \quad (14)$$

where E^f denotes the mass of fringe entrants and E^b the number of big bank entrants.

Return EE

Evolution of Cross-sectional Bank Size Distribution

- Given any sequence (z, z'), the distribution of fringe banks evolves according to

$$\eta(\mathbf{A} \times \mathbf{D}) = \int \sum_{\delta} Q((a,\delta), z, z', \mathbf{A} \times \mathbf{D})\eta(da, \delta) \tag{15}$$

$$\begin{aligned} Q((a,\delta), z, z', \mathbf{A} \times \mathbf{D}) = \quad & \sum_{\delta' \in \mathbf{D}} (1 - x^f(a, \delta, z, \eta, z')) I_{\{a^f(a,\delta,z,\eta) \in \mathbf{A})\}} G^f(\delta', \delta) \\ & + E^f I_{\{a^{f,e}(z',\eta) \in \mathbf{A})\}} \sum_{\delta' \in \mathbf{D}} G^{f,e}(\delta). \end{aligned} \tag{16}$$

- (16) makes clear how the law of motion for the distribution of banks is affected by entry and exit decisions.

Return BSD

Taxes to cover deposit insurance

- Across all states (η, z, z'), taxes must cover deposit insurance in the event of bank failure.

- Let post liquidation net transfers be given by

$$\Delta^{\theta} = (1 + r^D)d^{\theta} - \xi\left[\{p(1 + r^L) + (1 - p)(1 - \lambda) - c^{\theta}\}\ell^{\theta} + \tilde{a}^{\theta'}(1 + r^a)\right]$$

where $\xi \leq 1$ is the post liquidation value of the bank's assets and cash flow.

- Then aggregate taxes are

$$\tau(z, \eta, z') \cdot \Xi = \int x^f \max\{0, \Delta^f\} d\eta^f(a, \delta) + x^b \max\{0, \Delta^b\}$$

Return Timing

Incumbent Bank Decision Making

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

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

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

Return

Fringe Bank Problem

The value function of a fringe incumbent bank at the beginning of the period is then given by

$$V^f(a, \delta, z, \eta) = \max_{\ell \geq 0, d \in [0,\delta], A \geq 0} \left\{ \beta E_{z'|z} W^f(\ell, d, A, \delta, \eta, z') \right\},$$

s.t.

$$a + d \geq A + \ell \tag{17}$$

$$\ell(1 - \varphi^f) + A(1 - w\varphi^f) - d \geq 0 \tag{18}$$

$$\ell^b(\eta) + L^f(\zeta, \ell^b(\eta)) = L^d(r^L, z) \tag{19}$$

Fringe banks use the decision rule of the dominant bank in the market clearing condition (19).

Return

Solution Approach

Return Def. Eq.

- Solve the model using a variant of Krusell and Smith (1998) and Farias, Saure, and Weintraub (2012).
- Main difficulty arises in approximating the distribution of fringe banks and computing the reaction function from the fringe sector to clear the loan market:

$$\ell^b(a,\delta,z,\eta) + \underbrace{\int_{\mathbf{A}\times\mathbf{D}} \ell^f(a,\delta,z,a^b,\delta^b,\eta,\ell^b)d\eta(a,\delta)}_{=L^{s,f}(z,a^b,\delta^b,\eta,\ell^b)} = L^d(r^L,z)$$

- Approximate the cross-sectional distn of fringe banks using a finite set of moments:
  - the cross-sectional avg of assets plus deposits (denoted $\mathcal{A}$) 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

$$\mathcal{A} = \int_{\mathbf{A}\times\mathbf{D}} (a+\delta)d\eta(a,\delta), \quad \mathcal{M} = \int_{\mathbf{A}\times\mathbf{D}} d\eta(a,\delta)$$

Solution Approach (cont.)

Return Def. Eq.

- The evolution of these moments is approximated using a log-linear function that has $\{a^b, \delta^b, z, \mathcal{A}, \mathcal{M}, z'\}$ as states.

- The mass of entrants E^f and incumbents $\mathcal{M}$ are linked since

$$\eta'(a', \delta') = T^*(\eta(a, \delta)) + E^f \int_{\mathbf{D}} I_{a'=a^{f,e}} G^{f,e}(\delta)$$

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

- For each combination of state variables $\{a^b, \delta^b, z, \mathcal{A}, \mathcal{M}\}$ we iterate on $\ell^b(\cdot)$ and and the reaction function $L^{s,f}(\cdot)$ until we find a fixed point (i.e. the equilibrium in the Stackelberg game).

$$\ell^{b^*}(a^b, \delta^b, z, \mathcal{A}, \mathcal{M}) + L^{s,f}(a^b, \delta^b, z, \mathcal{A}, \mathcal{M}, \ell^{b^*}(\cdot)) = L^d(r^L, z)$$

Computational Algorithm

1. Guess **aggregate functions**. Make an initial guess of $L^f(a^b, \delta^b, z, \mathcal{A}, \mathcal{M})$ and the law of motion for $\mathcal{A}'$ and $\mathcal{M}'$.

$$L^f = H^{\mathcal{L}}(a^b, \delta^b, z, \mathcal{A}, \mathcal{M}).$$
$$\log(\mathcal{A}') = H^{\mathcal{A}}(a^b, \delta^b, z, \mathcal{A}, \mathcal{M}, z').$$
$$\log(\mathcal{M}') = H^{\mathcal{M}}(a^b, \delta^b, z, \mathcal{A}, \mathcal{M}, z').$$

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 $\{a_t^b, \mathcal{A}_t, \mathcal{M}_t\}_{t=1}^T$ and update aggregate functions. If convergence achieved stop. If not, return to (2).

Return Parametrization | Return Def. Eq.

Parameterization

For the stochastic deposit matching process, we use data from our panel of U.S. commercial banks:

- Assume dominant bank support is large enough so that the constraint never binds.

