The Bank Lending Channel Across Time and Space

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(Preliminary)

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

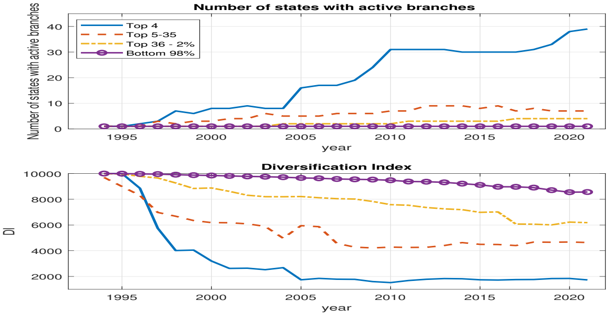
Our Question

- The Riegle-Neal Act of 1994 eliminated cross-state branching restrictions at the national level, allowing banks to grow across state lines.
- The distribution of bank size has become increasingly right skewed.
- How does geographic diversification affect bank lending and financial stability across time?
- How do changes in the size distribution of banks affect monetary policy effectiveness?

Roadmap

- Data: The Cross-sectional Size Distribution of Banks across Time and its implications for Diversification
- Model: A Quantitative Model of Banking Industry Dyanamics with Imperfect Competition.
- Applications:
  - Regional Spillovers
  - Bank Lending Channel

Deposits Across Space by Size

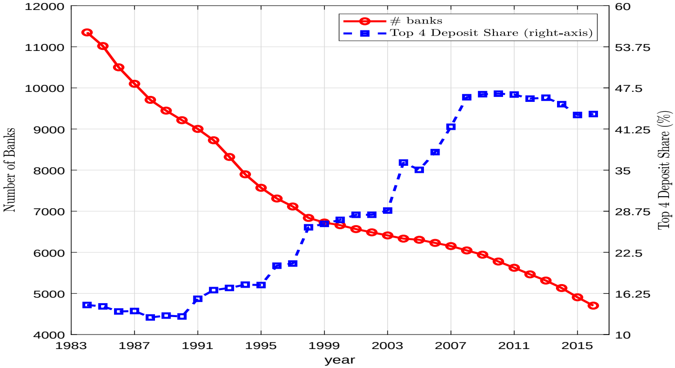


Note: Banks are ranked according to deposits. Source: Summary of Deposits

- Geographic diversification increased significantly resulting in large national banks.
  - top panel: top 4 banks in most states.
  - bottom panel: top 4 are more diversified across space.

Diversification

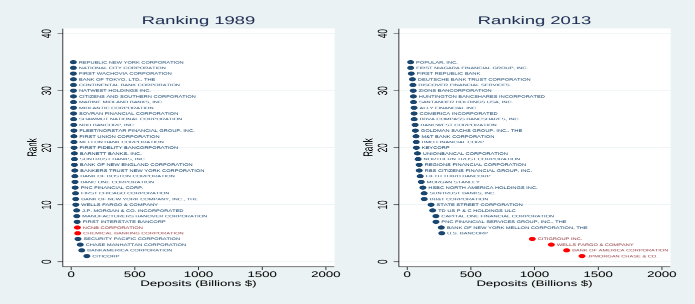
U.S. Banking Concentration



- Number of banks fell from 11,000 in 1984 to 5000 in 2018
- Share of total banking industry deposits held by the top 4 rose from 15% in 1984 to 44% in 2018.
- Apparent transition following Riegle-Neal between stochastic steady states (1984-93 vs 2009-18).

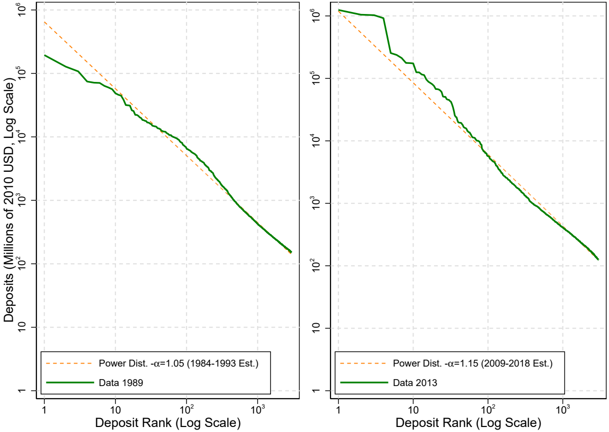
Deposit Distribution Pre- and Post-Reform

Figure: Deposit Distribution Pre- and Post-Reform



Note: Banks are ranked according to deposits. Deposits are in reported in real terms. Red bubbles identify banks that end up in the Top 4 of the distribution post-reform (2013). Source: Call Reports.

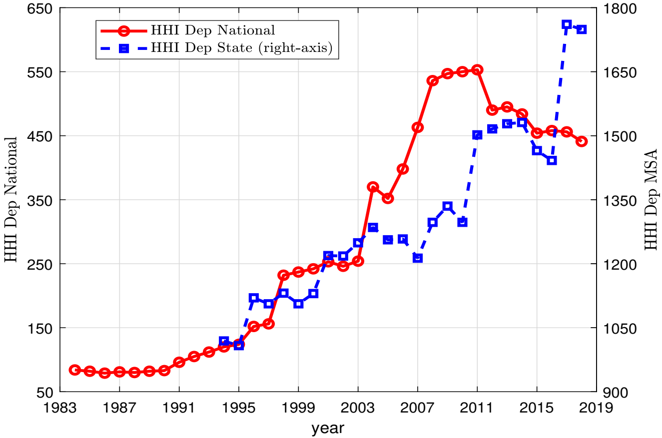
Deviations from Zipf's Law



- Bank size distribution deviates from Zipf's law which says the firm size distribution is well approximated by a Power Law distribution.
- Right tail has become thicker post-reform (i.e. big banks even bigger).

Zipf

Rise in Concentration: National and State Level



- HHI ($= \sum_i s_i^2$) at the national and state level increase after reform
- Anti-trust Department considers local HHI greater than 1500 (2500) moderately (highly) concentrated (restricting bank mergers).

Deposit Process by Bank Size

Using Arellano-Bond (1991), we estimate bank type deposit processes:

$$\log(d^j_{\theta,t}) = (1-\rho^d_\theta)\overline{d}_\theta + \rho^d_\theta \log(d^j_{\theta,t-1}) + u^j_{\theta,t}, \quad u^i_{\theta,t} \sim^{iid} N(0, \sigma^2_{\theta,u})$$

Table: Deposit Process Parameters

Size Group		*Pre-Reform Estimates (1984 - 1993)*				
Data	Model	$e^{\overline{d}_\theta}$	$\overline{d}_\theta$	ρ_θ	$\sigma_{u,\theta}$	σ_θ
Top 2%	$\theta = \int$	1.000	1.000	0.821	0.134	0.235

Size Group		*Post-Reform Estimates (2009 - 2018)*				
Data	Model	$e^{\overline{d}_\theta}$	$\overline{d}_\theta$	ρ_θ	$\sigma_{u,\theta}$	σ_θ
Top 4	$\theta = \backslash$	44.413	1.289	0.827	0.037	0.066
Top 5 - 35	$\theta = \nabla$	3.988	1.123	0.762	0.086	0.132
Top 36 - 2%	$\theta = \int$	0.451	0.987	0.738	0.106	0.157

Note: Average deposits (including other borrowings) are normalized to 1 for the Top 2% group in the pre-reform period. $\overline{d}_\theta$ is reported relative to this group.

- Big Banks have larger and better diversified deposit base.

