Geographical Expansion in US Banking: A Structural Evaluation

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May 2023

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Introduction

- Major changes in the US banking industry over the past few decades
  - Riegle-Neal Act (1994) allowed bank holding companies to acquire banks in any state
  - Led to a wave of geographical expansion and consolidation

- Implications on interest rates, lending and welfare
  - Diversification: Reduction of idiosyncratic risks
  - Competition: Changes in market concentration
  - Financial stability: Leverage, exposure to aggregate risk

- This paper: Structural approach to quantify these channels
  - **Today:** Effects of risk premia and markups for deposits and rates

Introduction: What We Do

1. **Motivating empirical evidence**
   - Banks significantly increased number of counties in which they operate since 1990s
   - Increase in concentration both at county and national levels
   - Geographical diversification $\rightarrow$ lower exposure to deposit and loan risks

2. **Model of oligopolistic banks operating across multiple markets**
   - Curvature in lending technology
   - Market-level deposit demand shocks

   $\Rightarrow$ Role for diversification

3. **Quantitative Analysis**
   - Measure intensive margin effects of markups and diversification
   - Comparison across time and document heterogeneous effects across locations

Related Literature

Banks' Risk Diversification

Stiroh (2006); Laeven & Levine (2007); Baele, De Jonghe, & Vander Vennet (2007); Cetorelli & Goldberg (2012); Goetz, Laeven, & Levine (2016); Correa & Goldberg (2020); Granja, Leuz, & Rajan (2022); Aguirregabiria et al. (2016)

Contribution: Structural GE model to study how geo risk affects banks' decisions & local outcomes

Oligopolistic Competition

Atkeson & Burstein (2008); Hottman, Redding, & Weinstein (2016); Rossi-Hansberg, Sarte, & Trachter (2020); Berger, Herkenhoff, & Mongey (2022)

Contribution: Rich heterogeneity in banks' marginal revenues and costs directly linked to micro-level data

Banks' Market Power

Drechsler, Savov, & Schnabl (2017); Wang, Whited, Wu, & Xiao (2020); Black & Strahan (2002);

Corbae & D'Erasmo (2021); Carlson, Correia, & Luck (2022)

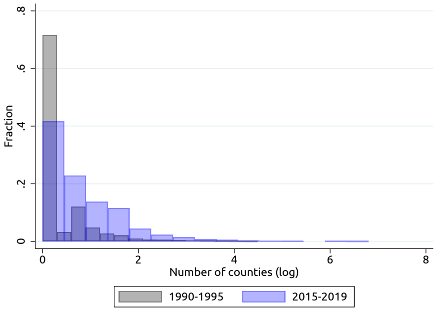
Contribution: Quantify how banks' market power interacts with the risk diversification benefits

Outline

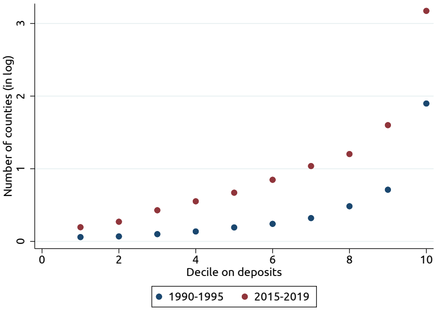
1. **Motivating Facts**
2. Structural Model
3. Quantitative Analysis
4. Next Steps

