

*Capital Requirements
in a Quantitative Model
of Banking Industry Dynamics*

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(*Preliminary and Incomplete*)

INTRODUCTION

- ▶ Capital requirements ensure that banks are not making investments that increase the risk of default and that they have enough capital to sustain operating losses while still honoring withdrawals.

QUESTION

- ▶ How much does a 33% rise in capital requirements affect failure rates and market shares of large and small banks?

ANSWER

- ▶ It leads to an increase of 9% in the market share of large banks and a 50% reduction in average entry/exit rates by small banks.
- ▶ Lower continuation values for small banks reduces their entry and big banks gain loan market share.

OVERVIEW

1. Document Banking Facts from Balance sheet and Income Statement Panel Data as in Kashyap and Stein (2000).
2. A Dynamic Model of the Banking Industry
 - ▶ Underlying Static Cournot Model with Exog. Distribution as in Allen & Gale (2000), Boyd & De Nicolo (2005).
 - ▶ Quantitative Theory:
 - ▶ Most quantitative models (e.g. Diaz-Gimenez, et. al. (1992)) assume perfect competition & CRS \rightarrow indeterminate size distn.
 - ▶ Cournot Competition with a Fringe: Ericson & Pakes (1995)/ Gowrisankaran & Holmes (2004)
 - ▶ Entry & exit along with buffer stock model of bank net asset accumulation generates endog. bank size distn.
3. Calibration (incomplete) to long-run averages of bank industry data.
4. Test: business cycle correlations.
5. Capital requirement counterfactual.

DATA SUMMARY FROM C-D (2011)

- ▶ 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).
- ▶ High Concentration: Top 1% banks have 76% of loan market share. [▶ Fig](#) [▶ Table](#)
- ▶ Signs of Non Competitive environment: Large Net Interest Margins, Markups, Lerner Index, Rosse-Panzar $H < 100$. [▶ Table](#)
- ▶ Net marginal expenses are increasing with bank size. Fixed costs (normalized) are decreasing in size. [▶ Table](#)
- ▶ Loan Returns, Margins, Markups, Delinquency Rates and Charge-offs are countercyclical. [▶ Table](#)

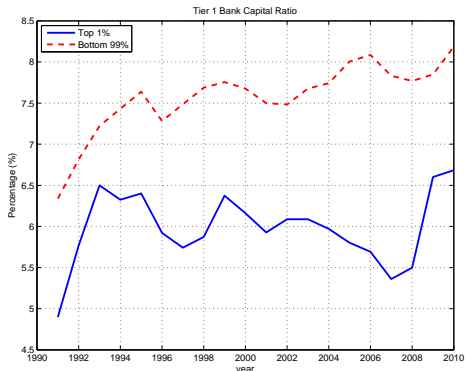
BALANCE SHEET DATA BY BANK SIZE

| Fraction Total Assets (%) | 1990 | | 2010 | |
|---------------------------|------------|--------|------------|--------|
| | Bottom 99% | Top 1% | Bottom 99% | Top 1% |
| Cash | 7.25 | 10.98 | 7.95 | 7.66 |
| Securities | 18.84 | 13.30 | 18.37 | 15.79 |
| Loans | 49.28 | 53.20 | 55.08 | 41.06 |
| Deposits | 69.70 | 62.75 | 64.37 | 56.02 |
| Fed Funds and Repos | 4.17 | 7.54 | 1.30 | 1.20 |
| Equity Capital | 6.20 | 4.66 | 9.94 | 10.66 |

Source: Call Reports.

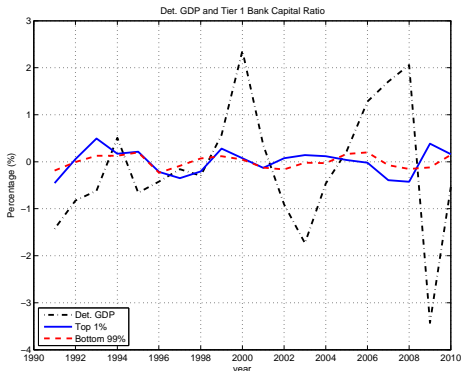
- ▶ While loans and deposits are the most important parts of the bank balance sheet, “precautionary holdings” of securities and equity capital are important buffer stocks.

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” ($\geq 5\%$) further suggesting a precautionary motive.

CAPITAL RATIO OVER THE BUSINESS CYCLE



- ▶ Capital Ratio is countercyclical for small and big banks (corr. -0.21 and -0.37 respectively).

MODEL OVERVIEW

- ▶ Banks intermediate between large numbers of
 - ▶ risk averse households who can deposit at a bank with deposit insurance.
 - ▶ risk neutral borrowers who demand funds to undertake risky projects.
- ▶ By lending to a large number of borrowers, a given bank diversifies risk that any particular household cannot accomplish individually.
- ▶ Bank balance sheet: $\text{Assets} = \text{Private Loans} + \text{Securities}$;
 $\text{Liabilities} = \text{Deposits} + \text{Short-term Borrowing} + \text{Equity Capital}$.
- ▶ In the loan market, strategic (Cournot competition) MPE as in Ericson and Pakes (1995) augmented with competitive fringe as in Gowrisankaran and Holmes (2004).
- ▶ A nontrivial size distribution of banks arises out of endogenous entry & exit as well as bank net asset accumulation decision.