Loan Portfolio Statistics by Bank Size

Table: Loan returns ($x = pr^L - (1-p)\lambda$)

Size Group		Pre-Reform (1984 - 1993)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 2 %	$\theta = \int$	0.048	0.603	0.010	0.014	0.013

Size Group		Post-Reform (2009 - 2018)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 4	$\theta = \setminus$	0.018	0.390	0.0015	0.0017	0.0025
Top 5- 35	$\theta = \nabla$	0.017	0.227	0.0042	0.0043	0.0056
Top 36 - 2%	$\theta = \int$	0.024	0.399	0.0063	0.0068	0.0070

Note: Loan returns are defined to be the fraction of performing loans (p) times loan interest rate (r^L) minus the chargeoff rate (which is fraction of non-performing loans ($1-p$) times the fraction lost in default (λ)). Source: Call Reports.

- Big Banks have better diversified loan portfolios as measured by a lower variance of loan returns.

Interest Margins by Bank Size

Table: Interest Margin ($x = pr^L - r^d$)

Size Group		Pre-Reform (1984 - 1993)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 2 %	$\theta = \int$	0.044	0.568	0.008	0.010	0.013

Size Group		Post-Reform (2009 - 2018)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 4	$\theta = \backslash$	0.047	-0.287	0.0017	0.0017	0.0020
Top 5- 35	$\theta = \nabla$	0.040	0.556	0.0035	0.0043	0.0044
Top 36 - 2%	$\theta = \int$	0.044	0.448	0.0045	0.0050	0.0056

Note: Loan returns are defined to be the fraction of performing loans (p) times loan interest rate (r^L) minus the deposit interest rate (r^d). Source: Call Reports.

- The pattern is similar to that of loan returns: not large differences in means but significant decline in volatility with bank size

Charge off rates

Table: Charge-off Rate ($x = (1-p)\lambda$)

Size Group		Pre-Reform (1984 - 1993)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 2 %	$\theta = \int$	0.009	0.625	0.006	0.009	0.008

Size Group		Post-Reform (2009 - 2018)				
Data	Model	Avg (%)	ρ_x	σ_u	$\hat{\sigma}_x^{ar(1)}$	$\hat{\sigma}_x$
Top 4	$\theta = \backslash$	0.014	0.653	0.0018	0.0023	0.0027
Top 5- 35	$\theta = \nabla$	0.009	0.314	0.0039	0.0041	0.0056
Top 36 - 2%	$\theta = \int$	0.008	0.442	0.0059	0.0065	0.0066

Note: The chargeoff rate (which is fraction of non-performing loans $(1-p)$ times the fraction lost given default (λ)). Source: Call Reports.

- Bigger banks have lower variance of chargeoffs.

Cost Structure by Bank Size

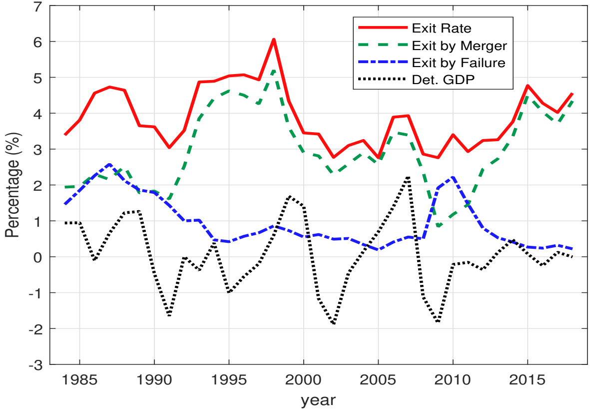
Table: Cost Structure by Bank Size (Pre and Post - Reform)

Size Group Data	Size Group Model	Avg. Cost	Mg Net Exp $c_\theta(\ell_\theta)/\ell_\theta$	Fixed Cost $c_{F,\theta}/\ell_\theta$
Pre-Reform Estimates (1984 - 1993)				
Top 2%	$\theta = \int$	2.58	1.76	0.81
Post-Reform Estimates (2009 - 2018)				
Top 4	$\theta = \backslash$	1.24	0.61	0.63
Top 5 - 35	$\theta = \nabla$	1.56	0.98	0.58
Top 36 - 2%	$\theta = \int$	1.96	1.44	0.52

Source: Call Reports.

- As in Diamond's (1984) delegated monitoring model, the motives to get bigger are increasing returns and diversification.

Exit Rates



Business Cycle Correlations

- (det-GDP,det-Exit): $corr(y, xr) = 0.37$
- (det-GDP,det-Failure): $corr(y, xf) = -0.20$
- (det-GDP,det-Merger): $corr(y, xm) = 0.46$

Summary of the Data

- Following Riegle-Neal there was rapid geographic expansion in big banks' deposit base translating to substantial industry concentration and larger HHI at the state level.
- With geographic expansion came geographic diversification; banks branching out nationally enjoy lower variance of deposits, loan returns, interest margins, and chargeoff rates than their smaller competitors.
- There were not sizeable differences in average interest margins across bank size; some evidence for Cournot competition.
- Evidence for increasing returns (decreasing average costs).
- Countercyclical bank exit and procyclical mergers (i.e. investment in growth).

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- Bank growth as in the ladder model of Besanko-Doraszelski (2004).
  - Riegle-Neal deregulation lowered the cost of geographic expansion beyond state level.
  - As banks grow, they expand their capacity and lower their variance of low cost deposit inflows modeled as a bank size dependent Markov processes for exogenous deposit inflows.
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- Banks Cournot compete in the loan market subject to deposit capacity constraints and compete with non-bank lenders.
- There is endogenous bank exit and entry which allows us to examine how monetary and regulatory policy can affect the bank size distribution and financial stability.

Model Basics

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- Banks can expand their deposit base to more states by investing at a cost from internal funds or costly seasoned equity.
- Aggregate, regional, and idiosyncratic shocks together with entry/exit and investment induce an endogenous bank size distribution over type and deposit size across regions.

Stochastic Processes

- Aggregate technology shocks follow a finite state Markov Process $F(Z', Z)$.
- Region $j \in \{e, w\}$ specific technology shocks z_j independent over time drawn with possible correlation across regions.
- Conditional on Z' and z_j', project success shocks are iid across borrowers drawn from $p(R_k, Z', z_j')$ which depends on borrower project risk choice R_k (i.e. endogenous bank portfolio losses).
- Entrepreneurs face a discrete choice problem to borrow from lender type $k \in \{\mathcal{B}, \mathcal{N}\}$) (i.e. banks and non-banks) subject to an additive idiosyncratic shock $\epsilon \in \{\epsilon_{\mathcal{B}}, \epsilon_{\mathcal{N}}\}$ drawn from an extreme value distribution ($\longrightarrow$ bank and shadow bank market shares as in Buchek, et. al. (2019)).
- "Funding shocks" (capacity constraint on deposits) which are iid across banks and follow type specific $\theta \in \{\int, \nabla, \backslash\}$ Markov Process $G_\theta(d_\theta', d_\theta)$.

Entrepreneurs - Loan Demand

- At b-o-p, risk neutral borrowers in region j demand a (unit) loan from lender $k \in \{\mathcal{B}, \mathcal{N}\}$ to fund a project which returns at e-o-p:

$$\begin{cases} 1 + z_j' Z' R_k & \text{with prob } p(R_k, Z', z_j') \\ 1 - \lambda' & \text{with prob } 1 - p(R_k, Z', z_j') \end{cases}.$$

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- Borrowers choose R_k with $dp(R_k, Z', z_j')/dR_k < 0$ (i.e. return-risk tradeoff) under limited liability and with chargeoffs $\log(\lambda') \sim N(\mu_\lambda, \sigma_\lambda)$ i.i.d. across borrowers and time.

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- R_k and project success are private info of ent. who will claim failure unless monitored as in Bernanke-Gertler (1989).
- Taking the vector of interest rates $\mathbf{r}_j = \{r_{\mathcal{B},j}, r_{\mathcal{N},r}\}$ and realizations of $\boldsymbol{\epsilon} = \{\epsilon_{\mathcal{B}}, \epsilon_{\mathcal{N}}\}$ and ω, entrepreneurs decide whether to fund the project ι, and if so, the lender type $k \in \{\mathcal{B}, \mathcal{N}\}$ and the risk-return R_k of their project.