- For fringe banks, use Arellano and Bond to estimate the AR(1)

$$\log(\delta_{it}) = (1-\rho_d)k_0 + \rho_d \log(\delta_{it-1}) + k_1 t + k_2 t^2 + k_{3,t} + a_i + u_{it} \quad (20)$$

  where t denotes a time trend, $k_{3,t}$ are year fixed effects, and u_{it} is iid and distributed $N(0, \sigma_u^2)$.

- Discretize using Tauchen (1986) method with 5 states. Discrete Process

- Computation: Variant of Ifrach/Weintraub (2012), Krusell/Smith (1998) Details

Return

Parameterization

Parameter		Value	Target
Dep. preferences	σ	2	Part. constraint
Agg. shock in good state	z_g	1	Normalization
Deposit interest rate (%)	$\bar{r} = r^d$	0.86	Int. expense
Net. non-int. exp. n bank	c^b	1.55	Net non-int exp. Top 1%
Net. non-int. exp. r bank	c^f	1.87	Net non-int exp. bottom 99%
Charge-off rate	λ	0.21	Charge off rate
Autocorrel. Deposits	ρ_d	0.83	Deposit Process Bottom 99%
Std. Dev. Error	σ_u	0.20	Deposit Process Bottom 99%
Securities Return (%)	r^a	0.92	Avg. Return Securities
Cost overnight funds	r^B	0.00	Fed Funds Rate
Capital Req. Top 10	(φ^b, w)	$(4.0, 0)$	Capital Regulation
Capital Req. Fringe	(φ^f, w)	$(4.0, 0)$	Capital Regulation

Return Mom

Parameters Chosen within Model

Parameter		Value	Targets
Agg. shock in crisis state	z_c	0.95	Freq. Top 10 bank exit
Agg. shock in bad state	z_b	0.978	Std. dev. Output
Weight agg. shock	α	0.886	Std. dev. net-int. margin
Success prob. param.	b	3.870	Borrower Return
Volatility borrower's dist.	σ_ϵ	0.106	Std. deviation default frequency
Success prob. param.	ψ	0.793	Net Interest Margin
Mean Entrep. project Dist.	μ_e	-0.84	Default freq.
Max. reservation value	$\overline{\omega}$	0.252	Elasticity Loan Demand
Discount Factor	β	0.96	Loans to asset ratio Top 10
Salvage value	ξ	0.71	Loans to asset ratio fringe
Mean Deposits	μ_d	0.043	Deposit mkt share fringe
Fixed cost b bank	κ^b	0.001	Fixed cost over loans top 10
Fixed cost f banks	κ^f	0.001	Fixed cost over loans fringe
Entry Cost f banks	Υ^f	0.002	Bank entry rate
Entry Cost b bank	Υ^b	0.007	Bank exit rate
Equity Issuance Cost	ζ^0	0.050	Equity Issuance over Assets Top 10
Equity Issuance Cost	ζ^1	30.00	Equity Issuance over Assets Fringe
			Equity over (r-w) assets top 10
			Equity over (r-w) weighted assets fringe

Note: ▸ Functional Forms ▸ Return Mom

Markov Process Matched Deposits

- The finite state Markov representation $G^f(\delta', \delta)$ obtained using the method proposed by Tauchen (1986) and the estimated values of μ_d, ρ_d and σ_u is:

$$G^f(\delta', \delta) = \begin{bmatrix} 0.632 & 0.353 & 0.014 & 0.000 & 0.000 \\ 0.111 & 0.625 & 0.257 & 0.006 & 0.000 \\ 0.002 & 0.175 & 0.645 & 0.175 & 0.003 \\ 0.000 & 0.007 & 0.257 & 0.625 & 0.111 \\ 0.000 & 0.000 & 0.014 & 0.353 & 0.637 \end{bmatrix},$$

- The corresponding grid is $\delta \in \{0.019, 0.028, 0.040, 0.057, 0.0.081\}$.

- The distribution $G^{e,f}(\delta)$ is derived as the stationary distribution associated with $G^f(\delta', \delta)$.

Return

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 $N(\mu_{\varepsilon}, \sigma_{\varepsilon}^2)$.
- Define success to be the event that $y > 0$, so in states with higher z or higher ε_e success is more likely. Then

$$p(R, z')1 - \Phi\left(\frac{-\alpha z' + bR^{\psi}}{(1-\alpha)}\right) \tag{21}$$

where $\Phi(x)$ is a normal cumulative distribution function with mean (μ_{ε}) and variance σ_{ε}^2.