AGENTS

- ▶ In each period,
 - ▶ a mass N of one period lived ex-ante identical borrowers are born
 - ▶ a sufficiently large mass Ξ of one period lived ex-ante identical households are born (no deposit market competition) ▶ HH Problem
- ▶ At most one dominant bank and a large number (a mass) of small, fringe banks where bank type is denoted $\theta \in \{b, f\}$.

STOCHASTIC PROCESSES

- ▶ Aggregate Technology Shocks $z_{t+1} \in \{z_b, z_g\}$ follow a Markov Process $F(z_{t+1}, z_t)$ with $z_b < z_g$
- ▶ Conditional on z_{t+1} , project success shocks which are iid across borrowers are drawn from $p(R_t, z_{t+1})$.
- ▶ “Liquidity shocks” (capacity constraint on deposits) which are iid across banks given by $\delta_t \in \{\underline{\delta}, \dots, \bar{\delta}\} \subseteq \mathbb{R}_{++}$ follow a Markov Process $G^\theta(\delta_{t+1}, \delta_t)$.

BORROWERS

- ▶ 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

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

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

LOAN MARKET ESSENTIALS

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

BANKS

- ▶ Two types of banks $\theta \in \{b, f\}$ for big and fringe.
- ▶ Banks face net proportional and fixed costs: (c^b, κ^b) and (c^f, κ^f) .
- ▶ There is limited liability on the part of banks.
- ▶ Entry costs to create big and fringe banks are denoted $\Upsilon^b \geq \Upsilon^f \geq 0$.
- ▶ Each period banks are randomly matched with a mass of depositors δ_t and decide how many deposits to accept $d_{it}^\theta \leq \delta_t$.

BANKS - CONT.

- ▶ Banks make loans $\ell_{i,t}^\theta$ and hold securities $a_{i,t+1}^\theta \in \mathbb{R}_+$.
- ▶ Securities have a return equal to r^a .
- ▶ Bank resource constraint at the beginning of the period is

$$\tilde{a}_{i,t}^\theta + d_{i,t}^\theta \geq \ell_{i,t}^\theta + a_{i,t+1}^\theta. \quad (2)$$

- ▶ End-of-period profits are

$$\begin{aligned} \pi_{i,t+1}^\theta = & \left\{ p(R_t, z_{t+1})(1 + r_t^L) + (1 - p(R_t, z_{t+1}))(1 - \lambda) - c_i^\theta \right\} \ell_{i,t}^\theta \\ & + r^a a_{i,t+1}^\theta - (1 + r^D) d_{i,t}^\theta - \kappa_i^\theta. \end{aligned}$$

BANKS - CONT.

- ▶ After loan, deposit, and asset decisions have been made, we can define bank equity capital $e_{i,t}^\theta$ as

$$e_{i,t}^\theta \equiv \underbrace{a_{i,t+1}^\theta + \ell_{i,t}^\theta}_{\text{assets}} - \underbrace{d_{i,t}^\theta}_{\text{liabilities}}. \quad (3)$$

- ▶ Banks face a Capital Requirement:

$$e_{i,t}^\theta \geq \varphi^\theta (\ell_{i,t}^\theta + w a_{i,t+1}^\theta) \quad (\text{CR})$$

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

- ▶ Banks face a Liquidity Requirement:

$$a_{i,t+1}^\theta \geq \gamma^\theta d_{i,t}^\theta. \quad (\text{LR})$$

BANKS - CONT.

- ▶ After the realization of shocks, banks have access to short-term borrowing $B_{i,t+1}^\theta$ at net rate $r_t^B(B_{i,t+1})$.
- ▶ Borrowing is fully collateralized (as in repos)

$$B_{i,t+1}^\theta \leq \frac{a_{i,t+1}^\theta}{(1 + r_t^B)} \quad (\text{BC})$$

- ▶ Beginning-of-next-period securities are defined as

$$\tilde{a}_{i,t+1}^\theta = a_{i,t+1}^\theta - (1 + r_t^B) \cdot B_{i,t+1}^\theta \geq 0. \quad (4)$$

BANKS - CONT.

- ▶ Bank dividends at the end of the period are

$$\mathcal{D}_{i,t+1}^{\theta} = \pi_{i,t+1}^{\theta} + B_{i,t+1}^{\theta} \geq 0. \quad (\text{NND})$$

- ▶ When $\pi_{i,t+1}^{\theta} < 0$ (negative cash flow), bank can borrow ($B_{i,t+1}^{\theta} > 0$) against assets (i.e. repos) to avoid exit but beginning-of-next-period's assets fall.
- ▶ When $\pi_{i,t+1}^{\theta} > 0$, bank can either lend/store cash ($B_{i,t+1}^{\theta} < 0$) raising beginning-of-next-period's assets and/or pay out dividends.

INDUSTRY STATE

- ▶ $\mu_t(\tilde{a}, \delta)$ denotes the distribution over matched deposits and securities for fringe banks.
- ▶ The aggregate industry state is

$$\zeta_t = \{\hat{a}_t, \hat{\delta}_t, \mu_t\} \quad (5)$$

where $\hat{a} = a^b$ if the dominant bank is active and equal to \emptyset otherwise; $\hat{\delta}_t$ is similarly defined.

INFORMATION

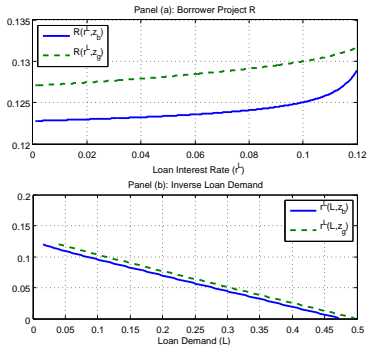
- ▶ Only borrowers know the riskiness of the project they choose R , their outside option ω , and their consumption.
- ▶ All other information is observable (e.g. success/failure).