Banks

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- Bank type determines the mean $\overline{d}_\theta$ and variance σ_θ of a bank's deposits consistent with the estimates in Table 1 with Markov matrix $G_\theta(d'_\theta, d_\theta)$.
  - $\overline{d}_\int < \overline{d}_\nabla < \overline{d}_\setminus$ (bigger banks have insured funding advantage)
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- A bank of type θ can invest $I \in \mathbb{R}_+$ to become a larger type bank (a reduced form way of capturing mergers and acquisitions) according to an endogenous transition function $T(\theta'|\theta = \nabla, I_\nabla)$ as in quality ladder models. T function

Bank Loan Supply

After being matched with a random number of depositors d_θ in state $s_j = (\boldsymbol{\mu}, Z, \lambda', z_j', Z')$, the profits in region j of a type θ bank for a given loan choice $\ell_{\theta,j}$ are given by

$$\begin{aligned}\pi_\theta(d_\theta, s_j) &= \left[p_j(R_{\mathcal{B}}, z_j', Z')r_{\mathcal{B},j}(\boldsymbol{\mu}, Z) - (1 - p_j(R_{\mathcal{B}}, z_j', Z'))\lambda'\right]\ell_{\theta,j} \\ &- c_\theta(\ell_{\theta,j}) + (\bar{r}\mathbf{1}_{\{a_\theta \geq 0\}} + r^a\mathbf{1}_{\{a_\theta < 0\}})a_\theta - r_{D,j}d_\theta - c_{F,\theta}, \quad (1)\end{aligned}$$

subject to

- $\ell_{\theta,j} + a_\theta = d_\theta$ for $\theta \in \{\int, \nabla\}$
- $\sum_j \ell_{\backslash,j} + a_\backslash = d_\backslash$
- interpret $a_\theta < 0$ (> 0) as external borrowing (storage).

where $\boldsymbol{\mu}(d_\theta)$ is the cross-sectional counting measure of banks.

Bank Loan Supply - Optimal Choice

- An individual regional or small bank's loan supply solves (national bank adds across regions)

$$\ell_{\theta,j}(d_\theta, s_j) = \underset{\ell_{\theta,j}}{\text{argmax}}\, E_{Z',z_j',\lambda'|Z}\left[\pi_\ell(d_\theta, s_j)\right].$$

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- Given that all banks have some degree of market power, a bank internalizes its impact on loan supply (and hence loan interest rate) and that other banks will best respond to its loan supply.
- The f.o.c. w.r.t. loans (i.e. marginal propensity to lend (MPL)) is

$$E_{Z',z'_j,\lambda'|Z}\left[\underbrace{\left(p_j r_{\mathcal{B},j} - (1-p_j)\lambda' - \frac{dc_\theta}{d\ell_{\theta,j}}\right)}_{(+)\text{ or }(-)}\right]$$

$$+ \quad E_{Z',z'_j,\lambda'|Z}\left[\ell_{\theta,j}\left(\underbrace{p_j}_{(+)} + \underbrace{\frac{\partial p_j}{\partial R_\mathcal{B}}\frac{\partial R_\mathcal{B}}{\partial r_{\mathcal{B},j}}(r_{\mathcal{B},j}+\lambda')}_{(-)}\right)\underbrace{\frac{dr_{\mathcal{B},j}}{d\ell_{\theta,j}}}_{(-)}\right]$$

$$- \quad \mathbf{1}_{\{a_\theta \geq 0\}}\bar{r} - \mathbf{1}_{\{a_\theta < 0\}} r^a = 0,$$

Banks - Investment and Exit

- If a bank chooses not to exit, it chooses how much to invest $I(d_\theta, s_j)$ to raise its deposit capacity θ'.
- Banks can finance I with internal funds π_ℓ or issue equity e_θ if there is insufficient internal funds so $e_\theta = max\{I - \pi_\theta, 0\}$.
- Issuing equity costs $\varsigma_\theta(e_\theta)$ with $d\varsigma_\theta/de_\theta > 0$ where $\varsigma_\int > \varsigma_\nabla > \varsigma_\backslash$ consistent with bank lending channel in Kashyap and Stein (2000).

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- Incumbent banks have the option to exit $x_\theta(d_\theta, s_j) = 1$ with limited liability with recovery rate of bank's assets given by ζ.

Bank Entry

- We consider an entry process similar to Farias, Saure, and Weintraub (2012).
- Potential entrants make entry decisions simultaneously bearing a positive entry cost κ funded by an initial equity injection by households who receive bank dividends in exchange.
- Entrants appear in the following period in state $(\theta' = \int, d'_{\int})$ (i.e., we assume that all entrants start as a small bank) where $d'_{\int}$ is drawn from $\overline{G}_{\int}$.
- We denote the number of entrants $N_{e,j}$ which is determined endogenously in equilibrium.

Timing

The timing of events is as follows:

1. At the beginning of the period, given Z, θ, d_θ, ω are realized which determines the banking industry distribution $\boldsymbol{\mu}$.
   1.1 Loan Demand: Entrepreneurs choose whether to borrow from banks or non-banks or their outside option. If they borrow they choose the risk-return tradeoff $R_{k,j}$ of their project
   1.2 Loan Supply: Banks and non-banks choose how many loans to supply as well as external funding
   1.3 Loan market clearing determines $\mathbf{r}_j = \{r_{\mathcal{B},j}, r_{\mathcal{N},j}\}$

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2. At the end of the period, Z', z'_j, and λ' are realized which along with $R_{k,j}$ determines portfolio charge-offs and profitability $\pi_{k,j}$
   2.1 Bank exit x_j and entry choices e_j are made.
   2.2 Bank investment I_j is chosen together with equity injections implying dividend payments.
   2.3 Households pay taxes to fund deposit insurance and consume. and consume.

Timing

Cross-Sectional Bank Size Distribution

The distribution of banks $\boldsymbol{\mu}$ evolves according to $\boldsymbol{\mu}' = \mathcal{H}(\boldsymbol{\mu}, N_e)$ where each component is given by:

$$\begin{aligned}
&\mu'_{\theta'}(d'_\theta) = \\
&\sum_{\theta \in \{\nabla, \int\}, j \in \{e,w\}, d_\theta \in D_\theta} \int_\lambda (1 - x(d_\theta, s_j))(1 - \rho^x_\theta) T(\theta'|\theta, I(d_\theta, s_j)) G_\theta(d'_\theta, d_\theta)\mu_\theta(d_\theta) df(\lambda) \\
&+ \sum_{d_\backslash \in D_\backslash} \int_\lambda (1 - x(d_\backslash, \mathbf{s}))(1 - \rho^x_\backslash) T(\theta'|\backslash, I(d_\backslash, \mathbf{s})) G_\backslash(d'_{\theta'}, d_\backslash)\mu_\backslash(d_\backslash) df(\lambda) \qquad (2) \\
&+ N_{e,j} \sum_{j, d_\int} \overline{G}_\int(d_\int)
\end{aligned}$$

- Equation (2) makes clear how the law of motion for the distribution of banks is affected by entry (N_e) and exit (x) decisions as well as the accumulating size decision (I).