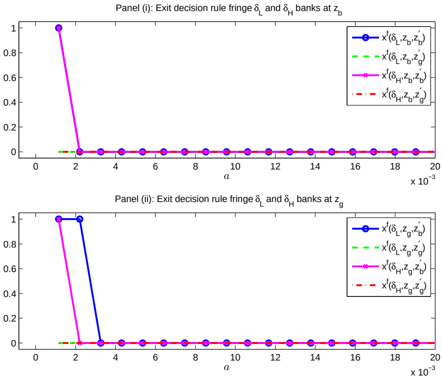
Return

Definition Model Moments

Aggregate loan supply	$L^s(z,\eta) = \ell^b + L^f(z,\eta,\ell^b)$
Aggregate Output	$L^s(z,\eta)\Big\{p(z,\eta,z')(1+z'R) + (1-p(z,\eta,z'))(1-\lambda)\Big\}$
Entry Rate	$E^f / \int \eta(a,\delta)$
Default frequency	$1 - p(R^*, z')$
Borrower return	$p(R^*, z')(z'R^*)$
Loan return	$p(R^*, z')r^L(z,\eta) + (1-p(R^*,z'))\lambda$
Loan Charge-off rate	$(1-p(R^*,z'))\lambda$
Interest Margin	$p(R^*, z')r^L(z,\eta) - r^d$
Loan Market Share Bottom 99%	$L^f(\eta,\ell^b(\eta))/\Big(\ell^b(\eta) + L^f(\eta,\ell^b(\eta))\Big)$
Deposit Market Share Bottom 99%	$\frac{\int_{a,\delta} d^f(a,\delta,z,\eta)d\zeta(a,\delta)}{\int_{a,\delta} d^f(a,\delta,z,\eta)d\eta(a,\delta)+d^b(a,\delta,z,\eta)}$
Capital Ratio Bottom 99%	$\int_{a,\delta}[\tilde{e}^f(a,\delta,z,\eta)/\ell^f(a,\delta,z,\eta)]d\eta(a,\delta)/\int_{a,\delta} d\eta(a,\delta)$
Capital Ratio Top 1%	$\tilde{e}^b(a,\delta,z,\eta)/\ell^b(a,\delta,z,\eta)$
Securities to Asset Ratio Bottom 99%	$\frac{\int_{a,\delta}[\tilde{a}^f(a,\delta,z,\eta)/(\ell^f(a,\delta,z,\eta)+\tilde{a}^f(a,\delta,z,\eta))]d\zeta(a,\delta)}{\int_{a,\delta} d\zeta(\tilde{a},\delta)}$
Securities to Asset Ratio Top 1%	$\tilde{a}^b(a,\delta,z,\eta)/(\ell^b(a,\delta,z,\eta)+\tilde{a}^b(a,\delta,z,\eta))$
Profit Rate	$\frac{\pi_{\ell_i(\theta)}(\cdot)}{\ell_i(\theta)}$
Lerner Index	$1 - \Big[r^d + c^{\theta,exp}\Big] / \Big[p(R^*(\eta,z),z',s')r^L(\eta,z) + c^{\theta,inc}\Big]$
Markup	$\Big[p^j(R^*(\eta,z),z',s')r^L(\eta,z) + c^{\theta,inc}\Big] / \Big[r^d + c^{\theta,exp}\Big] - 1$

Return

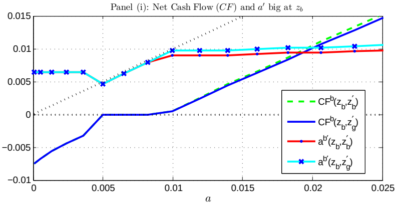
Fringe Bank Exit Rule across $\delta's$

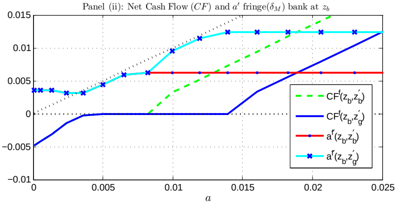


- Fringe banks with low assets are more likely to exit, particularly if they are small δ_L.

Return

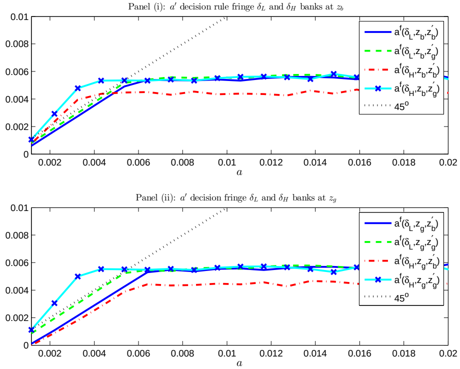
Big and Median Buffer and Cash Flow Policy





- Banks issue equity $(CF = \pi + B < 0)$ to continue when assets are low
- They pay dividends $(CF \geq 0)$ when unconstrained optimum level of assets can be achieved without external finance
- Banks accumulate more assets in good times (marginal value is higher) return

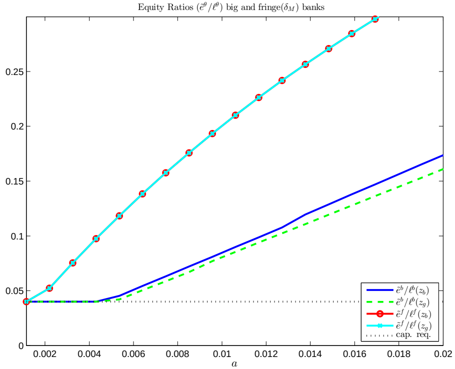
FRINGE BANKS $a^{f'}$ (DIFFERENT $\delta's$)



- The smallest fringe bank is more cautious than the largest fringe bank.

Return

Big and Median Fringe Capital Ratios $\tilde{e}^{\theta}/\ell^{\theta}$



- Recall that $\tilde{e}^{\theta}/\ell^{\theta} = (\ell^{\theta} + \tilde{a}^{\theta\prime} - d^{\theta})/\ell^{\theta}$
- The capital requirement is binding for the big bank at low asset levels but at higher asset levels becomes higher in recessions relative to booms.

Return Return Definition

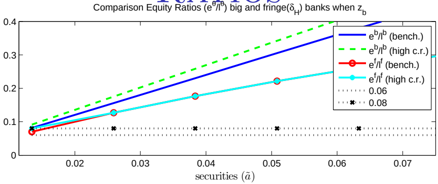
Monetary Policy and Bank Lending

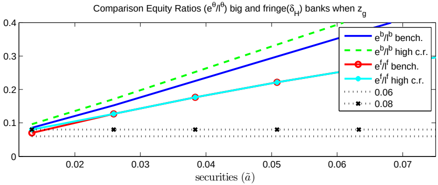
	Benchmark	Lower r^B	Δ (%)
Capital Ratio Top 10	4.23	5.43	28.43
Capital Ratio Fringe	13.10	13.39	2.19
Entry/Exit Rate (%)	1.547	1.904	23.09
Loans to Asset Ratio Top 10	96.31	73.84	-23.33
Loans to Asset Ratio Fringe	93.47	43.47	-53.49
Measure Banks Fringe	2.83	11.63	311.07
Loan mkt sh. Fringe (%)	53.93	45.69	-15.28
Loan Supply	0.229	0.344	50.19
L^s to Int. Output ratio (%)	89.47	89.23	-0.26
Loan Interest Rate (%)	6.79	3.85	-43.23
Borrower Project (%)	12.724	12.652	-0.57
Default Frequency (%)	2.69	1.61	-40.02
Avg. Markup	111.19	35.20	-68.34
Int. Output	0.26	0.39	50.58
Taxes/Output (%)	0.07	0.09	24.99

Return

- Reducing the cost of funds increases the value of the bank resulting in a large influx of fringe banks
- Reduction in borrowing cost relaxes ex-post constraint: higher big bank loan supply, lower interest rates and lower default rates.

