

# *A Quantitative Model of Bank Merger Dynamics*

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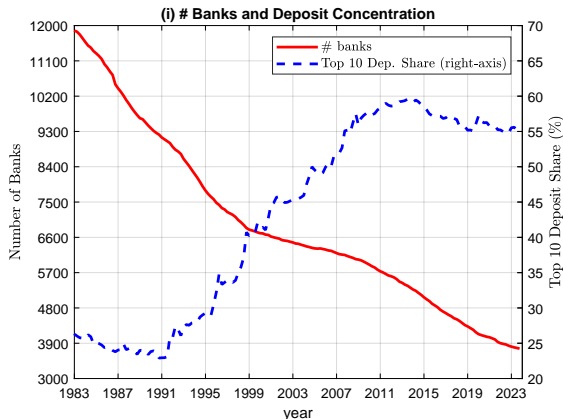
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# QUESTION



- What are the effects of banking industry consolidation due to Riegle-Neal on lending, markups, financial stability, and allocative efficiency?

# OUTLINE

1. Document banking industry data facts
2. Present a quantitative model of bank mergers dynamics motivated by our data findings
  - ▶ Dominant-Fringe Merger model following the framework of Gowrisankaran and Holmes (2004)
3. Estimate parameters in two steady states and validate untargeted moments versus data.
4. Conduct policy counterfactuals:
  - ▶ What would have happened absent Riegle-Neal?
  - ▶ How have mergers affected the transmission of monetary policy?
  - ▶ What is optimal dynamic merger regulation?

## DATA SUMMARY

1. Increase in deposit market concentration and decline in the number of banks post-Riegle-Neal is driven by mergers. [▶ Deposit Market](#)
2. Increase in markups on bank loans. [▶ Loan Markups](#)
3. Acquirers are substantially larger than targets. [▶ Acquirer vs. Target](#)
4. Marginal propensity to lend (MPL) regressions demonstrate that the MPL declines in bank size. [▶ Bank Marginal Propensity to Lend](#)
5. Granular regressions for the banking industry (Gabaix (2011)) demonstrate that deposit shocks to the largest banks have a substantial effect on aggregate bank lending. [▶ Bank Granularity](#)



## MODEL ESSENTIALS

- ▶ 2 types of bank  $i \in \{d, f\}$
- ▶ Each period begins with:
  - ▶ A measure  $\gamma$  of ex-ante identical fringe banks, each with  $D_f$  deposits
  - ▶ A dominant bank, with deposits  $D_d$
  - ▶ The ex-ante probability of loan default,  $\theta$
- ▶ First, the dominant bank makes a TOLI offer to a measure of fringe banks.
  - ▶ The measure of the fringe declines from  $\gamma$  to  $\Gamma$
  - ▶ The size of the dominant bank increases to  $D'_d = D_d + (\gamma - \Gamma)D_f$
- ▶ Second, loan market competition, a la Cournot, occurs.
  - ▶ Banks chose between loans and securities, with securities offering a risk free rate  $r_A > r_D$ .
  - ▶ Borrowers decide whether to fund their project, and then make a discrete choice between bank  $B$  and nonbank  $N$  loans.
- ▶ Following the loan stage:
  - ▶ Banks with positive profits pay dividends. Banks with negative profits choose to exit or inject costly equity.
  - ▶ New fringe banks can enter at cost  $K_f$ .
  - ▶ The next period begins with  $(\gamma = \Gamma - \gamma_x + \gamma_e, D'_d, \theta')$

# MERGER STAGE

- ▶ Starting in state  $s = (\gamma, D_d, \theta)$ :
- ▶ The dominant bank makes a TOLI offer to a measure  $\gamma - \Gamma$  of fringe banks.
- ▶ Let  $p(s, \Gamma)$  be the price of a unit of deposits. Then, the dominant bank solves the following problem:

$$v_d(s) = \max_{\Gamma \in [0, \gamma]} -p(\Gamma, s)(\gamma - \Gamma)D_f - H(\Gamma, s) + w_d(\Gamma, D'_d, \theta) \quad (1)$$

subject to

$$p(\Gamma, s)D_f \geq w_f(S) \quad (2)$$

- ▶ where  $H(\Gamma, s)$  are regulatory costs,  $w_d$  is the value of the dominant bank at the loan stage, and  $S = (\Gamma, D'_d, \theta)$
- ▶ If the dominant bank chooses to not acquire any fringe banks, then  $\Gamma^*(s) = \gamma$