Motivating Facts: Expansion and Consolidation

Distribution of (log) number of locations



Average number of locations

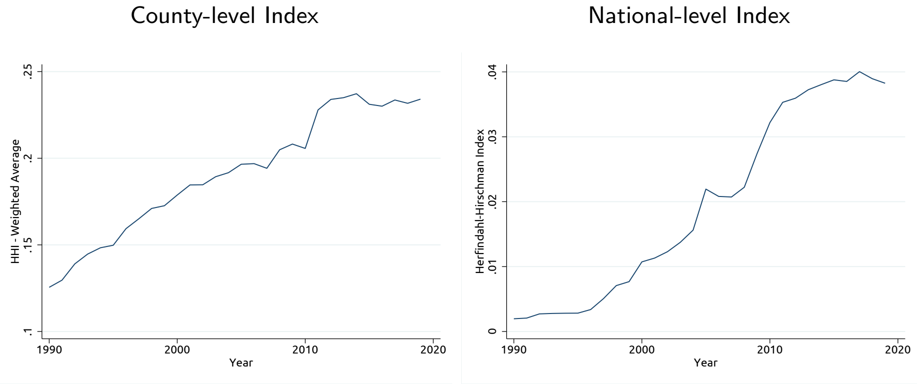


Source: Summary of Deposits (SOD), FDIC

Average number of counties per bank has doubled, driven by the largest banks

Motivating Facts: Concentration Over Time

- Herfindahl on deposits markets top 10%



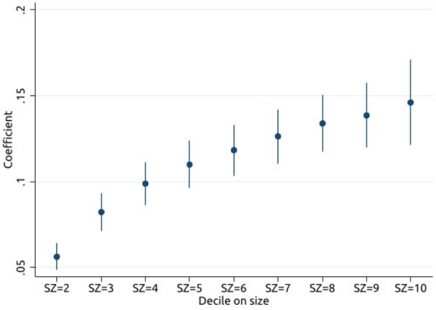
Source: Summary of Deposits (SOD), FDIC

Both local and national concentration have risen

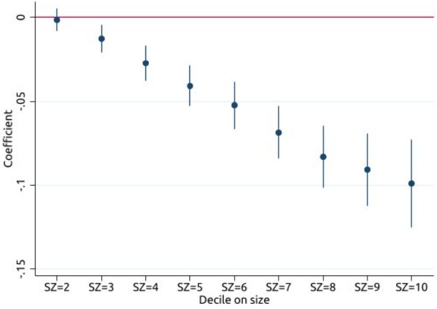
Motivating Facts: Leverage by Size

- Rise in concentration might affect riskiness/stability of banks, since larger banks are more leveraged and rely more on wholesale funding
- Regress ratios onto size (TA) deciles, and lender and time FE

Liabilities / Assets



Deposits / Liabilities



Source: Call Reports

Motivating Facts: Riskiness

How has expansion/consolidation changed bank riskiness?

1. Construct measures of banks' exposures to fluctuations in deposits, loans, performance
2. Study how these measures relate to banks' size and geographical diversification

Challenge: Difficult to interpret second moments from time series

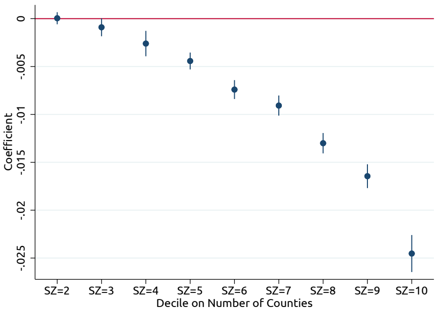
Our approach:

- Estimate covariance matrix of county-level deposit growth (assumed to be stationary)
- Use (time-varying) weights based on deposit shares to construct panel of risk exposures $\{\sigma_j^\tau\}$
- Regress onto size decile dummies ($\{\mathbf{1}_{k,\tau}\}_{k=2}^{10}$), bank ($\alpha_j$) and time ($\alpha_\tau$) FE

$$\sigma_j^\tau = \beta_1 + \sum_{k=2}^{10} \beta_k \times \mathbf{1}_{k,\tau} + \alpha_j + \alpha_\tau + \epsilon_{j,\tau}$$

Motivating Facts: Deposit Risk by Size

$$\sigma_j^\tau = \beta_1 + \sum_{k=2}^{10} \color{red}{\beta_k} \times \mathbf{1}_{k,\tau} + \alpha_j + \alpha_\tau + \epsilon_{j,\tau}$$



Deposit risk falls with size Correlations Details Decomp. Loan orig. Credit risk

Motivating Facts: Summary

- Geographical expansion offers scope for diversification
- However, leverage and concentration have also risen