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 $(\ell_{i,t}^b, d_{i,t}^b, a_{i,t+1}^b)$.
4. Having observed $\ell_{i,t}^b$, fringe banks choose $(\ell_{i,t}^f, d_{i,t}^f, a_{i,t+1}^f)$.
Borrowers choose whether or not to undertake a project and if so, R_t .
5. Aggregate shocks z_{t+1} to returns are realized, as well as idiosyncratic project success shocks.
6. Banks choose $B_{i,t+1}^\theta$ 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.

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.

BIG BANK PROBLEM

The value function of a “big” incumbent bank at the beginning of the period is then given by ▶ Loan decision

$$V^b(\tilde{a}, \delta, z, \zeta) = \max_{\ell, d \in [0, \delta], a' \geq \gamma^b d} \left\{ \beta E_{z'|z} W^b(\ell, d, a', \zeta, \delta, z') \right\}, \quad (6)$$

s.t.

$$\tilde{a} + d \geq a' + \ell \quad (7)$$

$$\ell(1 - \varphi^b) + a'(1 - w\varphi^b) - d \geq 0 \quad (8)$$

$$\ell + L^{s,f}(z, \zeta, \ell) = L^d(r^L, z) \quad (9)$$

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

- ▶ Market clearing (9) defines a “reaction function” where the dominant bank takes into account how fringe banks’ loan supply reacts to its own loan supply.

BIG BANK PROBLEM - CONT.

The end of period function is given by

$$W^b(\ell, d, a', \zeta, \delta, z') = \max_{x \in \{0,1\}} \{W^{b,x=0}(\ell, d, a', \zeta, \delta, z'), W^{b,x=1}(\ell, d, a', \zeta, \delta, z')\}$$

$$W^{b,x=0}(\ell, d, a', \zeta, \delta, z') = \max_{B' \leq \frac{a'}{(1+r^B)}} \left\{ \mathcal{D}^b + E_{\delta'|\delta}^b V^b(\tilde{a}', \delta', z', \zeta') \right\}$$

$$\text{s.t. } \mathcal{D}^b = \pi^b(\ell, d, a', \zeta, z') + B' \geq 0$$

$$\tilde{a}' = a' - (1 + r^B)B' \geq 0$$

$$\zeta' = H(z, \zeta, z')$$

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

BANK ENTRY

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

$$V^{\theta,e}(z, \zeta, z') \equiv \max_{a'} \{-a' + E_{\delta'} V^{\theta}(a', \delta', z', H(z, \zeta, z'))\} - \Upsilon^{\theta} \quad (10)$$

- ▶ Entry occurs as long as $V^{\theta,e}(z, \zeta, z') \geq 0$.
- ▶ The argmax of (10) defines the initial equity distribution of banks which enter.
- ▶ Free entry implies that

$$V^{\theta,e}(z, \zeta, z') \times E^{\theta} = 0 \quad (11)$$

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

EVOLUTION OF CROSS-SECTIONAL BANK SIZE DISTRIBUTION

- ▶ The distribution of fringe banks evolves according to

$$\begin{aligned} \mu'(a', \delta') = & \int \sum_{\delta} (1 - x^f(\cdot)) I_{\{a' = \bar{a}^f(\cdot)\}} G^f(\delta', \delta) d\mu(a, \delta) \\ & + E^f \sum_{\delta} I_{\{a' = a^{f,e}(\cdot)\}} G^{f,e}(\delta). \end{aligned} \quad (12)$$

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

TAXES TO COVER DEPOSIT INSURANCE

- ▶ Across all states (ζ, z, z') , taxes must cover deposit insurance in the event of bank failure.
- ▶ Let post liquidation net transfers be given by

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

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

- ▶ Then aggregate taxes are

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

DEFN. MARKOV PERFECT INDUSTRY EQ

Given policy parameters $(\varphi^\theta, w, \gamma^\theta, r^B, r^a)$, a pure strategy Markov Perfect Equilibrium (MPIE) is a set of functions $\{v(r^L, z), R(r^L, z)\}$ (borrower behaviour), $\{V_i^\theta, \ell_i^\theta, d_i^\theta, a_i^{\theta'}, B_i^{\theta'}, x_i^\theta\}$ (bank behaviour), a loan interest rate $r^L(\zeta, z)$, a deposit interest rate $r^D = \bar{r}$, the law of motion of the cross-sectional distribution $\zeta' = H(z', \zeta)$, an entry function $E(z, \zeta, z')$, and a tax function $\tau(z, \zeta, z')$ such that:

1. Given r^L , $v(r^L, z)$ and $R(r^L, z)$ are consistent with borrower's optimization.
2. At any interest rate r^L , loan demand $L^d(r^L, z)$ is given by (17).
3. At $r^D = \bar{r}$, the household deposit participation constraint is satisfied.
4. Bank functions, $\{V_i^\theta, \ell_i^\theta, d_i^\theta, a_i^{\theta'}, B_i^{\theta'}, x_i^\theta\}$, are consistent with bank optimization.
5. The law of motion for the industry state $H(z', \zeta)$ is consistent with entry and exit decision rules.
6. The interest rate $r^L(\zeta, z)$ is such that the loan market clears.
7. Across all states (ζ, z, z') , taxes cover deposit insurance.