# BANK PROFIT

- ▶ Following the loan stage, loan defaults ( $\theta'$ ) and chargeoffs ( $\lambda$ ) are realized. The profit of bank  $i \in \{d, f\}$  is given by:

$$\pi_i(L_i; S, \theta', \lambda'_i) = [\theta' r_B^L - (1 - \theta') \lambda'_i] L_i + r^A(D_i - L_i) - r^D(D_i) - C_i(L_i). \quad (3)$$

where  $C_i(L_i)$  is the cost of loan monitoring. We assume  $C_i(L_i)$  takes the following form:

$$C_i(L_i) = \kappa_i + C_{1i} L_i + C_{2i} L_i^2 \quad (4)$$

Further, we denote dividends by:

$$\mathcal{D}_i(L_i; S, \theta', \lambda'_i) = \pi_i(L_i; S, \theta', \lambda'_i) - \mathbf{1}_{\{\pi_i(\cdot) < 0\}} \psi_i(|\pi_i(L_i; S, \theta', \lambda'_i)|). \quad (5)$$

where  $\psi_i$  captures the costs of equity issuance.



# FRINGE BANK LOAN PROBLEM

- ▶ Given the stackelberg game in the loan market, taking the interest rates  $r_B^L$  and  $r_N^L$  as given, the problem of the fringe bank solves:

$$w_f(L_d, S, r_N^L) = \max_{\ell_f \leq D_f} \mathbb{E}_{\theta', \lambda'_f | \theta} \left[ \max_{\chi'_f \in \{0,1\}} (1 - \chi'_f) (\mathcal{D}_f(\ell_f; L_d, S, \theta', \lambda'_f) + \beta v_f(s')) \right]$$

- ▶ The entry decision satisfies:

$$v_i^e(L_d, S, r_N^L, \theta'; \gamma^e(x'_d, e'_d)) = \max_{e'_i \in \{0,1\}} (1 - e'_i) \{-K_i + v_i(s')\}, \quad (9)$$

- ▶ The evolution of the mass of fringe banks then is given by:

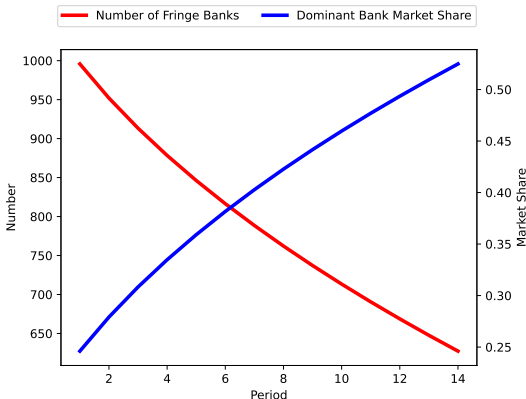
$$\gamma' = F(L_d, S, \theta') = \Gamma - \gamma^x(L_d, S, \theta') + \gamma^e(L_d, S, \theta'). \quad (10)$$

# MARKOV PERFECT EQUILIBRIUM

- Taking  $r^A$  and  $r^D$  as given, a **Markov Perfect Merger Equilibrium** is a set of bank value functions  $\{v_i, w_i\}$  and policy functions  $\{\Gamma, L_i, \ell_f, x'_i, \chi'_f, e'_i\}$  for  $i \in \{d, f\}$ ,  $\ell_N$ , prices  $\{p, r_B^L, r_N^L\}$ , and transition functions for  $\{\gamma', D'_d\}$  such that:
1. The pre-merger value function  $v_d$  solves (1). The merger quantity  $\Gamma$  maximizes (1).
  2. The merger pricing function  $p$  satisfies (2).
  3. The post-merger value functions  $w_d$  and  $w_f$  solve (6) and (9). The loan supply policy functions  $(L_d, \ell_f)$  and exit decision rules  $(x'_d, \chi'_f)$  maximize (6) and (9).
  4. Consistency requires  $\ell_f = L_f$  and  $\chi'_f = x'_f$ .
  5.  $r_B^L$  clears the loan market (7). ► Demand For Loans
  6.  $r_N^L$  satisfies the nonbank first order condition (21). ► Nonbank Loan Problem
  7. The mass of entrants  $\gamma^e$  solves the entry problem (9)
  8. Transition functions are consistent with mergers, entry, and exit (10)



# VALIDATION: UNTARGETED TRANSITION PATH



- ▶ We present the evolution of the endogenous state variables in the 14 years post-Riegle-Neal.
- ▶ We capture the decline in the number of banks and the growth of dominant bank quite accurately as in Figure 1.