Net effect? $\Rightarrow$ Need a model

Outline

1. Motivating Facts
2. **Structural Model**
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Environment

- Two types of agents
  - Representative household: Consumes, supplies funds and uses deposit services
  - Heterogeneous banks: Raise deposits and wholesale funding to make loans
- Continuum of markets (counties), each with a discrete number of banks
  - Not all banks operate in all markets $\rightarrow$ idiosyncratic risk
  - Oligopolistic competition for deposits

Household: Endowments and Preferences

Endowed with $\overline{W}$ units of goods (exogenous) invested in

- E_j: equity of bank j (exogenous)
- H_j: Wholesale lending to banks (endogenous)
- D_{ij}: deposit with bank j in county i (endogenous)
  - Nested CES aggregation across banks and counties

$$D_i = \left(\sum_{j=1}^{N_i} \psi_{ij} D_{ij}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \quad \text{and} \quad D = \left(\int_0^1 \phi_i D_i^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}$$

  - $\eta > \theta > 1$: elasticity of substitution across banks within and across counties resp.
  - ϕ_i: Household's preference for deposits in county i (only source of risk): $\int_0^1 \phi_i di = 1$
  - ψ_{ij}: Relative preference for deposits in bank j within county i: $\sum_j \psi_{ij} = 1$
- A storage technology with (exogenous) rate of return R

Household: Maximization Problem

$$\max_{C,\{D_{ij}\}} \qquad u(C,D) = C + \xi \frac{D^{1-\gamma}}{1-\gamma}$$

$$\text{s.t. } C = \left(\overline{W} - E - \int_0^1 \sum_{j=1}^{J_i} D_{ij} di \right) R + \int_0^1 \sum_{j=1}^{J_i} R_{ij}^D D_{ij} di + \Pi.$$

$R \equiv$ Return on (illiquid) investments (exogenous)

$R_{ij}^D \equiv$ Interest rate on deposit with bank j in county i (endogenous)

$\Pi \equiv$ Profits from banks

Household: Optimality and Demand Functions

Demand for deposits of bank j in county i Details

$$\frac{R - R^D_{ij}}{R - R^D_i} = \psi_{ij} \left(\frac{D_{ij}}{D_i} \right)^{-\frac{1}{\eta}}$$

Demand for the composite deposit good in county i Details

$$\frac{R - R^D_i}{R - R^D} = \phi_i \left(\frac{D_i}{D} \right)^{-\frac{1}{\theta}}$$

where the county-level and economy-wide spreads are given by:

$$R - R^D_i = \left(\sum_{j=1}^{N_i} \psi^{\eta}_{ij} \left(R - R^D_{ij} \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

$$R - R^D = \left(\int_0^1 \phi^{\theta}_i \left(R - R^D_i \right)^{1-\theta} di \right)^{\frac{1}{1-\theta}}$$

Microfoundation

Banks

Bank j operates in a set of counties M_j (exogenous)

- Makes loans $(L_j = E_j + \int_{i \in M_j} D_{ij} di + H_j)$
  - Return on loans: $R + z - \frac{\omega_j}{2} L_j$ (diminishing returns)

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- Competes for deposits by choosing interest rate $\{R_{ij}^D\}$
  - Total cost $R_{ij}^D + k_{ij}$ (costs of providing deposit services)

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- Has access to a competitive wholesale funding market
  - Cost $R + \frac{v_j}{2} H_j$ (convex cost of accessing wholesale market)

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Banks are heterogeneous in counties they operate in as well as in

- Cost of raising county-level deposits (k_{ij})
- Cost of accessing wholesale funding (ν_j)

Banks: Risk and Timing

Timeline

1. Banks choose deposit rates R_{ij}^D (or eq. spreads $R - R_{ij}^D$) and wholesale funding H_j
2. County-level demand shifters ϕ_i are realized
3. Household chooses $\{D_{ij}\}$, banks make (and collect) loans
4. Consumption occurs