Higher Capital Requirements and Equity Ratios





- Major impact for big bank: higher concentration and profits allow the big bank to accumulate more securities.
- Fringe banks with very low level of securities are forced to increase its capital level resulting in a lower continuation value (everything else equal).

Return

Capital Requirement Counterfactual

Question: How much does a 50% increase of capital requirements affect outcomes? Return Table No Cap. Requirements

Moment (%)	Benchmark ($\varphi = 4\%$)	Higher Cap. Req. ($\varphi = 6\%$)	Change (%)
Capital Ratio Top 10	4.23	6.09	44.19
Capital Ratio Fringe	13.10	15.67	19.57
Entry/Exit Rate (%)	1.547	0.843	-45.54
Sec. to Asset Ratio Top 10	3.68	5.57	51.19
Sec. to Asset Ratio Fringe	6.52	7.00	7.36
Measure Banks Fringe	2.83	2.41	-14.64
Loan mkt sh. Fringe (%)	53.93	52.15	-3.30
Loan Supply	0.229	0.209	-8.71
L^s to Int. Output ratio (%)	89.47	89.54	0.08
Loan Interest Rate (%)	6.79	7.30	7.56
Borrower Project (%)	12.724	12.742	0.14
Default Frequency (%)	2.69	3.01	12.19
Avg. Markup	111.19	123.51	11.08
Int. Output	0.26	0.23	-8.78
Taxes/Output (%)	0.07	0.03	-58.97

Capital Requirements and Competition

Question: How much does imperfect competition affect capital requirement counterfactual predictions? Return

Moment (%)	Benchmark Model $\varphi = 4\%$	Benchmark Model $\varphi = 6\%$	Benchmark Model Δ (%)	Perfect Competition $\varphi = 4\%$	Perfect Competition $\varphi = 6\%$	Perfect Competition Δ (%)
Capital Ratio (%)	13.10	15.667	19.57	9.92	11.77	18.64
Entry/Exit Rate (%)	1.55	0.84	-45.54	0.81	0.69	-14.81
Measure Banks	2.83	2.414	-14.64	5.36	5.13	-4.13
Loan Supply	0.23	0.21	-8.71	0.25	0.24	-2.46
Loan Int. Rate (%)	6.79	7.30	7.56	6.27	6.43	2.50
Borr. Proj. (%)	12.724	12.742	0.14	12.71	12.71	0.04
Def. Freq. (%)	2.69	3.01	12.19	2.44	2.51	3.07
Avg. Markup	111.19	123.51	11.08	113.91	118.58	4.11
Int. Output	0.26	0.23	-8.78	0.28	0.27	-2.47
L^s to output (%)	89.47	89.54	0.08	89.42	89.43	0.02
Taxes/output (%)	0.07	0.03	-58.97	0.126	0.107	-15.20

- Policy effects are muted in the perfectly competitive environment.

Imperfect Competition and Volatility

Coefficient of Variation (%)	Benchmark Model	Perfect Competition ($\uparrow \Upsilon^b$)	Change (%)
Loan Interest Rate	4.92	1.78	-63.78
Borrower Return	6.99	6.17	-11.75
Default Frequency	2.08	2.15	3.36
Int. Output	7.46	2.09	-72.03
Loan Supply	7.208	1.127	-84.37
Capital Ratio Fringe	13.83	12.07	-12.70
Measure Banks	0.79	1.90	139.71
Markup	4.73	1.56	-67.02
Loan Supply Fringe	3.13	1.127	-64.05

Return

Imperfect Competition and Business Cycle Correlations

	Benchmark	Perfect Comp.	data
Loan Interest Rate r^L	-0.96	-0.36	-0.18
Exit Rate	-0.07	-0.16	-0.25
Entry Rate	0.01	-0.19	0.62
Loan Supply	0.97	0.61	0.58
Deposits	0.95	0.02	0.11
Default Frequency	-0.21	-0.80	-0.08
Loan Interest Return	-0.47	0.65	-0.49
Charge Off Rate	-0.22	-0.80	-0.18
Markup	-0.96	0.29	-0.19
Capital Ratio Top 1%	-0.16	-	-0.75
Capital Ratio Bottom 99%	-0.03	-0.05	-0.12

Return

The role of Capital Requirements

Question: What if there are no capital requirements? Return

	Benchmark Model			Perfect Competition		
Moment	$\varphi = 4\%$	No CR	Δ (%)	$\varphi = 4\%$	No CR	Δ (%)
Cap. ratio top 10	4.23	0.19	-87.41	-	-	-
Cap. ratio bottom Fringe	13.10	15.73	20.05	9.92	6.67	-32.71
Entry/Exit Rate (%)	1.55	4.81	210.75	0.81	1.04	28.50
Loan mkt sh. Fringe (%)	53.93	87.44	62.14	100	100	0.0
Measure Banks	2.83	4.54	60.54	5.36	5.32	-0.68
Loan Supply	0.23	0.16	-28.44	0.25	0.24	-3.06
Loan Int. Rate (%)	6.79	8.47	24.83	6.27	6.47	3.11
Borrower Proj. (%)	12.72	12.81	0.67	12.71	12.71	0.04
Default Freq. (%)	2.69	4.74	76.39	2.44	2.53	3.79
Avg. Markup	111.19	177.73	59.84	113.91	119.74	5.12
Int. Output	0.26	0.18	-28.57	0.28	0.27	-3.08
L^s to output ratio (%)	89.47	89.63	0.18	89.42	89.44	0.02
Taxes/GDP (%)	0.07	0.11	55.80	12.60	17.22	36.72

- No capital requirement relaxes ex-ante constraint: higher entry/exit rate, larger measure of small banks, big bank acts strategically lowering its loan supply leading to higher interest rates and higher default rates.