# PRICE AND MARKET SHARE CHANGES: TRANSITION PATH

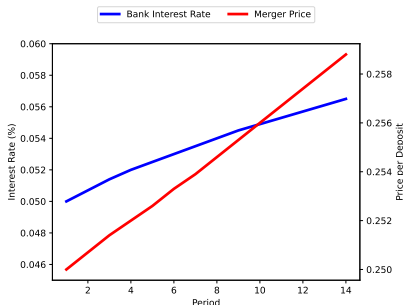


FIGURE: Evolution of Market Prices

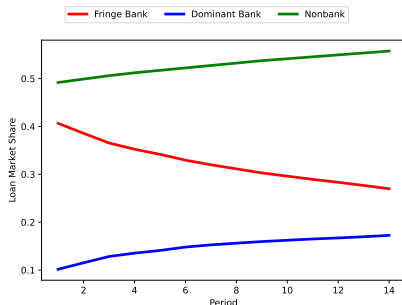


FIGURE: Evolution of Loan Market

- ▶ Bank mergers increase the price of loans and the value of fringe banks.
- ▶ The growth of the nonbanking sector is partially due to bank mergers.





## CONCLUSION

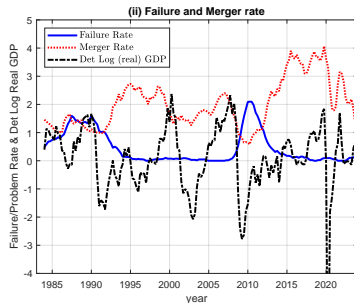
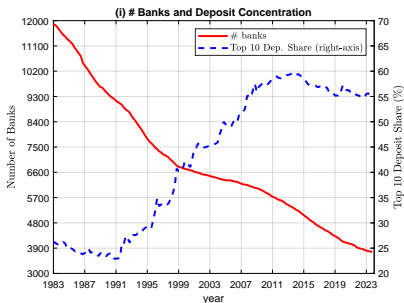
- ▶ We document evidence on banking mergers, granularity, and the marginal propensity to lend.
- ▶ We develop a model based on the dominant-fringe framework of Gowrisankaran and Holmes (2004), to study the effects of bank mergers.
- ▶ We use the model to conduct counterfactuals
- ▶ Maintaining pre-Riegle-Neal merger restrictions would create more competition, leading to lower interest rates, but a less valuable bank sector with more frequent bank failures
- ▶ Allowing more mergers improves allocative efficiency, but decreases total bank lending.

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# Appendix

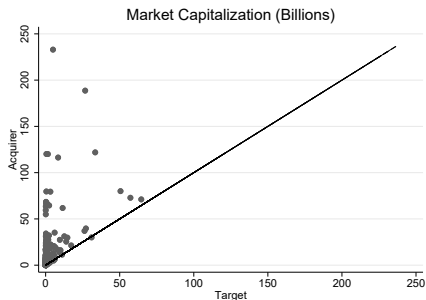
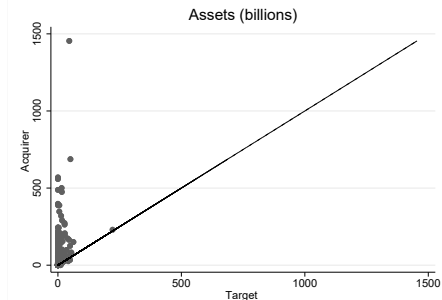
# DEPOSIT MARKET CONCENTRATION



- Rise in top 10 bank share and decline in the number of fringe banks is driven by merger activity. [► Back](#)



# ACQUIRERS VS. TARGETS



- Acquirers are larger than targets, whether measured by assets or market capitalization.
- The median acquirer is seven times larger than median target.

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# BANK MARGINAL PROPENSITY TO LEND

- ▶ We are interested in estimating the following relationship:

$$\Delta L_{it} = \beta_{k(i)} \Delta D_{it} + \zeta_{it} \quad (12)$$

- ▶ Following the MPC literature, the deposit shock process is given by:

$$\begin{aligned}
 \log(D_{it}) &= \xi_k X_{it} + z_{it} + \varepsilon_{it} \quad \text{where} \quad z_{it} = z_{it-1} + \eta_{it} \\
 \Rightarrow \Delta D_{it} &= \xi_k \Delta X_{it} + \underbrace{\eta_{it} + \Delta \varepsilon_{it}}_{=\nu_{it}}
 \end{aligned} \quad (13)$$

Then the deposit process in (13) implies that equation (12) can then be written as

$$\Delta L_{it} = \beta_k \xi_k \Delta X_{it} + \beta_k \nu_{it} + \zeta_{it}. \quad (14)$$

so that the idiosyncratic shocks  $\nu_{it}$  help identify the MPL.