$\Rightarrow$ Banks are uncertain about ϕ_i when setting spreads

- Idiosyncratic but no aggregate risk

Bank j's Problem

$$\Pi_j = \max_{\{R_{ij}^D\},H_j} \mathbb{E}\left\{\left(R + z - \frac{\omega_j}{2}L_j\right)L_j - \left(R + \frac{v_j}{2}H_j\right)H_j - \int_{i\in M_j} \mathcal{D}_{ij} \times \left(R_{ij}^D + k_{ij}\right) di\right\}$$

with $L_j = \int_{i\in M_j} \mathcal{D}_{ij} di \; + H_j + E_j$

$M_j \equiv$ set of counties in which the bank operates (exogenous)

$E_j \equiv$ equity (exogenous)

$\mathcal{D}_{ij} \equiv$ demand function of spreads

Bank j's Problem: Optimal Spreads

$$R - R_{ij}^D = \underbrace{\frac{\eta(1-s_{ij}) + \theta s_{ij}}{\eta(1-s_{ij}) + \theta s_{ij} - 1}}_{\text{Markup}} \underbrace{\left\{ k_{ij} - z + \omega_j \left[H_j + E_j + \frac{\mathbb{E}\left[\mathcal{D}'_{ij} \int \mathcal{D}_{kj} dk\right]}{\mathbb{E}\mathcal{D}'_{ij}} \right] \right\}}_{\text{Marginal Cost}}$$

where $\quad s_{ij} \equiv \dfrac{R - R_{ij}^D}{R - R_i^D} \dfrac{D_{ij}}{D_i} = \psi_{ij} \left(\dfrac{D_{ij}}{D_i} \right)^{\frac{\eta-1}{\eta}} \in (0,1)$ is the 'market share'

- Markups increasing in market share s_{ij} (since $\eta > \theta > 1$)
  - Low s_{ij} $\Rightarrow$ the bank competes mostly within county (elasticty η)
  - High s_{ij} $\Rightarrow$ the bank competes mostly with other counties (elasticty θ)
  - As $s_{ij} \to 0$ (monopolistic competition), markups $\to \frac{\eta}{\eta-1}$

Wholesale

Marginal Cost

$$MC_{ij} \equiv k_{ij} - z + \omega_j \left(H_j + E_j + \frac{\mathbb{E}\left[\mathcal{D}'_{ij} \int_{k \in M_j} \mathcal{D}_{kj} dk\right]}{\mathbb{E}\left[\mathcal{D}'_{ij}\right]} \right)$$

$$= k_{ij} - z + \omega_j \mathbb{E}\left(L_j\right) \left(\underbrace{1 + \int_{k \in M_j} \frac{\mathbb{E}\left(D_{kj}\right)}{\mathbb{E}(L_j)} \frac{\rho_{ik}\sigma_i\sigma_k}{\mu_i\mu_k} dk}_{\equiv RP_{ij}} \right)$$

where $\sigma_k \equiv stdev(\phi_k)$, $\rho_{ik} \equiv Corr(\phi_i, \phi_k)$, and $\mu_i \equiv E(\phi_i)$.

- Positive covariance with other counties $\rightarrow$ Risk premium (RP_{ij})

Risk Premium and Diversification

$$\ln RP_{ij} \approx \int_{k\in M_j} \frac{\mathbb{E}\left(D_{kj}\right)}{\mathbb{E}\left(L_j\right)} \frac{\sigma_i\sigma_k}{\mu_i\mu_k} dk + \underbrace{\int_{k\in M_j} \frac{\mathbb{E}\left(D_{kj}\right)}{\mathbb{E}\left(L_j\right)} \frac{(\rho_{ik}-1)\sigma_i\sigma_k}{\mu_i\mu_k} dk}_{Diver_{ij} \ \leq \ 0}$$

- $Diver_{ij}$: Effect of diversification
  - Reduction in risk premium (marginal costs) due to imperfect correlation
- What we do
  - Directly recover RP_{ij} and $Diver_{ij}$ using micro-level data
  - Show cross-sectional patterns and changes over time

Outline

1. Motivating Facts
2. Structural Model
3. **Quantitative Analysis**
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Overview

- Transparent calibration strategy
  - Recover key parameters directly using model equations and rich micro data
- Solution algorithm
  - Allocations (rates and quantities) given parameters Details
- **Today**: Decompositions using first-order approximations
  - Effect of diversification and markups on deposits (prices and quantities)