COMPUTING THE MODEL

- ▶ All equilibrium objects are a function of the distribution of banks.
- ▶ Since the distribution of banks is an infinite dimensional object we solve the model using an extension of the algorithm proposed by Krusell and Smith (1998) or Farias et. al. (2011) adapted to this environment.

▶ Details

PARAMETERS CHOSEN INDEPENDENT OF MODEL

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)

$$\log(\delta_{it}) = (1 - \rho_d)k_0 + \rho_d \log(\delta_{it-1}) + k_1 t + k_2 t^2 + k_{3,t} + a_i + u_{it} \quad (13)$$

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

PARAMETERS CHOSEN INDEPENDENT OF MODEL

| Parameter | | Value | Target |
|-------------------------------|-----------------------|---------|----------------------------|
| Mass of Borrowers | B | 1 | Normalization |
| Mass of Households | Ξ | B | Assumption |
| Depositors' Preferences | σ | 2 | Participation Const. |
| Aggregate Shock in Good State | z_g | 1.0 | Normalization |
| Aggregate Shock in Bad State | z_b | 0.975 | Std. Dev. GDP [†] |
| Transition Probability | $F(z_g, z_g)$ | 0.86 | NBER data [†] |
| Transition Probability | $F(z_b, z_b)$ | 0.43 | NBER data [†] |
| Autocorrelation Deposits | ρ_d | 0.47 | Dep. Process |
| Std. Dev. Error Dep. | σ_u | 0.66 | Dep. Process |
| Dep Int. Rate (%) | \bar{r} | 0.86 | Interest Expense |
| Sec. Return (%) | r^a | 1.2 | Return Securities |
| Net Exp. Top 1% (%) | c^b | 1.62 | Net Exp. Top 1% |
| Net Exp. Bottom 99% (%) | c^f | 1.60 | Net Exp. Bottom 99% |
| Capital Req. Top 1% (%) | (φ^b, w) | (6.0,0) | Regulation |
| Capital Req. Bottom 99% (%) | (φ^f, w) | (6.0,0) | Regulation |
| Liquidity Req. (%) | $\gamma^b = \gamma^f$ | 0.0 | Regulation |

PARAMETERS CHOSEN WITHIN MODEL

| Parameter | | Value | Targets |
|-----------------------------|----------------------|-------|--|
| Weight Aggregate Shock | α | 0.88 | Default frequency |
| Success Prob. Parameter | b | 3.77 | Borrower return [†] |
| Mean Entrep. Dist. | μ_ε | -0.85 | Bank entry rate |
| Volatility Entrep. Dist. | σ_ε | 0.10 | Loan return |
| Success Prob. Parameter | ψ | 0.78 | Loan mkt share bottom 99% |
| Loss Rate | λ | 0.21 | Charge off rate |
| Max. Reservation Value | \bar{w} | 0.25 | Avg. Loan Markup |
| Discount Factor | β | 0.95 | Deposit mkt share bottom 99% |
| Mean Deposits | μ_d | 0.04 | Capital ratio bottom 99% |
| Asset Recovery Rate at exit | ξ | 0.70 | Capital ratio top 1% |
| Cost over night funds (%) | r^B | 1.0 | Sec. to asset ratio bottom 99% |
| Fixed Cost Top 1% (%) | κ^b | 0.001 | Fixed cost top 1% |
| Fixed Cost Bottom 99% (%) | κ^f | 0.001 | Fixed cost bottom 1% |
| Entry Cost Bottom 99% | Υ^f | 0.01 | Sec. to asset ratio top 1% |
| Entry Cost Top 1% | Υ^b | 0.05 | Ratio profit rate top 1% to bottom 99% |

Note: [†] Not from commercial bank data set.

▶ Functional Forms

MODEL MOMENTS

| Moment (%) | Model | Data |
|---|-------|--------|
| Default Frequency $1 - p(R^*, z')$ | 2.65 | 2.15 |
| Borrower Return $p(R^*, z')(z'R^*)$ | 12.71 | 12.94 |
| Entry Rate | 1.17 | 1.60 |
| Exit Rate [†] | 1.17 | 1.65 |
| Loan Return $p(R^*, z')r^L$ | 6.34 | 5.17 |
| Net Interest Margin [†] | 5.45 | 5.08 |
| Charge-Off Rate $(1 - p(R^*, z'))\lambda$ | 0.55 | 0.79 |
| Loan Market Share Bottom 99% | 40.63 | 37.90 |
| Deposit Market Share Bottom 99% | 27.28 | 35.56 |
| Equity Capital Ratio Top 1% | 15.61 | 7.50 |
| Equity Capital Ratio Bottom 99% | 38.54 | 11.37 |
| Securities to Asset Ratio Top 1% | 13.46 | 15.79 |
| Securities to Asset Ratio Bottom 99% | 23.91 | 20.74 |
| Avg. Loan Markup | 98.94 | 102.73 |
| Ratio profit rate top 1% to bottom 99% | 89.98 | 63.79 |

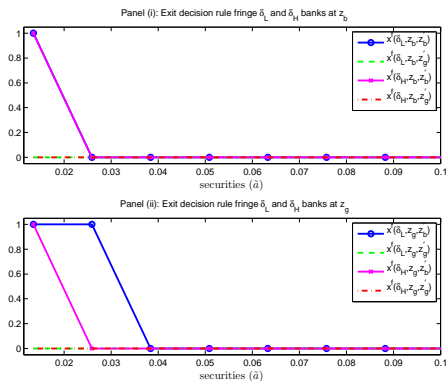
Fine tune calibration (too much precautionary saving in capital ratios)