# BANK MPL REGRESSION

	Dependent Variable $\Delta \log(L_{it})$					
$\nu_{it}$	0.515*** (0.00103)	0.514*** (0.00103)	0.520*** (0.00170)	0.519*** (0.00170)	0.456*** (0.00256)	0.455*** (0.00256)
$\nu_{it} \times I_{t10}$		0.358*** (0.0221)		0.345*** (0.0453)		0.305*** (0.0633)
Bank FE	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Period	1984-2019		1984-1993		2011-2019	
N	946299	946299	353150	353150	169536	169536
R-sq	0.362	0.362	0.398	0.398	0.287	0.287
adj. R-sq	0.348	0.349	0.371	0.371	0.260	0.260

- Results suggest the average MPL out of deposits is 0.51, with the largest banks having a higher MPL of 0.86. [► Back](#)



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## DEMAND FOR LOANS

- ▶ Demand for loans comes from ex-ante identical borrowers who demand one-period loans to fund a risky project.
- ▶ Every period, given  $r_B^L, r_N^L$ , and shock  $\omega$ , borrowers decide whether to invest ( $\iota = 1$ ) or not ( $\iota = 0$ ).

$$\max_{\{\iota\}} (1 - \iota) \cdot \omega + \iota \cdot E_{\delta}[\Pi_E(\theta, r_B^L, r_N^L, \delta)] \quad (18)$$

- ▶ Conditional on choosing  $\iota = 1$ , entrepreneurs observe  $\delta = \{\delta_B, \delta_N\}$  and then choose which type of lender  $k \in \{B, N\}$  to borrow from to solve:

$$\Pi_E(\theta, r_B^L, r_N^L, \delta) = \max_{k \in \{B, N\}} \alpha E_{\theta'|\theta}[\pi(r_k^L, \theta)] + \delta_k \quad (19)$$

where

$$\pi_E(r_k^L, \theta') = \begin{cases} \max\{0, R - r_k^L\} & \text{with prob } \theta' \\ \max\{0, -(\lambda' + r_k^L)\} & \text{with prob } 1 - \theta' \end{cases} \cdot$$

## NONBANK LOAN PROBLEM

- ▶ The profit of the representative nonbank is given by:

$$\pi_N(\ell_N, S, \theta', \lambda') = [\theta' r_N^L - (1 - \theta') \lambda' - c_N] \ell_N \quad (20)$$

- ▶ The first order condition of the non-bank with respect to  $\ell_N$  is given by

$$r^D = E_{\theta'|\theta} [\theta' r_N^L - (1 - \theta') \lambda'] - c_N. \quad (21)$$

## PARAMETERS AND TARGETS

Parameter		Value	Target
Deposit Interest Rate (%)	$\bar{r} = r^D$	0.0014	Avg Interest Expense Deposits
Bank Discount Factor	$\beta$	0.998	$(1 + r^D)^{-1}$
Return on Securities	$r_A^+$	0.0180	Return on Net Securities
Default Frequency (Good Times)	$\theta_G$	0.969	Mean Default Frequency (Non-Crisis)
Default Frequency (Bad Times)	$\theta_B$	0.80	Mean Default Frequency (Financial Crisis)
Loan Loss Rate	$\bar{\lambda}$	0.31	Average Charge-off rate
Standard Dev Loan Loss rate $f$	$\sigma_\lambda$	0.15	Std dev charge off rates $f$
Standard Dev Loan Loss rate $d$	$\sigma_\lambda$	0.15	Std dev charge off rates $d$
Number of Borrowers	$N$	8.5	Deposit to Output
Return on investing	$R$	0.20	Net Interest Margin
Price coefficient	$\alpha$	42.0	Elasticity of Loan Demand
Lower bound demand shock	$\underline{\omega}$	0.693	Normalization
Upper bound demand shock	$\bar{\omega}$	1.193	Dividend Issuance $d$ and $f$
Mean size of Fringe Bank $f$	$D_f$	0.001	Relative Size Fringe to Top 10
Linear Cost Loans $d$	$C_d^1$	0.010	Net Marginal Expenses Top 10
Quadratic Cost Loans $d$	$C_d^2$	0.001	Elasticity Net Marginal Expenses Top 10
Fixed cost $d$	$\kappa_d$	0.0028	Fixed cost over loans Top 10
Mean Dist Cost Loans $f$	$C_f^1$	0.010	Net Marginal Expenses Fringe
Quadratic Cost Loans $f$	$C_f^2$	0.001	Elasticity Net Marginal Expenses Fringe
Fixed cost $f$	$\kappa_f$	$0.012 \times D_f$	Fixed cost over loans Fringe
External finance param. $d$	$\psi_d^1$	0.05	Avg. equity issuance to loan ratio Fringe
External finance param. $f$	$\psi_f^1$	0.50	Avg. equity issuance to loan ratio Fringe
Entry Cost $f$	$K_f$	$0.55 \times D_f$	Entry Rate
Regulatory Merger Cost	$h$	0.001	Post-Dodd-Frank Bank Market Share Top 10
Marginal Cost Nonbank	$c_N$	0.375	Bank Loan to Total Loans