Definition of Equilibrium

A pure strategy Markov Perfect Industry Equilibrium (MPIE) is:

1. $\{\iota_j, K_j, R_{K,j}\}$ are consistent with entrepreneur optimization inducing an aggregate loan demand function $L^d_j(Z, \mathbf{r}_j)$. Borrower Problem
2. $\{A', D', S'_\theta, S'_\mathcal{N}\}$ are consistent with household optimization inducing a deposit matching process. HH Problem
3. $\{\ell_{\theta,j},\ l_{\theta,j},\ x_{\theta,j},\ \rceil_{\theta,j},\ V_\theta\}$ are consistent with bank optimization inducing an aggregate loan supply function $L^s_{\mathcal{B},j}$. Bank Problem
4. Free entry is satisfied. Free Entry
5. $\{\ell_{\mathcal{N},j}\}$ is consistent with non-bank optimization. NonBank Problem
6. The law of motion for the industry state $\boldsymbol{\mu}' = \mathcal{H}(\mu, \{N^e_j\}_j)$ induces a sequence of cross-sectional distributions that are consistent with entry, exit, and investment decision rules.
7. The vector of interest rate $\mathbf{r}_j(Z, \mu)$ clear the loan market.
8. Stock prices consistent with bank valuation V_θ.
9. Lump sum taxes $\tau'_D(\boldsymbol{s})$ cover the cost of deposit insurance. Tax

Parameterization

- A model period is one year.
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  - Banks play Nash against the long run average cross-sectional distribution of competitors conditional on a finite set of moments.
- Calibrate the model to the post-crisis stochastic steady state (the ergodic distribution of the MPE) with all type $\theta \in \{\int, \nabla, \setminus\}$ banks.
- Given that there is symmetry in the underlying stochastic processes and parameter values in the model, the two regions yield similar long run averages in the tables.

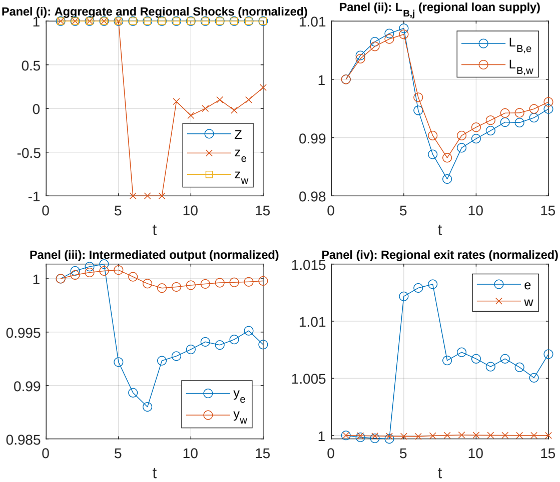
Calibration | Target Moments | Additional Moments | Transition | SizeDist

Regional Spillovers

- Construct an event window of 15 periods in which:
  - the aggregate shock Z is kept constant at its mean Z_M (i.e., we eliminate aggregate fluctuations derived from Z),
  - the regional shock in the w region $z_w = z_H$,
  - the regional shock in the $e-$region is equal to z_H for the inital 5 periods, it decreases to z_L for 3 periods, and then moves according to its stochastic process.
  - Thus, only exogenous variable which changes is z_e.

- We simulate this window 1,000 times and present the average response of the economy in Figures 4 and 5.

Regional Spillovers Event Analysis



More Regional

Regional Spillovers

- The negative regional shock generates an immediate negative response in lending in region e with the corresponding decline in output (Panels (*ii*) and (*iii*)).
    - In response to drop in loans, interest rates rise (not shown).

- Importantly, while the $w-$region does not experience any shock, bank losses and failure in the $e-$region induce a decline in lending and output in the $w-$ region as well.

- Bank failure increases for small and regional banks in the $e-$ region that are less diversified (Panel (*iv*))

- National \ banks are better diversified but losses in one region that, in few instances result in national bank failure, lead to long lasting effects that spill across the two regions.

The Bank Lending Channel

- The bank lending channel of monetary policy suggests that banks play a special role in the transmission of monetary policy.

- The channel works through how monetary policy affects the cost of external funding across banks of different sizes.
  - The corporate finance approach to the bank lending channel, as elucidated in Kashyap and Stein (2000), posits that larger banks are less sensitive to increases in fed funds rates since they have easier access to external funding.
  - Thus, bigger banks lower their loan supply less than smaller banks in response to a rise in external funding costs like fed funds.

- We implement this idea by raising the external funding cost r^a by 75 basis points both both pre-Riegle-Neal (from $r^a = 0.0125$ to $r^a = 0.02$, a 60%Δ) and post-crisis (from $r^a = 0.005$ to $r^a = 0.0125$, a 150%Δ) evaluated for (10 periods).

Bank Lending Channel

	Pre - Reform			Post - Reform		
	Baseline	$\uparrow r_0^a$	$\Delta\%$	Baseline	$\uparrow r_0^a$	$\Delta\%$
Avg. Def. Freq.	1.79	1.80	0.64	1.60	1.61	0.88
Loan Int. Rate	4.69	4.94	5.42	3.55	4.28	20.56
Bank Loan Supply	94.89	85.29	-10.11	101.91	73.48	-27.90
Bank Loans to Output	68.36	62.32	-8.83	65.18	48.41	-25.73
Bank Loans to Total Loans	67.82	61.88	-8.75	64.74	48.11	-25.69
Avg Loans $\int$	0.57	0.55	-3.48	0.70	0.35	-50.11
Avg Loans ∇	-	-	-	5.08	3.14	-38.21
Avg Loans $\backslash$	-	-	-	20.24	16.35	-19.22

- Raising external borrowing costs lower average loans both pre and post-reform with substitution into non-bank lending.
- Importantly, we see larger banks are less sensitive to the rise in funding costs than smaller banks as in Kashyap and Stein.

Conclusion

- We modeled the incentive to grow (acquire a broader deposit base and expand geographically in the presence of increasing returns) following a banking regulatory shift in a model with imperfect competition.
- The resulting cross-sectional distribution of bank size is consistent with the rise in concentration as in the data.
- Geographic expansion can have important effects on the structure of the banking sector and financial stability (markups, default frequencies, and bank failure) as well as the effectiveness of monetary policy via the bank lending channel.
    - Despite geographic diversification leading to lower national bank distress, shocks in one region can spill over to other through its national lending strategies.

Appendix

Non-Bank Problem

- The non-bank lending and dividend/equity issuance policy $(\mathcal{D}_{\mathcal{N}},]_{\mathcal{N}})$ satisfies the following cash flow condition

$$\mathcal{D}_{\mathcal{N}} = \sum_j \left\{ \left[p_j(R_{\mathcal{N}}, z_j', Z') r_{\mathcal{N},j}(\boldsymbol{\mu}, Z) - (1 - p_j(R_{\mathcal{N}}, z_j', Z'))\lambda' \right] - c_{\mathcal{N}} \right\} \ell_{\mathcal{N},j}$$

subject to flow constraint $S_{\mathcal{N}}]_{\mathcal{N}} = \sum_j \ell_{\mathcal{N},j}$.

- Given $\beta(1+\overline{r}) = 1$, the first order condition of the non-bank with respect to $\ell_{\mathcal{N},j}$ is given by

$$\overline{r} = E_{Z',z_j',\lambda'|Z} \left[p(R_{\mathcal{N}}(r_{\mathcal{N},j}, Z), Z', z_j') - (1 - p(R_{\mathcal{N}}(r_{\mathcal{N},j}, Z), Z', z_j'))\lambda' \right] - c_{\mathcal{N}} \tag{3}$$

- Equation (3) is one equation in one unknown which pins down the interest rate $r_{\mathcal{N},j}$ of the non-bank sector as a function of Z.

return

Computational Algorithm

- Use Farias, Suare, and Weintraub (2012) to approximate the Markov-perfect equilibrium by assuming that firms, at each time, make decisions based on their own state and the *long-run* average industry state that prevails in equilibrium.
- In short, the algorithm searches over an entry rate until the free entry condition is satisfied (provided all other equilibrium conditions are met).