EQUILIBRIUM PROPERTIES

We find an equilibrium where bank failure and entry is more common among fringe banks:

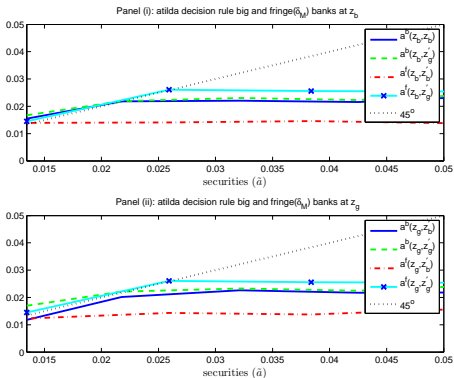
- ▶ The dominant bank does not exit (along the equilibrium path)
- ▶ If the aggregate state turns bad, exit occurs along the equilibrium path by all δ sizes of fringe banks if they have low asset levels (more so for the smallest δ).
- ▶ Borrowers take on more risk in good times but project failure is more likely in bad states.

FRINGE BANK EXIT RULE ACROSS δ' s



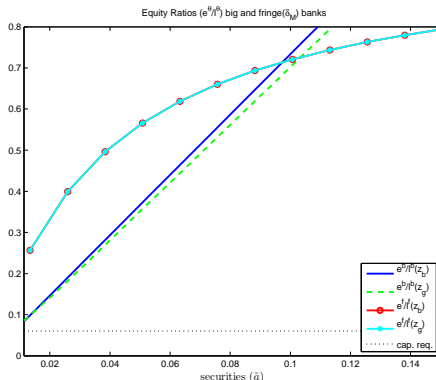
- ▶ Fringe banks with low assets are more likely to exit, particularly if they are small δ_L .

BIG AND MEDIAN FRINGE CHOICE $\tilde{a}^{\theta'}$



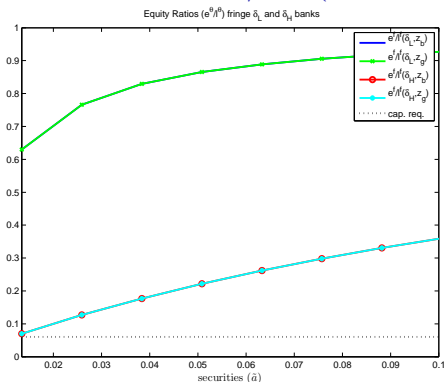
- ▶ $\tilde{a}^{\theta'} < \tilde{a}^{\theta}$ implies that banks are dis-saving
- ▶ In general, when starting assets are low and the economy enters a boom, banks accumulate future assets.

BIG AND MEDIAN FRINGE CAPITAL RATIOS $e^{\theta} / \ell^{\theta}$



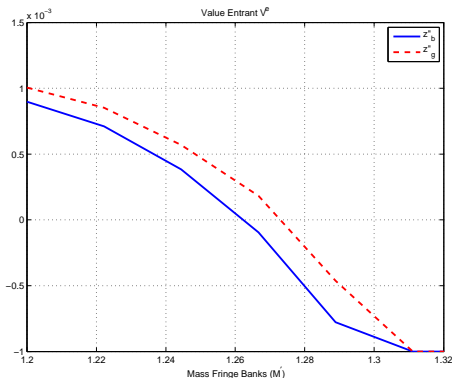
- ▶ The capital requirement is nonbinding for all asset levels.
- ▶ At low asset levels, the fringe bank has a significantly higher ratio than the dominant bank.

FRINGE CAPITAL RATIOS e^f / ℓ^f (ACROSS δ 's)



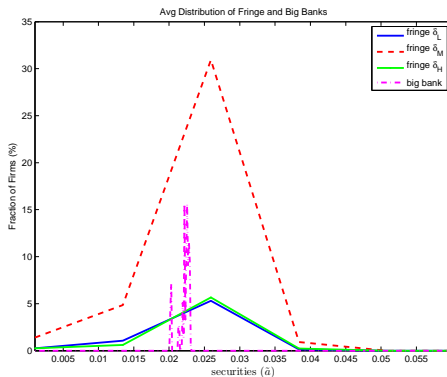
- ▶ Small fringe banks have much higher capital ratios than large fringe banks.
- ▶ Biggest fringe banks have nearly binding capital requirements.

VALUE FRINGE POTENTIAL ENTRANT



- ▶ The benefit of entering is smaller the more competition a bank faces.
- ▶ Entry values are higher in good times than bad times.

AVG. DISTRIBUTION OF FRINGE AND BIG BANKS



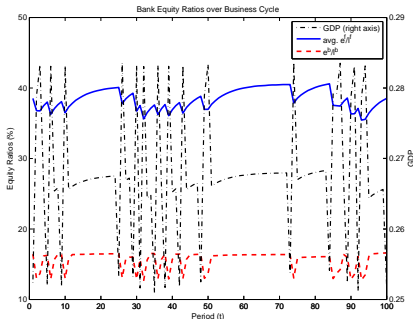
- ▶ Average net security holdings of the big bank is lower than that of the fringe banks.