Countercyclical Capital Requirements

Question: What if capital requirements are higher in good times?

	Benchmark ($\varphi = 0.04$)	Countercyclical CR ($\varphi(z_b) = 0.06$, $\varphi(z_g) = 0.08$)	Δ (%)
Capital Ratio Top 10	4.23	25.13	494.65
Capital Ratio Bottom Fringe	13.10	12.66	-3.38
Entry/Exit Rate (%)	1.547	0.001	-99.94
Measure Banks Fringe	2.83	1.55	-45.33
Loan mkt sh. Fringe (%)	53.93	26.47	-50.91
Securities to Asset Ratio Top 10	3.68	21.09	472.48
Securities to Asset Ratio Fringe	6.52	25.51	291.26
Loan Supply	0.229	0.206	-10.08
L^s to Int. Output ratio (%)	89.47	89.53	0.07
Loan Interest Rate (%)	6.79	7.38	8.76
Borrower Project (%)	12.724	12.748	0.19
Default Frequency (%)	2.69	2.98	10.91
Avg. Markup	111.19	114.02	2.55
Int. Output	0.26	0.23	-10.11
Taxes/Output (%)	0.07	0.01	-87.57

Return

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Question: How much does imperfect competition affect capital requirement counterfactual predictions?

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- Lower profitability leads to lower entry (drops 50%) but higher total exits ($M \cdot x$) $\rightarrow$ higher taxes/output.

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Return CR

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- Lower profitability leads to lower entry (drops 50%) but higher total exits ($M \cdot x$) $\rightarrow$ higher taxes/output.
- Volatility of almost all variables decrease $\rightarrow$ average capital ratio is 12% lower (reduced precautionary holdings). ▸ Table
- Some correlations are inconsistent with the data; for example, strong countercyclicality of the default frequency (10 times the data) results in procyclical loan interest returns and markups. ▸ Table

▸ Return CR

C-D 2013: Too-Big-To-Fail

Question: How much does too big to fail affect risk taking?
Counterfactual where the national bank is guaranteed a subsidy in states with negative profits.

National Bailout Bank Problem

Moment	Benchmark	Nat. Bank Bailout Change (%)
Loan Supply	0.78	6.13
Loan Interest Rate (%)	5.69	-8.85
Markup	108.44	-15.04
Market Share bottom 99%	39.64	-7.06
Market Share Top 10 / Top 1%	20.97 / 39.38	52.02 / -20.57
Prob. Exit Top 10 / Top 1%	0 / 1.67	n.a. / 65.87
Borrower Risk Taking R (%)	14.78	-0.02
Default Frequency (%)	1.22	-2.13
Entry/Exit Rate (%)	2.78	-0.11
Int. Output	0.89	6.15
Taxes/Output (%)	17.84	9.79

- National bank increases loan exposure to region with high downside risk while loan supply by other banks falls (spillover effect). Net effect is higher aggregate loans, lower interest rates and default frequencies. more
- Lower profitability reduces smaller bank entry.

National Bank Problem under Too Big to Fail

- If realized profits for a national bank are negative, then the government covers the losses so that the bank stays in operation.

- The problem of a national bank becomes

$$V_i(n,\cdot,\mu,z,s;\sigma_{-i}) = \max_{\{\ell_i(n,j)\}_{j=e,w}} E_{z',s'|z,s}\Big[\sum\nolimits_{j=e,w}$$
$$\max\Big\{0, \pi_{\ell_i(n,j)}(n,j,c^n,\mu,z,s,z',s';\sigma_{-i})\Big\} + \beta V_i(n,\cdot,\mu',z',s';\sigma_{-i})\Big]$$

subject to

$$\sum_{\theta}\int \ell_i(\theta,j,\mu,s,z;\sigma_{-i})\mu^{(\theta,j)}(di) - L^{d,j}(r^{L,j},z,s) = 0,$$

where $L^{d,j}(r^{L,j},z,s)$ is given in (4).

Return

Too-Big-to-Fail (cont.)

Table : Benchmark vs Too Big to Fail

	Loan Decision Rules $\bar{\ell}(\theta, j, \mu, z, e)$ $(\mu = \{1, 1, 1, \cdot\}, z = z_b, s = e)$			
Model	$\bar{\ell}(n, e, \cdot)$	$\bar{\ell}(n, w, \cdot)$	$\bar{\ell}(r, e, \cdot)$	$\bar{\ell}(r, w, \cdot)$
Dynamic (benchmark)	7.209	82.562	45.450	31.483
National Bank Bailouts	85.837	82.562	32.668	31.483

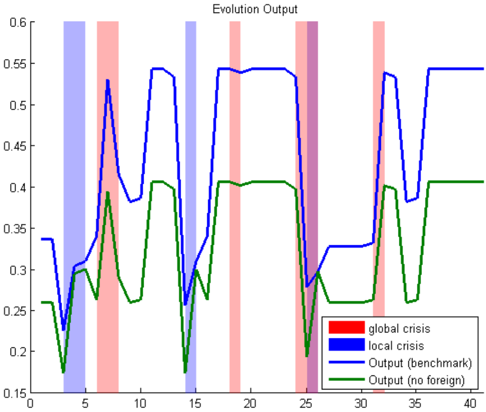
The possible loss of charter value without too-big-to-fail is enough to induce national banks to lower loan supply in order to reduce exposure to risk. Return