Data Sources and Description

Deposits and Rates

- FDIC's SOD: Deposits by branch, aggregated to the bank-county level
- RateWatch: Interest rates on savings accounts and 6-month CDs (2011-2019)
- Imputation for missing interest rate observations Details

Bank-level Variables

- Call Reports: Total Assets, Total Liabilities, Equity

Calibration I

1. Assume $\eta = 6$, $\theta = 4$ (Later: Robustness).

2. R: Yield on Treasuries (5-year)

$$\psi_{ij} = \left(R - R_{ij}^{D}\right) D_{ij}^{\frac{1}{\eta}} \left(\frac{1}{\bar{\bar{\psi}}} \sum_{j} \left(R - R_{ij}^{D}\right) D_{ij}^{\frac{1}{\eta}} \right)^{-1}$$

$$\phi_{i} = \left(R - R_{i}^{D}\right) D_{i}^{\frac{1}{\theta}} \left(\frac{1}{\bar{\phi} I} \sum_{i} \left(R - R_{i}^{D}\right) D_{i}^{\frac{1}{\theta}} \right)^{-1} \qquad \to \{\mu_i, \sigma_i, \rho_{ik}\}$$

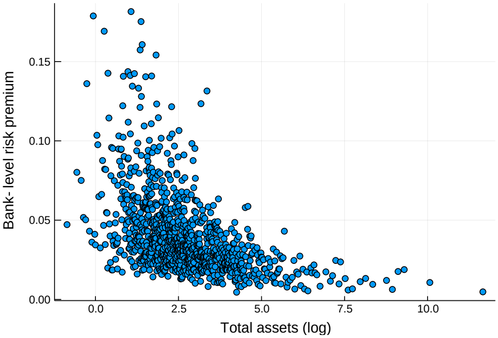
3. We can then construct

$$\ln RP_{ij} \approx \int_{k \in M_j} \frac{\mathbb{E}\left(D_{kj}\right)}{\mathbb{E}\left(L_j\right)} \frac{\rho_{ik}\sigma_i\sigma_k}{\mu_i\mu_k} dk \qquad MKP_{ij} = \frac{\eta(1 - s_{ij}) + \theta s_{ij}}{\eta(1 - s_{ij}) + \theta s_{ij} - 1}$$

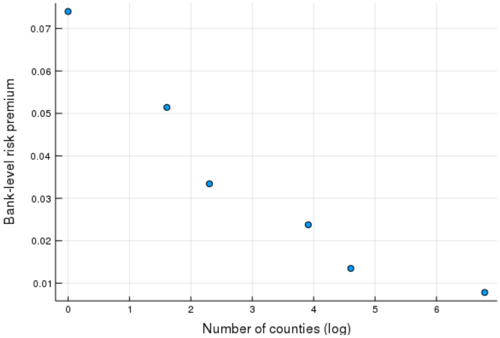
Risk Premium and Bank Characteristics

$$\ln RP_j = \sum_i \frac{\mathbb{E}\left(D_{ij}\right)\Lambda_i}{\sum_{i=1}^{M_j}\mathbb{E}\left(D_{ij}\right)\Lambda_i} \cdot \ln RP_{ij}$$