TEST: BUSINESS CYCLE CORRELATIONS

| Variable Correlated with GDP | Model | Data |
|--|-------|-------|
| Loan Interest Rate r^L | -0.82 | -0.18 |
| Exit Rate | -0.62 | -0.47 |
| Entry Rate | 0.53 | 0.25 |
| Loan Supply | 0.83 | 0.72 |
| Deposits | 0.81 | 0.22 |
| Default Frequency | -0.62 | -0.61 |
| Loan Return | -0.05 | -0.26 |
| Charge Off Rate | -0.62 | -0.56 |
| Price Cost Margin Rate | -0.05 | -0.31 |
| Markup | -0.83 | -0.20 |
| Capital Ratio Top 1% (risk-weighted) | -0.79 | -0.75 |
| Capital Ratio Bottom 99% (risk-weighted) | -0.48 | -0.12 |

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

CAPITAL RATIOS OVER THE BUSINESS CYCLE



- ▶ Capital Ratios are countercyclical because loans are more procyclical than “precautionary” asset choices.

CAPITAL REQUIREMENT COUNTERFACTUAL

Question: How much does a 33% increase of capital requirements affect banks of different sizes?

| Moment | Benchmark ($\varphi = 6\%$) | Higher Cap. Req. ($\varphi = 8\%$) | Change (%) |
|-------------------------------|----------------------------------|---|---------------|
| Exit/Entry Rate Fringe (%) | 1.17 | 0.50 | -57.57 |
| Measure Banks bottom 99% | 1.30 | 1.13 | -13.21 |
| Loan Mkt Share bottom 99% (%) | 40.63 | 37.02 | -8.87 |
| Dep. Mkt Share bottom 99% (%) | 27.28 | 27.36 | 0.27 |
| Avg. Loan supply top 1% | 0.14 | 0.15 | 4.23 |
| Capital Ratio top 1% (%) | 15.61 | 20.06 | 28.51 |
| Capital Ratio bottom 99 % (%) | 38.54 | 40.18 | 4.26 |
| Avg. Sec holdings top 1% | 0.022 | 0.029 | 30.91 |
| Avg. Sec holdings bottom 99% | 0.018 | 0.022 | 23.07 |

- ▶ A lower continuation value for fringe banks, reduces entry and the degree of competition (mass fringe is 13% lower).
- ▶ Big banks strategically increase loans only slightly (+4%) so their capital ratio increases linearly with securities.

CAPITAL REQUIREMENT COUNTERFACTUAL: AGGREGATES

Question: How much does a 33% increase of capital requirements affect outcomes?

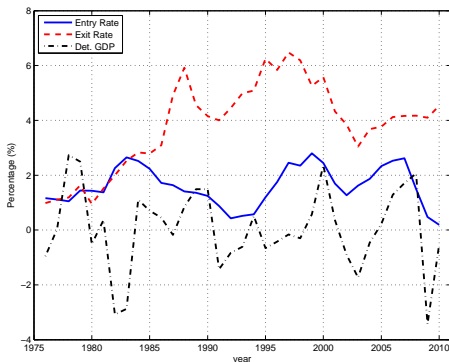
| | Benchmark | Higher Cap. Req. | Change |
|----------------------|---------------------|---------------------|--------|
| Moment | ($\varphi = 6\%$) | ($\varphi = 8\%$) | (%) |
| Loan Supply | 0.24 | 0.23 | -2.27 |
| Loan Int. Rate (%) | 6.50 | 6.64 | 2.15 |
| Borrower Project (%) | 12.71 | 12.72 | 0.05 |
| Def. Frequency (%) | 1.10 | 2.73 | 148.80 |
| Exit Rate (%) | 1.17 | 0.50 | -57.57 |
| Output | 0.27 | 0.26 | -2.29 |
| Taxes/Output (%) | 0.04 | 0.02 | -65.89 |

- ▶ A lower mass of fringe banks results in a lower loan supply and higher interest rates and default frequency.

CONCLUSION

- ▶ We develop a structural model with an endogenous bank size distribution to assess the quantitative significance of macro-prudential regulations like capital requirements.
- ▶ We find that a 33% increase in capital requirements leads to a 50% reduction in average small bank entry/exit rates and an increase of 9% in the market share of large banks.
- ▶ This leads to a modest (2%) increase in loan interest rates, a modest (-2%) decrease in loan intermediated output, and a large (-65%) decrease in taxes/output to fund deposit insurance.
- ▶ Next step is to embed this IO model into a GE framework.

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: | x | | | |
|--|-------|-------|-------------|--------------|
| | Entry | Exit | Exit/Merger | Exit/Failure |
| 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 |

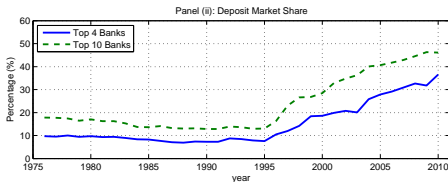
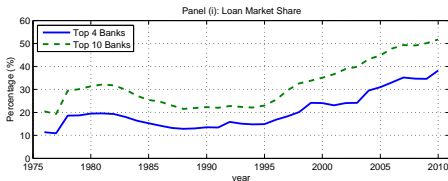
Note: Big banks that exited by merger: 1996 Chase Manhattan acquired by Chemical Banking Corp. 1999 First American National Bank acquired by AmSouth Bancorp.

► 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)).

MEASURES OF BANKING COMPETITION

| Moment | Value (%) | Std. Error (%) | Corr w/ GDP |
|---------------------|-----------|----------------|-------------|
| Net 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) and Bikker and Haaf (2002).
- ▶ Countercyclical markups imply more competition in good times (new amplification mechanism).