Allowing Foreign Bank Competition

Moment	Data	$\Upsilon^f = \infty$	Benchmark
Loan Market Share Foreign %	69.49	0.00	56.63
Loan Interest margin %	6.94	9.89	7.76
Dividend / Asset Foreign %	4.15	-	3.94
Dividend / Asset National %	2.07	6.56	4.11
Avg. Equity issuance Foreign %	3.65	-	0.83
Avg. Equity issuance National %	2.83	1.44	0.30
Exit Rate Foreign %	2.29	-	2.72
Exit Rate Domestic %	3.78	0.00	3.98
Entry Rate %	2.66	0.00	5.66
Default Frequency %	4.01	6.31	6.13
Charge off Rate %	2.12	1.25	1.21
Output	-	0.33	0.43
Loan Supply	-	0.28	0.37
Taxes / Output	-	0.00	1.57

- Less concentrated industry with lower interest rate margins, higher exit rates with banks more exposed to risk and more volatile
- Lower interest rates $\rightarrow$ lower default frequency and charge off rates
- Higher output, loan supply but higher taxes as well

Foreign Bank Competition: Real Effects



- Foreign bank competition induces higher output and larger output and credit contractions/expansion due to changes in domestic conditions
- Volatility of output and loan supply increases (+12.91% and 10.11%)

Welfare Consequences

Question: What are the welfare consequences of allowing foreign bank competition?

	z_c		z_b		z_g	
	η_L	η_H	η_L	η_H	η_L	η_H
$f(\mu=\{0,1\},z,\eta)$	10.72	2.81	30.02	9.90	38.65	7.90
$\alpha_h(\mu=\{0,1\},z,\eta)$	0.54	0.52	0.72	0.73	0.93	0.96
$\overline{\alpha}_h$	**0.799**					
$\alpha_e(\mu=\{0,1\},z,\eta)$	4.09	3.89	5.44	5.27	6.11	5.87
$\overline{\alpha}_e$	**5.527**					
$\alpha_e(\mu=\{0,1\},z,\eta)$	4.63	4.42	6.17	6.00	7.04	6.83
$\overline{\alpha}_e$	**6.326**					

Decomposing Effects: Higher Competition vs Foreign Competition
Return

Decomposing Effects: Higher Competition or Foreign Competition?

Question: What are the welfare consequences of allowing foreign bank competition from a domestic banking sector with high competition?

	z_c		z_b		z_g	
	η_L	η_H	η_L	η_H	η_L	η_H
$\alpha_h(\mu=\{0,1\},z,\eta)$	0.11	0.13	0.14	0.23	0.11	0.41
$\alpha_h(\mu=\{1,0\},z,\eta)$	0.60	0.74	0.38	0.66	0.78	0.74
$\alpha_h(\mu=\{1,1\},z,\eta)$	0.48	0.48	0.49	0.52	0.69	0.64
$\overline{\alpha}_h$	**0.577**					
$\alpha_e(\mu=\{0,1\},z,\eta)$	1.21	0.94	1.66	0.97	1.06	0.94
$\alpha_e(\mu=\{1,0\},z,\eta)$	0.73	0.71	0.84	0.82	0.98	0.93
$\alpha_e(\mu=\{1,1\},z,\eta)$	0.85	0.82	0.86	0.80	1.11	1.04
$\overline{\alpha}_e$	**0.960**					
$\alpha_e(\mu=\{0,1\},z,\eta)$	1.32	1.07	1.80	1.20	1.16	1.34
$\alpha_e(\mu=\{1,0\},z,\eta)$	1.33	1.45	1.21	1.48	1.76	1.67
$\alpha_e(\mu=\{1,1\},z,\eta)$	1.32	1.30	1.35	1.31	1.80	1.68
$\overline{\alpha}_e$	**1.537**					

Test 2: The Bank Lending Channel

Question: Kashyap and Stein (2000) ask "Is the impact of monetary policy on lending behavior stronger for banks with less liquid balance sheets, where liquidity is measured by the ratio of securities to assets?

- They find strong evidence in favor of this bank lending channel.
- We analyze a reduction in r^B (overnight borrowing rate) from 1.2% to 0% on a pseudo-panel of banks from the model.
- In the first stage, we estimate the following cross-sectional regression for each t:

$$\Delta L_{it} = a_0 + \beta_t B_{it-1} + u_t$$

where $\Delta L_{it} = \frac{\ell_{it} - \ell_{it-1}}{\ell_{it-1}}$, and $B_{it} = \frac{a'_{it}}{(a'_{it} + \ell_{it})}$ is the measure of liquidity

- Then use the sequence of β_t to estimate the second stage as follows

$$\beta_t = b_0 + b_1 \Delta \text{output}_t + \phi dM_t$$

where dM_t is a dummy variable that equals 1 if $r^B_t = 0\%$

Expansionary Policy and Bank Lending - cont.

Question: Kashyap and Stein ask "Is the impact of monetary policy on lending behavior stronger for banks with less liquid balance sheets, where liquidity is measured by the ratio of securities to assets?

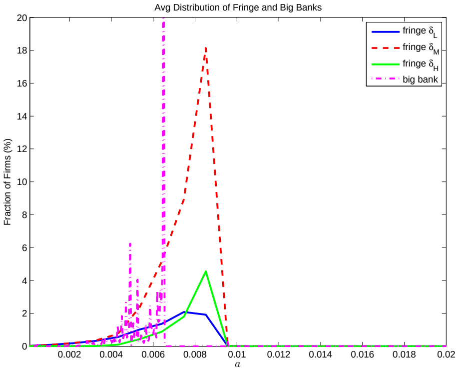
Sample	Bottom 99%	Bottom 92%
	β_t	β_t
Monetary Policy: dM_t	-0.929	-1.177
s.e.	0.2575***	0.2521***
Δoutput$_t$	2.53	2.306
s.e.	0.619***	0.586***
N	5000	5000
R^2	0.35	0.46

Note: *** significant at 1% level

- Our results are consistent with those presented in Kashyap and Stein.
- We find that $\frac{\partial\left(\frac{\partial L_{it}}{\partial B_{it}}\right)}{\partial M_t} < 0$ and that $\frac{\partial L^3_{it}}{\partial B_{it}\partial M_t \partial size_{it}} > 0$ (i.e. the mechanism at play is stronger for the smallest size banks).