Bank Size



Number of Active Counties

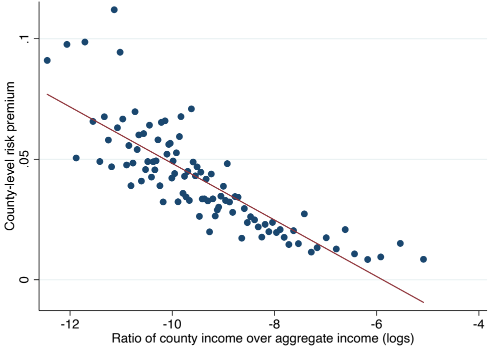


Risk premium declines with size and number of counties

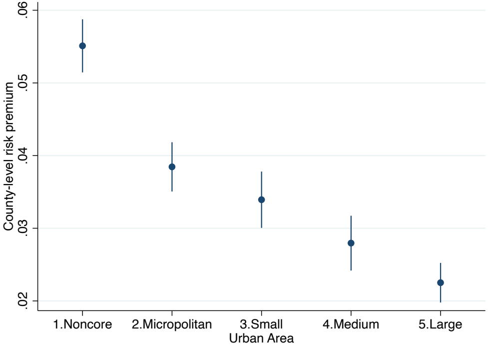
Risk Premium and County Characteristics

$$\ln RP_i = \sum_j s_{ij} \cdot \ln RP_{ij}$$

County Relative Size



Urban vs Rural

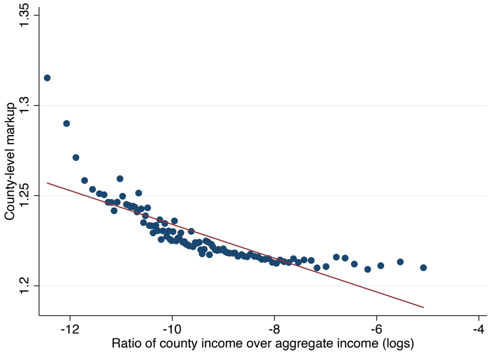


Risk premium higher for smaller, rural (and poorer) counties

Markups and County Characteristics

$$\ln MKP_i = \sum_j s_{ij} \cdot \ln MKP_{ij}$$

County Relative Size



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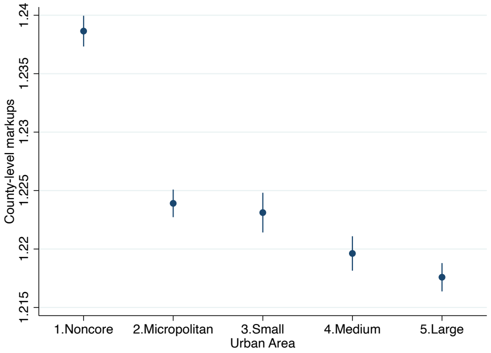
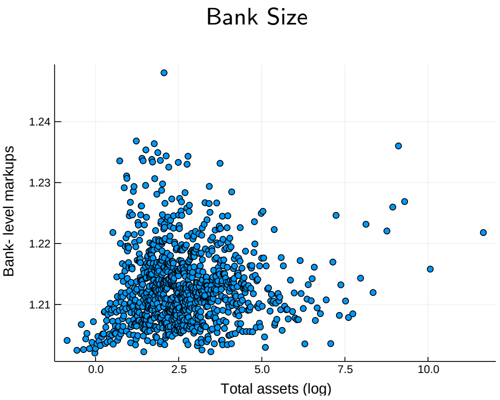
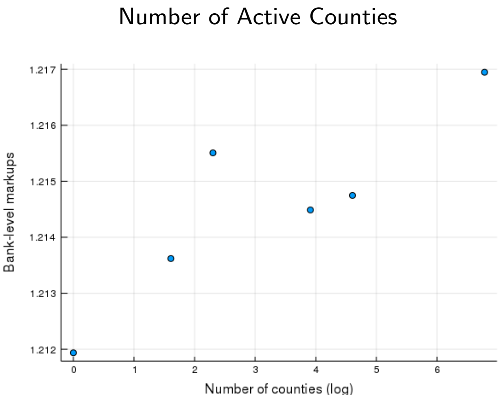


Markups higher for smaller, rural (and poorer) counties

Markups and Bank Characteristics

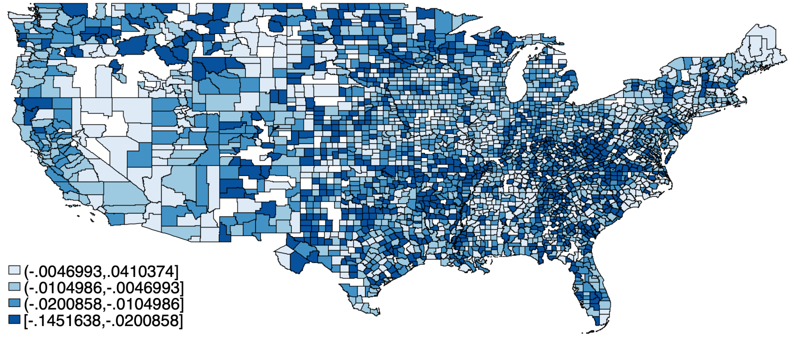




Markups rise (but only marginally) with bank size and geo spread

Diversification Gains

$$\left(\sum_j s_{ij} Diver_{ij}\right)_{2010s} - \left(\sum_j s_{ij} Diver_{ij}\right)_{1990s}$$