[▶ Definitions](#)[▶ Figures](#)[▶ Return](#)

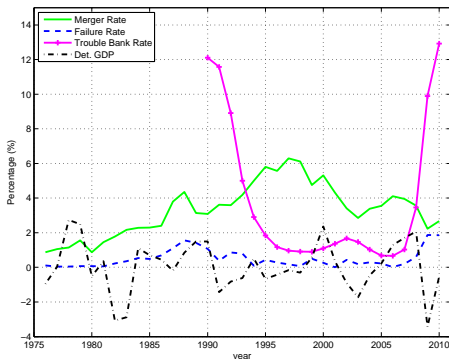
COSTS BY BANK SIZE

| Moment (%) | Non-Int Inc. | Non-Int Exp. | Net Exp. (c^θ) | Fixed Cost ($\kappa^\theta/\ell^\theta$) |
|------------|-------------------|-------------------|-------------------------|--|
| Top 1% | 2.32 [†] | 3.94 [†] | 1.62 [†] | 0.72 [†] |
| Bottom 99% | 0.89 | 2.48 | 1.60 | 0.99 |

- ▶ Marginal Non-Int. Income, Non-Int. Expenses (estimated from trans-log cost function) and Net Expenses are increasing in size.
- ▶ Fixed Costs (normalized by loans) are decreasing in size.
- ▶ 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 $y \in \{\text{Top 4, Top 1\%, Top 10\%, Bottom 99\%}\}$
- ▶ let $x \in \{\text{Enter, Exit, Exit by Merger, Exit by Failure}\}$
- ▶ 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 “ $x = \text{enter}$ ” in period t over total number of banks that “ $x = \text{enter}$ ” 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 Net Interest Margin is defined as:

$$r_{it}^L - r_{it}^D$$

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

- ▶ The markup for bank is defined as:

$$\text{Markup}_{tj} = \frac{p_{\ell_{tj}}}{mc_{\ell_{tj}}} - 1 \quad (14)$$

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:

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

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)

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 | $< 4\%$ | $< 4\%$ | $< 4\%$ |
| Signif. Undercapitalized | $< 3\%$ | $< 3\%$ | $< 6\%$ |
| Critically Undercapitalized | $< 2\%$ | $< 2\%$ | $< 2\%$ |

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

▶ 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 |
| Price Cost Margin Rate | -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 \bar{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 DECISION MAKING

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

$$v(r^L, z) = \max_R E_{z'|z} p(R, z') (z'R - r^L). \quad (15)$$

- ▶ The borrower chooses to demand a loan if

$$v(r^L, z) \geq \omega. \quad (16)$$

- ▶ Aggregate demand for loans is given by

$$L^d(r^L, z) = N \cdot \int_{\underline{\omega}}^{\bar{\omega}} 1_{\{\omega \leq v(r^L, z)\}} d\Upsilon(\omega). \quad (17)$$

▶ Return

INCUMBENT BANK DECISION MAKING

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

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

- ▶ $\frac{dr^L}{d\ell_i^f} = 0$ for competitive fringe.
- ▶ The total supply of loans by fringe banks is

$$L^{s,f}(z, \zeta, \ell^b) = \int \ell_i^f(\tilde{a}, \delta, z, \zeta, \ell^b) \mu(d\tilde{a}, d\delta). \quad (18)$$

▶ Return

FRINGE BANK PROBLEM

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

$$V^f(\tilde{a}, \delta, z, \zeta) = \max_{\ell \geq 0, d \in [0, \delta], a' \geq \gamma^f d} \{ \beta E_{z'|z} W^f(\ell, d, a', \delta, \zeta, z') \},$$

s.t.

$$\tilde{a} + d \geq a' + \ell \quad (19)$$

$$\ell(1 - \varphi^f) + a'(1 - w\varphi^f) - d \geq 0 \quad (20)$$

$$\ell^b(\zeta) + L^f(\zeta, \ell^b(\zeta)) = L^d(r^L, z) \quad (21)$$

Fringe banks use the decision rule of the dominant bank in the market clearing condition (21).

▶ Return

COMPUTATIONAL ALGORITHM

- ▶ Instead of the law of motion for the distribution $\zeta' = H(z, z', \zeta)$, we approximate the fringe part by \bar{A}' and M' that evolve according to

$$\begin{aligned}\log(\bar{A}') &= h_0^a + h_1^a \log(z) + h_2^a \log(a^b) + h_3^a \log(\bar{A}) + h_4^a \log(M) + h_5^a \log(\zeta) \\ \log(M') &= h_0^m + h_1^m \log(z) + h_2^m \log(a^b) + h_3^m \log(\bar{A}) + h_4^m \log(M) + h_5^m \log(\zeta)\end{aligned}$$

- ▶ We approximate the equation defining the “reaction function” $L^f(z, \zeta, \ell)$ by $L^f(z, a^b, \bar{A}, M, \ell)$ with

$$L^f(z, a^b, \bar{A}, M, \ell) = \ell^f(\bar{A}, z, a^b, M, \ell) \times M \quad (22)$$

where $\ell^f(\bar{A}, z, a^b, M, \ell)$ is the solution to an auxiliary problem

▶ Return

COMPUTATIONAL ALGORITHM (CONT.)