Return

Long Run Asset Distn. of Big/Small Banks



- Average asset holdings of the big bank is lower than that of fringe banks.

Return

Timing

At the beginning of period t,

1. Liquidity shocks are realized δ_t.
2. Starting from beginning of period state (ζ_t, z_t), borrowers draw ω_t.
3. Dominant bank chooses (ℓ_t^b, d_t^b, A_t^b).
4. Having observed ℓ_t^b, fringe banks choose (ℓ_t^f, d_t^f, A_t^f). Borrowers choose whether or not to undertake a project and if so, R_t.
5. Return shocks z_{t+1} are realized, as well as idiosyncratic project success shocks.
6. Banks choose B_{t+1}^{θ} and dividend policy. Exit and entry decisions are made (in that order).
7. Households pay taxes τ_{t+1} to fund deposit insurance and consume.

▸ Taxes ▸ Return

Parameterization

For the stochastic deposit matching process, we use data from our panel of U.S. commercial banks:

- For fringe banks, use Arellano and Bond to estimate the AR(1)

$$\log(\delta_{it}) = (1-\rho_d)k_0 + \rho_d \log(\delta_{it-1}) + k_1 t + k_2 t^2 + k_{3,t} + a_i + u_{it} \quad (22)$$

  where t denotes a time trend, $k_{3,t}$ are year fixed effects, and u_{it} is iid and distributed $N(0, \sigma_u^2)$.

- Discretize using Tauchen (1986) method with 5 states. Discrete Process

- Consistent with observed lower variance of deposits, assume dominant bank $\delta = \bar{\delta}^b$ is constant and large enough so that the constraint never binds.

Computation: Variant of Ifrach/Weintraub (2012), Krusell/Smith (1998)

Details Return

The Role of Imperfect Competition

Question: How much does imperfect competition affect capital requirement counterfactual predictions?

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Return

Countercyclical Capital Requirements

Question: What if capital requirements are higher in good times (i.e. $\varphi = 0.04) \rightarrow (\varphi(z_b) = 0.06, \varphi(z_g) = 0.08)$)? Table

- Bank exit/entry drops to nearly zero and 60 basis point rise in interest rates.
- Intermediated output drops 10% but taxes/output drop 90%.
- Lower fringe bank entry $\rightarrow$ 50% drop in small bank market share (more concentrated industry).

Return

Other Counterfactual Experiments

C-D 2013.

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  - **Experiment 4:** While national banks increase loan exposure with too-big-to-fail, their actions spill over to smaller banks who reduce loans. Lower profitability of smaller banks induces lower entry.

C-D 2014b: Global Banking Competition

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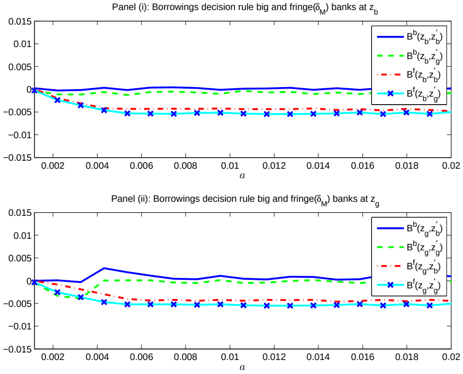
- Lower interest rates $\rightarrow$ lower default (-2.85%) and charge offs (-3.2%).
- Higher output (+30%),higher taxes, and higher household welfare (CE equivalent) (+0.79%).

Future Research

- Stress tests ▸ Stress
- Interbank market clearing adds another endogenous price and systemic channel.
- Deposit insurance and deposit market competition
- Mergers
- Maturity Transformation - long maturity loans
- Heterogeneous borrowers that leads to specialization in banking

▸ Return

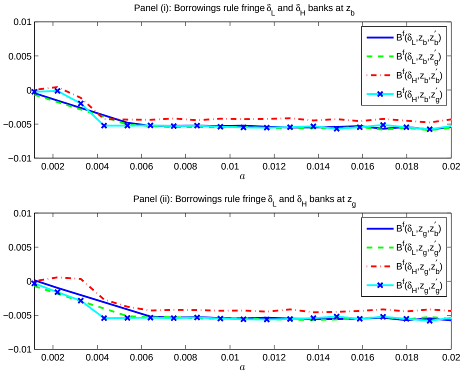
BIG BANK AND MEDIAN FRINGE B^{θ}



- The only type bank which borrows short term to cover any deficient cash flows is the big bank at low asset levels when $z = z_g$ and $z' = z_b$.

Return

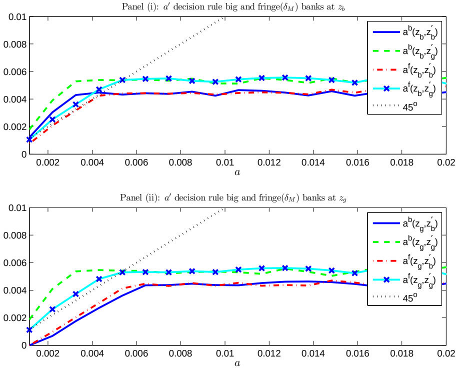
Fringe Banks B^f (different $\delta' s$)



- the largest fringe stores significantly less as the economy enters a recession.