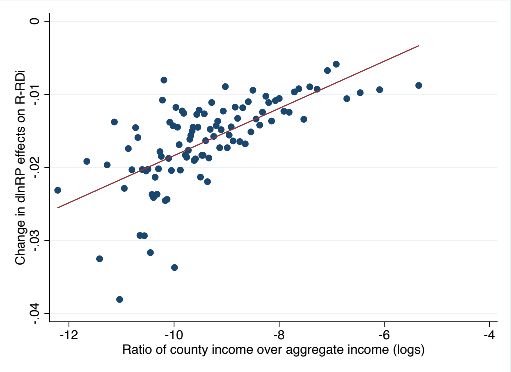
Most counties gained from diversification, but a fair amount of heterogeneity

Note: $Diver_{ij} = \int_{k \in M_j} \frac{\mathbb{E}\left(D_{kj}\right)}{\mathbb{E}\left(L_j\right)} \frac{(\rho_{ik}-1)\sigma_i\sigma_k}{\mu_i\mu_k} dk$ < 0: reduction in RP_{ij} relative to perfect correlation

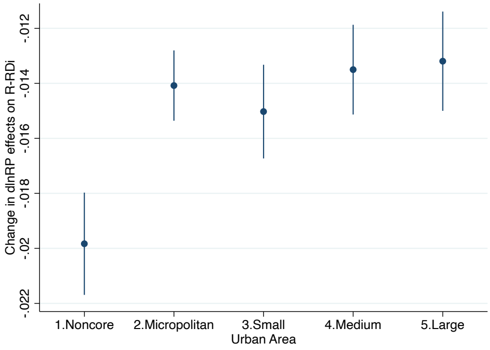
Diversification Gains and County Characteristics

$$\left(\sum_j s_{ij} Diver_{ij}\right)_{2010s} - \left(\sum_j s_{ij} Diver_{ij}\right)_{1990s}$$

County Relative Size



Urban vs Rural

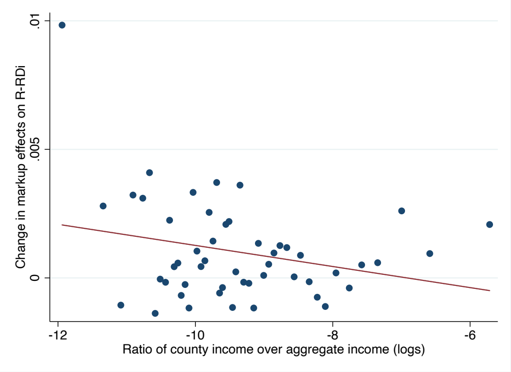


Larger gains in smaller, rural (and poorer) counties

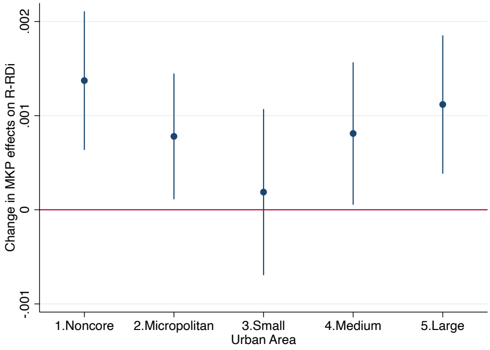
Markup Changes and County Characteristics

$$\left(\sum_j s_{ij} MKP_{ij}\right)_{2010s} - \left(\sum_j s_{ij} MKP_{ij}\right)_{1990s}$$