1. Guess **aggregate functions**. Make an initial guess of $\ell^f(\bar{A}, z, a^b, M, \ell; \bar{\delta})$ that determines the reaction function and the law of motion for \bar{A}' and M' .
2. Solve the **dominant bank** problem.
3. Solve the problem of **fringe banks**.
4. Using the solution to the fringe bank problem V^f , solve the **auxiliary problem** to obtain $\ell^f(\bar{A}, z, a^b, M, \ell; \bar{\delta})$.
5. Solve the **entry problem** of the fringe bank and big bank to obtain the number of entrants as a function of the state space.
6. **Simulate** to obtain a sequence $\{a_t^b, \bar{A}_t, M_t\}_{t=1}^T$ and update aggregate functions.

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:

$$G^f(\delta', \delta) = \begin{bmatrix} 0.26 & 0.43 & 0.25 & 0.05 & 0.00 \\ 0.12 & 0.36 & 0.37 & 0.12 & 0.01 \\ 0.04 & 0.24 & 0.43 & 0.24 & 0.04 \\ 0.01 & 0.12 & 0.37 & 0.36 & 0.12 \\ 0.00 & 0.05 & 0.25 & 0.43 & 0.26 \end{bmatrix},$$

- ▶ The corresponding grid is $\delta \in \{0.009, 0.019, 0.040, 0.085, 0.179\}$.
- ▶ The distribution $G^{e,f}(\delta)$ is derived as the stationary distribution associated with $G^f(\delta', \delta)$.

▶ Return

FUNCTIONAL FORMS

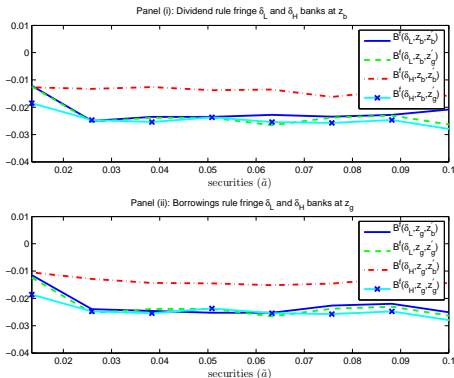
- ▶ Borrower outside option is distributed uniform $[0, \bar{\omega}]$.
- ▶ For each borrower, let $y = \alpha z' + (1 - \alpha)\varepsilon - bR^\psi$ where ε is drawn from $N(\mu_\varepsilon, \sigma_\varepsilon^2)$.
- ▶ Define success to be the event that $y > 0$, so in states with higher z or higher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

$$p(R, z') = 1 - \Phi\left(\frac{-\alpha z' + bR^\psi}{(1 - \alpha)}\right) \quad (23)$$

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

◀ Return

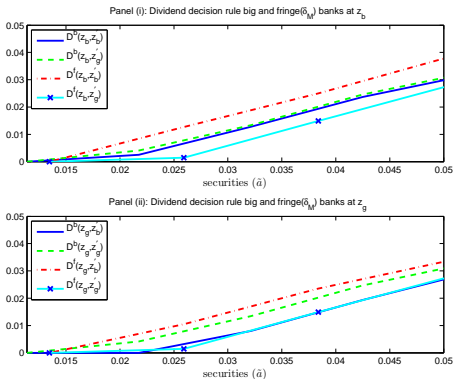
FRINGE BANKS B^f (DIFFERENT δ' s)



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

▶ Return

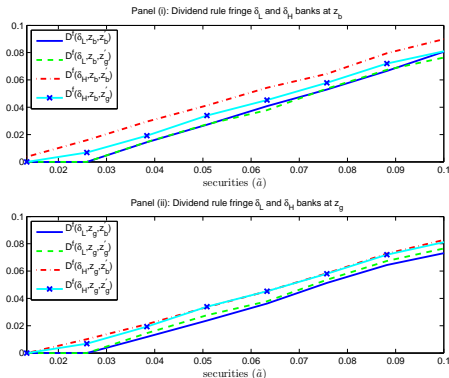
BIG BANK AND MEDIAN FRINGE DIVIDENDS



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

[▶ Return](#)

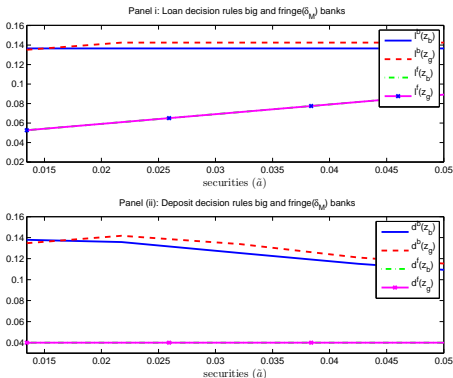
FRINGE BANKS DIVIDENDS (DIFFERENT δ' s)



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

▶ Return

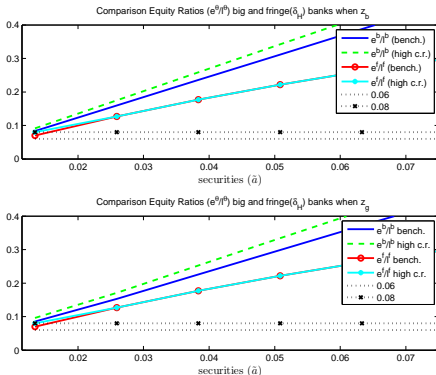
BIG BANK AND MEDIAN FRINGE LOANS AND DEPOSITS



- ▶ If the dominant bank has sufficient assets, it extends more loans in good than bad times.
- ▶ At low asset levels, it extends less loans in good than bad times because there is a greater chance of loan losses associated with a downturn.

[Return](#)

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).