Return

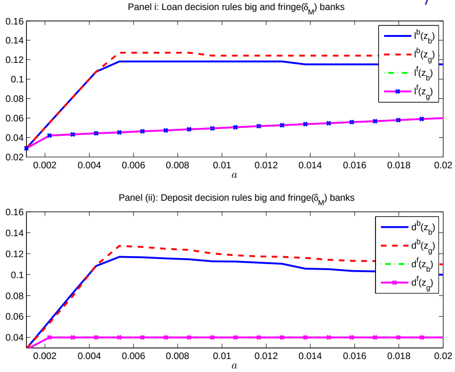
Big and Median Fringe Buffer Choice $a^{\theta'}$



- $a^{\theta'} < a^{\theta}$ implies that banks are dis-saving
- In general, when starting assets are low and the economy enters a boom, banks accumulate future assets.

Return

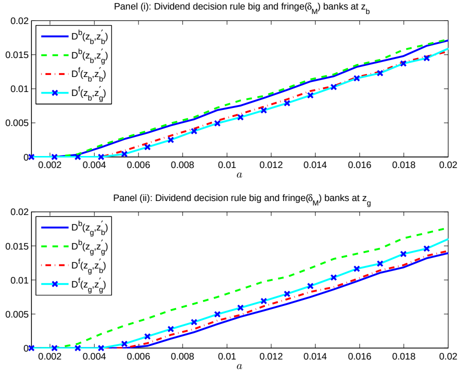
Big and Median Fringe Loan/Deposit



- If the dominant bank has sufficient assets, it extends more loans/accepts more deposits in good than bad times.
- However at low asset levels, loans are constrained by level of capital
- Loans are always increasing in asset levels for small banks.

Return

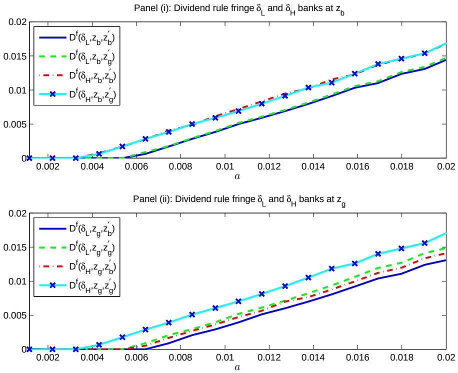
Big Bank and Median Fringe Dividends



- Strictly positive payouts arise if the bank has sufficiently high assets.
- There are bigger payouts as the economy enters good times.

Return

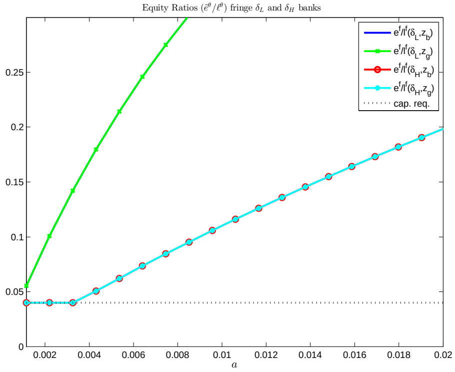
Fringe Banks Dividends (different $\delta's$)



- The biggest fringe banks are more likely to make dividend payouts than the smallest fringe banks.

Return

Fringe Capital Ratios $\tilde{e}^f/\ell^f$ (across $\delta' s$)



- Big fringe banks behave like the dominant bank. Return

Deposit Process Estimation

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

$$\log(x_{it}^{\theta}) = b_i^{\theta} + b_{2,t}^{\theta} + b_3^{\theta} t + e_{it}^{\theta}$$

- Let $\log(\delta_{it}^{\theta}) = e_{it}^{\theta}$ and use Arellano and Bond to estimate the AR(1) for deposit shocks:

$$\log(\delta_{it}^{\theta}) = (1-\rho_d^{\theta})k_0^{\theta} + \rho_d^{\theta}\log(\delta_{it-1}^{\theta}) + u_{it}^{\theta}, \tag{23}$$

where u_{it}^{θ} is iid, distributed $N(0,\sigma_u^{\theta})$ and $\sigma_d^{\theta} = \frac{\sigma_u^{\theta}}{(1-(\rho_d^{\theta})^2)^{1/2}}$.

- Discretize using Tauchen (1986) method with 5 states.
- Results:
  - Fringe: $\sigma_u^f = 0.182$, $\rho_d^f = 0.885 \Rightarrow \sigma_d^f = 0.389$
  - Top 10: $\sigma_u^b = 0.157$, $\rho_d^b = 0.384 \Rightarrow \sigma_d^b = 0.191$
- Bigger banks have less volatile funding inflows (implications for buffers).

Return

Top-Down Stress Tests - Statistical approach

Table : A CLASS-style Panel Regression: NIM

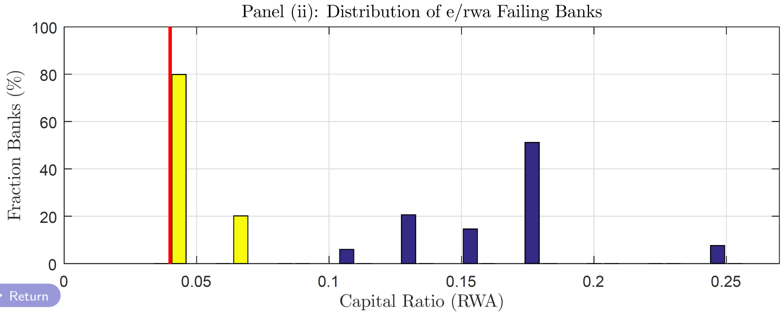
	Whole Sample 2001-2015	Normal Times 2001-2006	Financial Crisis 2007-2009
AR(1)	0.739***	0.972***	0.553***
Term Spread	0.009	0.002	0.128*
3M T-Bill	0.014	0.003	0.097**
Time trend	X	X	X
Controls	X	X	X
Observations	6621	2905	1374
R^2	0.55	0.73	0.44

Notes: specifiaction adopted from Hirtle et al. (2015). See p.34 for definition of covariates. Data from FDIC's Call & Thrift reports, form FFIEC031

- running the regression mainly on normal times data favours persistent bank dynamics that carry over to stress horizon

Return

Capital Ratio Failing Banks: Hurdle Rate



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