## PARAMETERS THAT CHANGE

Parameter		Pre-Riegle-Neal	Post-Dodd-Frank
Fixed cost $d$	$\kappa_d$	0.0028	0.0035
Fixed cost $f$	$\kappa_f$	$0.012 \times D_f$	$0.028 \times D_f$
Marginal Cost nonbank	$c_N$	0.375	0.315

## CALIBRATION

Name	Calc	Data Pre	Data Post	Model Pre	Model Post
Average Charge-off rate	$E_{\theta'}[(1 - \theta')\lambda']$	0.96%	0.94%	0.96 %	0.96 %
Elasticity of Loan Demand	$-\alpha r_B^L(1 - s_B)$	-1.1	-1.1	-1.00	-1.39
Deposit Share Top 10 to Fringe	$\frac{D_d}{D_d + \gamma D_f}$	24.77%	57.79%	24.60%	55.26%
Loan Share Top 10 to Fringe	$\frac{L_d}{L_d + \gamma L_f}$	28.55%	52.86%	21.51%	40.68%
Bank Loans to Total Loans Ratio	$\frac{L_d}{L_d + L_d + \gamma L_f}$	44.54%	33.28%	51.51%	39.70%
Net Interest Margin	$E_{\theta}[\theta' r_B^L - r_D]$	4.94%	4.35%	4.63%	5.18%
Net Marginal Expenses Top 10	$\frac{c(L_D)}{L_D}$	1.15%	1.35%	1.03%	1.04%
Net Marginal Expenses Fringe	$\frac{c(L_F)}{L_F}$	2.00%	1.69%	1.00%	1.00%
Elasticity Net Mg Expenses Top 10	$\frac{dC_D(L_d)}{dL_d}$	0.95%	1.03%	1.05%	1.08%
Elasticity Net Mg Expenses Fringe	$\frac{dC_f(L_f)}{dL_f}$	0.78%	0.84%	1.00%	1.00%
Fixed cost over loans Top 10	$\frac{\kappa_D}{L_D}$	0.89%	0.78%	1.02%	0.88%
Fixed cost over loans Fringe	$\frac{\kappa_F}{L_F}$	0.99%	5.83%	1.20%	2.80%
Bank Failure Rate Top 10	$x_d$	0.00%	0.00%	0.00%	0.00%
Bank Failure Rate Fringe	$\gamma x$	0.76%	0.44%	0.03%	0.44%
Relative Size Dominant to Fringe	$\frac{D_f}{D_d}$	324.79	688.47	325.00	717.36
Dividends/Assets Top 10	$\mathcal{D}_d / D_d$	0.36%	0.74%	1.65%	1.99%
Dividend/Assets Fringe	$\mathcal{D}_f / D_f$	0.39%	0.66%	1.50%	0.43%
Loan Markup Top 10	$\frac{\theta r^L}{r_D + c'(L_d)}$	56.29%	205.37%	218.16%	258.73%
Loan Markup Fringe	$\frac{\theta r^L}{r_D + c'(L_f)}$	46.64%	149.73%	204.25%	135.03%
Interest Rate	$r_B^L$	6.69%	3.18%	4.93%	5.49%
Ratio of Loans to Deposits Top 10	$\frac{L_d}{D_d}$	83.3%	64.1%	84.18%	55.51%
Ratio of Loans to Deposits Fringe	$\frac{L_f}{D_d}$	73.3%	79.7%	99.99%	99.99%