Computational Algorithm

1. Solve the problem of the entrepreneur (5)-(6) and derive the total loan demand function (8). Given the extreme value distribution implies bank and non-bank market shares given in (10), we can calculate bank loan demand as in (9).
2. Solve the problem of the nonbank (3) to obtain the residual loan demand for bank loans.
3. Set tolerances ϵ^{ℓ}, ϵ^{I}, ϵ^{x}, ϵ^{e}, and ϵ^{μ} to small values. Start with a number of entrants $N^{e,g}(Z)$ where iteration $g = 0$ is an initial guess.
4. Guess an investment decision rule $I^h(\cdot)$ and an exit decision rule $x^h(\cdot)$ where iteration $h = 0$ is an initial guess.
5. Using $N^{e,g}$, $I^h(\cdot)$, and $x^h(\cdot)$ and a large sequence of shocks $\{Z_t, z_{j,t}, z_{-j,t}\}_{t=1}^{T}$, simulate the distribution of banks $\{\boldsymbol{\mu}_t\}_{t=1}^{T}$. Discard the initial 250 periods and compute the average industry state $\overline{\boldsymbol{\mu}}^h(Z)$ by taking the average of the observed distribution conditional on Z.

Computational Algorithm - cont.

6. Obtain an equilibrium in the loan market:
   a. Guess a loan decision rule $\ell^k(\cdot)$ where iteration $k = 0$ is an initial guess.
   b. For each $\{\theta, d\}$, given that the industry state $\overline{\boldsymbol{\mu}}^h(Z)$ and $\ell^k(\cdot)$ determines the loan supply function of a bank' competitors, obtain the best response $\ell^{k+1}(\cdot)$ by maximizing profits in equation (**??**).
   c. Compute $\Delta^\ell = \|\ell^{k+1}(\cdot) - \ell^k(\cdot)\|$.
   d. If $\Delta^\ell < \epsilon^\ell$, an equilibrium in the loan market has been found, continue to the next step. If not, return to step b with the updated loan decision rule $\ell^{k+1}(\cdot)$.
7. Solve the bank problem to obtain investment and exit rules:
   a. For each $\{\theta, d, s_j\}$, solve the bank problem to obtain $I^{h+1}(\cdot)$ and $x^{h+1}(\cdot)$.
   b. Using $I^{h+1}(\cdot)$ and $x^{h+1}(\cdot)$, compute a new long-run industry state $\overline{\boldsymbol{\mu}}^{h+1}(Z)$ using the transition operator in equation (2).
   c. Compute $\Delta^I = I^{h+1}(\cdot) - I^h(\cdot)\|$, $\Delta^x = \|x^{h+1}(\cdot) - x^h(\cdot)\|$, and $\Delta^\mu = \|\overline{\boldsymbol{\mu}}^{h+1}(Z) - \overline{\boldsymbol{\mu}}^h(Z)\|$.
   d. If $\Delta^I < \epsilon^I$, $\Delta^x < \epsilon^x$, and $\Delta^\mu < \epsilon^\mu$ continue to the next step. If not, return to step b with the updated industry state $\overline{\boldsymbol{\mu}}^{h+1}(Z)$.

Computational Algorithm - cont.

8. Obtain the value of an entrant (net of entry costs) $V^e(Z, \overline{\boldsymbol{\mu}}^{h+1}(Z))$ in equation (11). If $\|V^e(Z, \overline{\boldsymbol{\mu}}^{h+1}(Z))\| < \epsilon^e$ an equilibrium has been found. If not, update the number of entrants $N^{e,g+1}(Z)$ and return to step 5 with the updated number of entrants. The update of $N^{e,g}(Z)$ is done taking into account the value of $V^e(Z, \overline{\boldsymbol{\mu}}^{h+1}(Z))$. If $V^e(Z, \overline{\boldsymbol{\mu}}^{h+1}(Z)) > 0$, set $N^{e,g+1}(Z) > N^{e,g}(Z)$. If $V^e(Z, \overline{\boldsymbol{\mu}}^{h+1}(Z)) < 0$, set $N^{e,g+1}(Z) < N^{e,g}(Z)$.
9. A final check on the equilibrium is how well the "average" industry (conditional on Z) approximates the observed distribution along the equilibrium path. We compute the distance between the average distribution of the distance between the observed distribution and the average distribution and the values are small.

Return

Cost - Structure Pre and Post-reform

	Pre-Reform		Post-Reform	
Moment (%)	Data	Model	Data	Model
Avg Net Mg Expense θ^1	2.00	2.75	1.44	1.52
Fixed Cost / Loans θ^1	0.81	0.50	0.52	0.70
Avg Net Mg Expense θ^2	-	-	0.98	0.76
Fixed Cost / Loans θ^2	-	-	0.58	1.00
Avg Net Mg Expense θ^3	-	-	0.61	0.62
Fixed Cost / Loans θ^3	-	-	0.63	0.70
Avg Cost θ^1	2.81	3.25	1.96	2.22
Avg Cost θ^2	-	-	1.56	1.76
Avg Cost θ^3	-	-	1.24	1.32

- Increasing returns is one of the drivers of bank grow

return

Diversification Index

- Let $\ell_{i,m,t}$ denote the amount of loans originated by lender i in market m in period t.
- The share of loans of lender i in state m in period t is $s_{i,m,t} = \frac{\ell_{i,m,t}}{\sum_{m \in M_{i,t}} \ell_{i,m,t}} \times 100$ where $L_{i,t} = \sum_{m \in M_{i,t}} \ell_{i,m,t}$ is the total amount of loans originated by lender i in period t and $M_{i,t}$ denotes the states in which lender i operates.
- The diversification index is

$$DI_{i,t} = \sum_{m \in M_{i,t}} s^2_{im,t}. \tag{4}$$

- This index ranges between 0 and 10,000 and a smaller value indicates a more diversified lender.
  - e.g. lender in 2 states with equal shares DI=5,000
  - e.g. lender in 2 states with 90% in one and 10% another DI=8,200

Return

Zipf's Law

- Some firm dynamics studies have found that the firm size distribution is well approximated by a Power law distribution due to a thicker right tail than the lognormal.
- Let $x_r = cr^{-\alpha}$ where r is the rank of a variable and x_r is the value of the variable for the bank in rank r.
- The pareto distn is a straight line with slope -1.
- Estimate α by ML: if $-\alpha = 1$, then Zipf's Law holds. Table reports $-\alpha$:

	year				
	1976	1980	1990	2005	2016
Assets	1.018	1.019	1.026	1.129	1.274
Deposits	1.000	0.993	1.001	1.090	1.259
Loans	1.001	1.013	1.097	1.172	1.356
Employees	1.028	1.028	1.005	1.058	1.204

- There is a clear deviation from Zipf's Law since the mid 2000's

Return

Borrower Decision Problem

- In region j, entrepreneurs choose whether to operate the technology ($\iota \in \{0,1\}$), the type of lender ($K \in \{\mathcal{B}, \mathcal{N}\}$), and the type of technology (R_K):

$$\max_{\{\iota\}} (1-\iota)\cdot \omega' + \iota \cdot E_{\epsilon}[\Pi_E(Z, \boldsymbol{r_j}, \epsilon)] \tag{5}$$

where the value of investing (conditional on ϵ) $\Pi_E(\boldsymbol{r_j}, \epsilon, z_j', Z')$ is

$$\Pi_E(Z, \boldsymbol{r_j}, \epsilon) = \max_{\{K, R_K\}} \Big\{ \mathbf{1}_{\{K=\mathcal{B}\}} E_{z_j', Z'|Z}\left[\pi_E(r_{\mathcal{B},j}, R_{\mathcal{B}}, z_j', Z') + \epsilon_{\mathcal{B}}\right] + \mathbf{1}_{\{K=\mathcal{N}\}} E_{z_j', Z'|Z}\left[\pi_E(r_{\mathcal{N},j}, R_{\mathcal{N}}, z_j', Z') + \epsilon_{\mathcal{N}}\right] \Big\}, \tag{6}$$

and

$$\pi_E(r_{K,j}, R_K, z_j', Z') = \begin{cases} \max\{0, z_j' Z' R_K - r_{K,j}\} & \text{with prob } p_j(R_K, z_j', Z') \\ \max\{0, -(\lambda' + r_{K,j})\} & \text{with prob } 1 - p_j(R_K, z_j', Z') \end{cases} \tag{7}$$

Return

Parameters and Targets

Parameter		Value	Target
Deposit Interest Rate (%)	r^D	0.005	Avg Interest Expense Deposits
Mean Charge Off Rate	μ_λ	0.424	Avg Charge Off Rate
Std. Dev Charge Off Rate	σ_λ	0.199	Std Dev Charge Off Rate
Autocorrel Agg Productivity	ρ_Z	0.299	TFP US (Fernald)
Std. Dev Agg Productivity	σ_{u^Z}	0.010	TFP US (Fernald)
Exit Value Recovery	ζ	0.804	Recovery Value Bank Failures (FDIC)
Bank Discount Factor	β	0.995	$1/(1+\bar{r})$
Correlation Regional Shocks	ρ_z	0.000	Normalization
Linear External Borrowing Cost	r_0^a	$\bar{r} + 0.0025$	Normalization
Quadratic External Borrowing Cost	r_1^a	0.0025	Normalization

Return

Parameters and Targets (cont.)

Parameter		Value	Target
Measure Borrowers	B	320.0	Bank Loans to Output Ratio
Borrower Success Prob. Function	a	4.291	Avg. Borrower Return
Borrower Success Prob. Function	b	28.94	Avg. Default Frequency
Borrower Success Prob. Function	σ_e	0.107	Avg. Loan Interest Rate
Outside Option	$\overline{\omega}$	0.462	Elasticity of Loan Demand
Std. Dev Reg Shocks	σ_z	0.020	Std Dev Loan Returns
Linear Cost Loans $\int$	$c^0_{\int}$	0.001	Avg Net Mg Expense $\int$
Quadratic Cost Loans $\int$	$c^1_{\int}$	0.025	Elasticiticy Mg Expense $\int$
Fixed Operating Cost $\int$	$c_{F,\int}$	0.002	Fixed Cost / Loans $\int$
Linear Cost Loans ∇	c^0_{∇}	0.002	Avg Net Mg Expense ∇
Quadratic Cost Loans ∇	c^1_{∇}	0.025	Elasticiticy Mg Expense ∇
Fixed Operating Cost ∇	$c_{F,\nabla}$	0.010	Fixed Cost / Loans ∇
Linear Cost Loans $\setminus$	$c^0_{\setminus}$	0.006	Avg Net Mg Expense $\setminus$
Quadratic Cost Loans $\setminus$	$c^1_{\setminus}$	0.005	Elasticiticy Mg Expense $\setminus$
Fixed Operating Cost $\setminus$	$c_{F,\setminus}$	0.025	Fixed Cost / Loans $\setminus$
Proportional Cost Loans $\mathcal{N}$	$c_{\mathcal{N}}$	0.029	Share Bank Loans / Total Loans
Transition Probability Function	α	100.00	Loan Market Share $\int$
Transition Probability Function	δ	0.600	Fraction of Banks $\int$
Transition Probability Function	ξ	0.850	Transition $\int$ to ∇
Fixed Equity Issuance Costs $\int$	$\varsigma^0_{\int}$	0.001	Avg Equity Issuance $\int$
Proportional Equity Issuance Costs $\int$	$\varsigma^1_{\int}$	0.050	Fract $\int$ Banks Issue Equity
Fixed Equity Issuance Costs ∇	ς^0_{∇}	0.005	Avg Equity Issuance *mathcalr*
Proportional Equity Issuance Costs ∇	ς^1_{∇}	0.025	Fract ∇ Banks Issue Equity
Fixed Equity Issuance Costs $\setminus$	$\varsigma^0_{\setminus}$	0.020	Avg Equity Issuance $\setminus$
Proportional Equity Issuance Costs $\setminus$	$\varsigma^1_{\setminus}$	0.010	Fract $\setminus$ Banks Issue Equity
Entry Cost	κ	0.015	Total Number of Banks

Target Moments

Moments (%)	Data	Model
Charge - Off Rate	1.15	0.68
Std Dev Charge Off Rate	0.20	0.20
Avg. Borrower Return	12.94	13.72
Avg. Default Frequency	2.94	1.60
Loan Interest Rate	3.13	3.55
Elasticity of Loan Demand	-1.1	-1.19
Avg Net Mg Expense $\int$	1.44	1.78
Elasticiticy Mg Expense $\int$	0.025	0.03
Fixed Cost / Loans $\int$	0.52	0.17
Avg Net Mg Expense ∇	0.98	1.35
Elasticiticy Mg Expense ∇	0.0025	0.0025
Fixed Cost / Loans ∇	0.58	0.11
Avg Net Mg Expense $\setminus$	0.61	0.66
Elasticiticy Mg Expense $\setminus$	0.00005	0.00005
Fixed Cost / Loans $\setminus$	0.63	0.05
Loan Market Share $\int$	9.82	30.08
Fraction of Banks $\int$	65.71	80.24
Avg Equity Issuance $\int$	0.08	0.06
Fract $\int$ Banks Issue Equity	7.05	16.05
Avg Equity Issuance ∇	0.08	0.17
Fract ∇ Banks Issue Equity	6.40	65.28
Avg Equity Issuance $\setminus$	0.03	1.18
Fract $\setminus$ Banks Issue Equity	1.95	64.59
Bank Loans to Output Ratio	33.72	65.18
Share Bank Loans / Total Loans	50.00	64.73
Transition $\int$ to ∇	2.30	13.94
Total Number of Banks	103	55.35

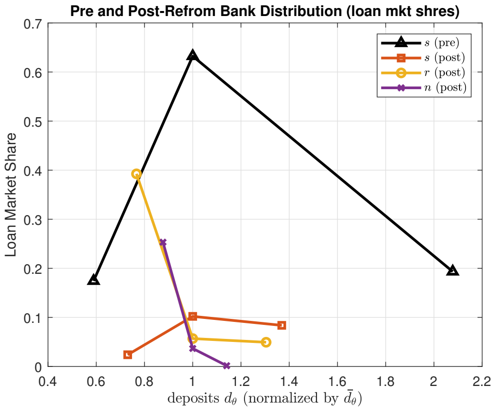
Return

Additional Moments

Moments (%)	Data	Model
Exit (Failure) Rate	0.65	19.75
Deposit to Output Ratio	38.14	44.69
Markup	32.71	87.81
Avg. Net Interest Margin	4.43	3.09
Avg Cost $\int$	1.96	1.94
Avg Cost ∇	1.56	1.45
Avg Cost $\setminus$	1.24	0.71
Fraction of Banks ∇	30.37	18.04
Fraction of Banks $\setminus$	3.92	1.72
Loan Market Share ∇	37.76	49.95
Loan Market Share $\setminus$	52.42	19.96
Number of Banks $\int$	68	44.35
Number of Banks ∇	31	10.02
Number of Banks $\setminus$	4	0.97
Deposit Market Share $\int$	9.27	31.35
Deposit Market Share ∇	36.59	47.02
Deposit Market Share $\setminus$	54.14	21.63

Return

Bank Size Distribution



- Market shares normalized by mean deposits by size $\overline{d}_\theta$. Right skewed distribution after multiplying by $\overline{d}_\theta$.
- The model generates a fraction of banks that is decreasing in size as we observe in the data.

Return

Branching Restrictions

- Recall from an earlier figure that bank concentrations were roughly constant for the decade before Riegle-Neal (1984-1993) - our initial equilibrium - and following the crisis (2009-2018) - our final equilibrium. concentration
- We calibrated our model to the post-crisis period where branching restrictions were absent in order to estimate the full set of model parameters.
- Here we consider the pre-reform stochastic steady state where there were restrictions on growth outside the state.
  - We assume the deposit process and cost structure for (1984-1993) and raise the cost of transitioning from $\int$ to $\{\nabla, \backslash\}$.
- What are the non-targeted implications for pre-reform model moments? Is there consistency with data?

Return Transitions

Pre and Post Reform Moments

Table: Data & Model Moments Pre and Post-reform

	Pre - Reform			Post - Reform	
	Data	Model		Data	Model
Moments (%)		d_θ only	All changes		
Charge - Off Rate	1.08	0.76	0.76	1.15	0.68
Avg. Default Frequency	3.16	1.73	1.79	2.94	1.60
Loan Interest Rate	6.42	4.39	4.69	3.13	3.55
Markup	31.56	58.16	43.29	32.71	87.81
Exit Rate	2.50	12.30	9.59	0.65	19.75
Total Number of Banks	190.00	130.00	166.72	103.00	55.35

Note: The Pre-Reform case denoted by "d_θ only" presents the equilibrium pre-reform when only the process for d_θ is adjusted (relative to the post-reform). The case "All changes" corresponds to the case where $\bar{r}$, $\phi^0_{\int}$, and $c_{F,\int}$ are also adjusted.

Return Transitions

Implications of Reform

- We see the post-crisis equilibrium exhibits lower borrower default frequency and bank charge-off rates.
- Post-reform markups are higher, exit rates are higher, and the number of banks is lower, than pre-reform. One way to interpret the higher exit rates and lower number of banks is as a merger wave that took place following Riegle-Neal.
- A factor in the lower default rates is the lower equilibrium loan interest rates which induce borrowers to undertake less risky projects (i.e. lower $r_{\mathcal{B}}$ induces lower $R_{\mathcal{B}}$ which in turn induces lower $p(R_{\mathcal{B}}, Z', z')$).
- Decomposition in Table 6 sets the pre-reform interest rates and costs to their post-crisis values.
- The differences in interest rates on deposits and costs between the two periods do not appear to have a big impact on equilibrium interest rates on loans according to our decomposition.

Return Transitions

Loan Demand - cont.

- In region j, entrepreneurs choose whether to operate the technology ($\iota \in \{0,1\}$), the type of lender ($K \in \{\mathcal{B}, \mathcal{N}\}$), and the type of technology (R_K) to maximize expected utility. ▸ Borrower Problem
- Borrower value $V_{E,j}(Z, \mathbf{r}_j)$ is decreasing in interest rates.
- Total demand for loans in region j is given by

$$L_j^d(Z, \mathbf{r}_j) = \int_0^{\overline{\omega}} \mathbf{1}_{\{\omega \leq V_{E,j}(Z,\mathbf{r}_j)\}} d\Omega(\omega). \tag{8}$$

- Loan demand for commercial banks in region j is given by

$$L_{\mathcal{B},j}^d(Z, \mathbf{r}_j) = s_{\mathcal{B},j}(Z, \mathbf{r}_j) L_j^d(Z, \mathbf{r}_j). \tag{9}$$

  where the share of borrowers choosing a loan from a lender of type k in region j is given by

$$s_{k,j}(Z, \mathbf{r}_j) = \frac{\exp\left(\alpha E_{z_j', Z'|Z}\left[\pi_E(r_{k,j}, R_k, z_j', Z')\right]\right)}{\sum_{\hat{k}\in\{\mathcal{B},\mathcal{N}\}} \exp\left(\alpha E_{z_j', Z'|Z}\left[\pi_E(r_{\hat{k},j}, R_{\hat{k}}, z_j', Z')\right]\right)} \tag{10}$$

  with π_E e-o-p realized profits subject to limited liability.

▸ Return

Households

A representative household in each region j solves

$$V_H(A, D, \{S_i\}_{\forall i}, S_{\mathcal{N}}) = \max_{\{A', D', \{S_i'\}_{\forall i}, S_{\mathcal{N}}'\}} E\left[C' + \beta V_H(A', D', \{S_i'\}_{\forall i}, S_{\mathcal{N}}')\right]$$

subject to

$$\begin{aligned} & C' + A' + D' + \sum_i [P_i + \mathbf{1}_{\{e_i=1\}} \cdot \kappa] S_i' + S_{\mathcal{N}}' P_{\mathcal{N}} \\ = \quad & y + \sum_i (\mathcal{D}_i + P_i) S_i + (1+\bar{r}) A_j + (1+r_D) D_j + (\mathcal{D}_{\mathcal{N}} + P_{\mathcal{N}}) S_{\mathcal{N}} - \tau_D', \end{aligned}$$

and $C' \geq 0$ where P_i and S_i' are the post-dividend stock price and stock holding of bank i, respectively, and $P_{\mathcal{N}}$ and $S_{\mathcal{N}}'$ are the price of a claim to non-bank dividends cum equity and stock holdings. Return

Bank Entry Problem

- The value of an entrant in region j given cross-sectional dist. μ is

$$V_{e,j}(Z', \mu) = -\kappa + \beta E_{d'_{\int}, s'_j} \left[V_{\int}(d'_{\int}, s'_j) \right]. \tag{11}$$

- Potential entrants in region j enter if $V_{e,j}(Z', \mu) \geq 0$.

- The number of entrants $N_{e,j}(Z', \mu)$ is determined endogenously in equilibrium. Free entry implies that

$$V_{e,j}(Z', \mu) \times N_{e,j}(Z', \mu) = 0. \tag{12}$$

Return

Government

- The government collects lump-sum taxes to cover the cost of deposit insurance.
- Post-liquidation net transfers are given by

$$\begin{aligned}\Delta'(d_\theta, s_j) &= (1 + r_{D,\theta})d_\theta \\ &- \zeta_\theta[1 + p \cdot r_{\mathcal{B}}(Z, \mu) - (1-p)\lambda']\ell_{\theta,j} - \zeta_\theta(1+\bar{r})(d_\theta - \ell_{\theta,j})\end{aligned}$$

where $\zeta_\theta \leq 1$ is the post-liquidation value of the bank's asset portfolio.

- Aggregate taxes are given by

$$\tau'_D(\boldsymbol{s}) \cdot H = \sum_{\theta, d_\theta, j} \left[\int_{\lambda'} x(d_\theta, s_j) \max\{0, \Delta'(d_\theta, s'_j)\} \mu_\theta(d_\theta) df(\lambda') \right].$$

return

Non-Banks

- A representative non-bank that discounts the future at rate β specializes in extending loans at interest rate $r_{\mathcal{N}}$ to entrepreneurs in a perfectly competitive market.
- Non-banks are financed with equity from households.
- When lending to entrepreneurs non-banks face a marginal cost $c_{\mathcal{N}}$
- Like banks, the representative non-bank can diversify entrepreneurs' idiosyncratic risk but it is subject to same technology and chargeoff shocks.

non-bank problem

return

Bank Decision Problems

After loans have been extended, the value of an incumbent (small or regional) bank in period t at the exit stage is

$$V(d_\theta, s_j) = \max_{x \in \{0,1\}} \left\{ V^{x=0}(d_\theta, s_j), V^{x=1}(d_\theta, s_j) \right\}$$

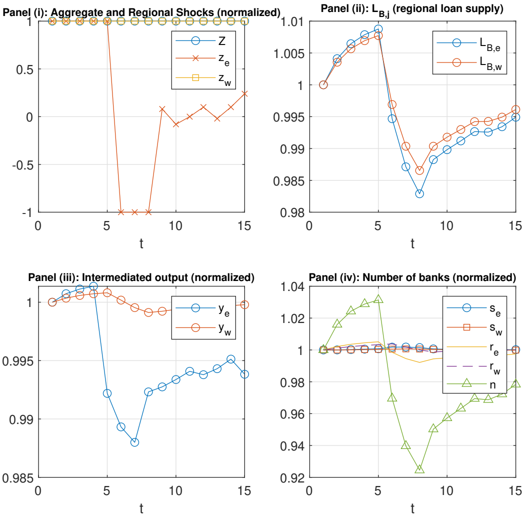
where

$$\begin{aligned} V^{x=0}(d_\theta, s_j) &= \max_{\ell} \Big\{ \pi_\theta(d_\theta, s_j) - I - 1_{\{e_\theta > 0\}} \cdot \varsigma_\theta\left(e_\theta\right) \\ + &\quad \beta \rho_\theta^x E_{\theta', d'_{\theta'}, s'_j | d_\theta, s_j} \left[V(d'_{\theta'}, s'_j) \right] + (1-\beta) \rho_\theta^x E_{\theta', d'_{\theta'}, s'_j | d_\theta, s_j} \left[V^{x=1}(d'_{\theta'}, s'_j) \right] \Big\} \end{aligned}$$

s.t. $T(\theta' | \theta, I)$, $\mu' = \mathcal{H}(\mu, \{N_{e,j}\}_j)$, $e_\theta = max\{I - \pi_\theta\}$,

and $V^{x=1}(d_\theta, s_j) = max\{0, \text{salvage value}\}$. return

Regional Spillovers Event Analysis I



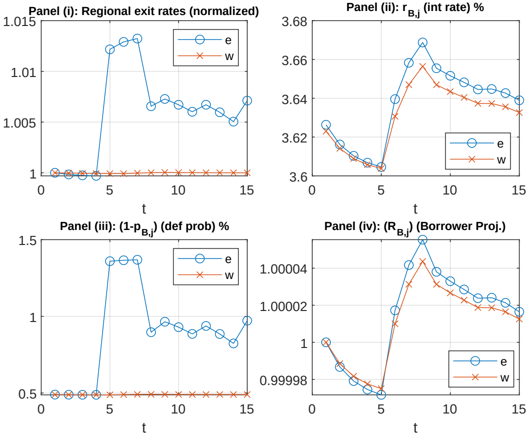
return

Regional Spillovers

- The negative regional shock generates an immediate negative response in lending in region e with the corresponding decline in output (Panels (*ii*) and (*iii*)).
- Importantly, while the $w-$region does not experience any shock, bank losses and failure in the $e-$region induce a decline in lending and output in the $w-$ region as well.
- The spillover derives mostly from changes in national \ lending which is primarily driven by a decline in the average number of active \ banks (Panel (*iv*) Figure 4).

return

Regional Spillovers Event Analysis II



return

Regional Spillovers

- While small $\int$ and regional ∇ banks are less diversified and more exposed to a regional recession than $\setminus$ banks, the small decline in active $\int$ and ∇ banks derives from bank entry given that the z_j process is i.i.d. over time (unlike this experiment realization).

- National $\setminus$ banks are better diversified but losses in one region that, in some instances result in national bank failure, lead to long lasting effects that spill across the two regions.

- It takes longer for the economy to recover from a loss of a national bank as all banks are born small and need to invest to grow so a decline in lending by national banks is not easily replaced.

- Figure 5 shows that the regional recession and the corresponding decline in lending due to the increase in the exit rate in the $e-$ region (Panel (i)) induces an increase in bank loan interest rates in both regions (Panel (ii)), default probability (Panel (iii)) and borrower risk taking (Panel (iv)).

return

Bank Size Transitions

Table: Bank-Type Transition Matrix $T(\theta^{'}|\theta, I_{\theta}(d_{\theta}, s_j))$

	Data				*Model*			
	Post - Reform Period (1994† - 2018)				*Post - Reform Period (1994 - 2018)*			
	$\theta' = \int$	$\theta' = \nabla$	$\theta' = \setminus$	Exit	$\theta' = \int$	$\theta' = \nabla$	$\theta' = \setminus$	Exit
Entrant	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
$\theta = \int$	0.93	0.02	0.00	0.05	0.66	13.94	0.00	0.20
$\theta = \nabla$	0.02	0.97	0.01	0.00	0.40	0.35	0.05	0.20
$\theta = \setminus$	0.00	0.02	0.98	0.00	0.00	0.38	0.46	0.16

As in the data:

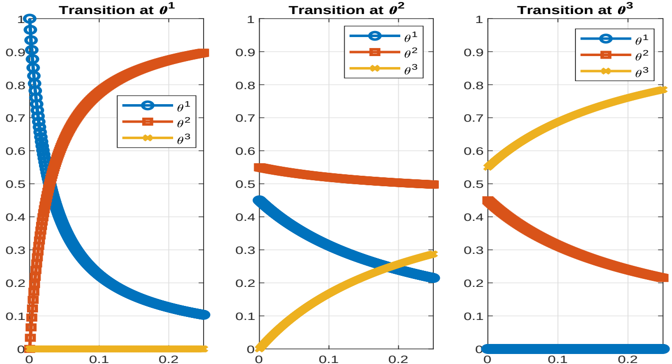
- Exit rates in the model are decreasing in size.
- Bank size is persistent.

▸ Size Distribution ▸ Branching Restrictions ▸ Return

Transition Probabilities Post-Reform

$$T\left(\theta'|\theta=\nabla, I_{\nabla}\right)=\begin{cases}\frac{(1-\delta)\alpha\cdot I_{\nabla}\cdot(\Delta\overline{d}_{\backslash,\nabla})^{-\xi}}{1+\alpha\cdot I_{\nabla}\cdot(\Delta\overline{d}_{\backslash,\nabla})^{-\xi}} & \text{if } \theta'=\backslash\\ \frac{1-\delta+\delta\alpha\cdot I_{\nabla}\cdot(\Delta\overline{d}_{\backslash,\nabla})^{-\xi}}{1+\alpha\cdot I_{\nabla}\cdot(\Delta\overline{d}_{\backslash,\nabla})^{-\xi}} & \text{if } \theta'=\nabla\\ \frac{\delta}{1+\alpha\cdot I_{\nabla}\cdot(\Delta\overline{d}_{\backslash,\nabla})^{-\xi}} & \text{if } \theta'=\int\end{cases},$$

where $\Delta\overline{d}_{\backslash,\nabla}=(\overline{d}_{\backslash}-\overline{d}_{\nabla})>0$. Return



Timing

The timing of events is as follows: Return

1. At the beginning of the period, given Z, θ, d_θ, ω are realized which determines the banking industry distribution $\boldsymbol{\mu}$ given household asset decisions.
   1.1 Entrepreneurs choose whether to invest in the risky technology or to choose their outside option $\iota \in \{0, 1\}$ and, if so, they draw ϵ.
   1.2 Those borrowers who choose to undertake a project choose the type of lender $K \in \{\mathcal{B}, \mathcal{N}\}$ and the level of technology R_K.
   1.3 Banks (Non-banks) choose how many loans $\ell_{\theta,j}$ ($\ell_{\mathcal{N},j}$) to extend as well as well as external funding/securities a_θ.
   1.4 Loan market clearing determines $\mathbf{r}_j = \{r_{\mathcal{B},j}, r_{\mathcal{N},j}\}$

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   1.4 Loan market clearing determines $\mathbf{r}_j = \{r_{\mathcal{B},j}, r_{\mathcal{N},j}\}$
2. At the end of the period, Z', z'_j, and λ' are realized which determines project returns $p(R_k, z'_j, Z')$, bank profitability $\pi_\theta(d_\theta, s_j)$, and non-bank profitability $\pi_{\mathcal{N}}(\mathbf{s})$.
   2.1 Bank exit x_θ and entry $e_\daleth$ choices are made.
   2.2 Bank investment I_θ is chosen together with equity injections $\rceil_\theta$ implying dividend payments $\mathcal{D}_\theta$.
   2.3 Households pay taxes τ'_D to fund deposit insurance and consume.