County Relative Size



Urban vs Rural



Markup changes are small across the board

Implications: A Simple Decomposition

For spreads

Diversification: $$\Delta \ln(R - R^D_{ij}) \approx \frac{\omega_j \mathbb{E}(L_j) \cdot RP_{ij}}{MC_{ij}} \quad Diver_{ij}$$

Markups: $$\Delta \ln(R - R^D_{ij}) \approx \ln MKP_{ij} - \ln \frac{\eta}{\eta - 1}$$

Aggregation: $$\Delta \ln(R - R^D) \approx \int_0^1 s_i \Delta \ln(R - R^D_i) di \approx \int_0^1 s_i \cdot \sum_j s_{ij} \cdot \Delta \ln(R - R^D_{ij}) \ di$$

For deposits

$$\Delta \ln D_i \approx (\theta - \frac{1}{\gamma}) \Delta \ln(R - R^D) - \theta \Delta \ln(R - R^D_i)$$

$$\Delta \ln D \approx -\frac{1}{\gamma} \Delta \ln(R - R^D)$$

Calibration II: ω_j

In the model, ω_j captures diminishing returns in lending

- But, more broadly, it is meant to index curvature in payoffs

Not obvious how to pin it down

- From lending rates ($R_j^L = R + z - \omega_j L_j$) ?
- From spreads ($R - R_{ij}^D = R + z - k_{ij} - \omega_j \mathbb{E}(L_j) \cdot RP_{ij}$) ?
- From curvature in utility?

Strategy: Show results for 2 different curvature assumptions

- "Low ": Estimated from spreads $\omega_j \mathbb{E}(L_j) = 0.02$
- "High": Approximation of log utility $\omega_j \mathbb{E}(L_j) = 0.035$

Results

		$\Delta \ln(R - R^D)$		
		Diversification		Markups
Period		High Curvature	Low Curvature	
1990s	$\theta = 4$	-1.2%	-0.8%	0.8%
2010s	$\theta = 4$	-4.8%	-2.9%	1.4%
Change		-3.6%	-2.1%	0.6%
1990s	$\theta = 2$	-0.5%	-0.3%	1.7%
2010s	$\theta = 2$	-2.1%	-1.3%	3.5%
Change		-1.6%	-1.0%	1.7%

Opposing, roughly similar in magnitude, effects on spreads

Conclusion

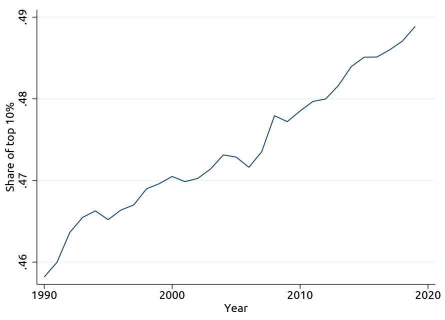
- Structural approach to evaluate changes in US banking industry
  - Focus the role of idiosyncratic risk and market power in deposit markets
  - Flexible, but transparent empirical strategy
- Significant but opposing effects from diversification and markups
- Next steps
  - Effects on lending and welfare Go
  - Extensions: Local lending Go, Money....

APPENDIX

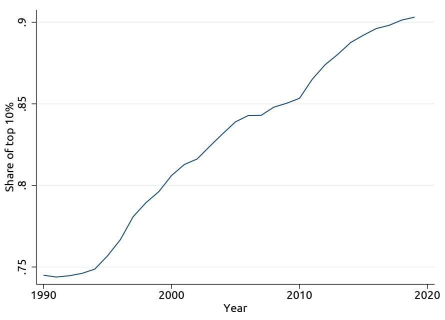
Concentration on Deposits Market Back

- Share on deposits of the top 10%

County-level



National-level

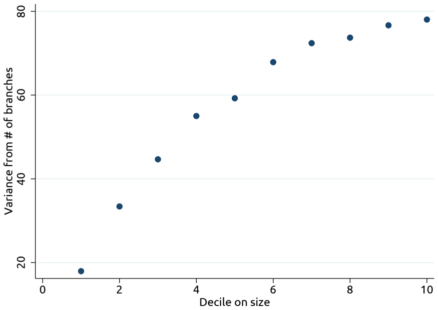


Source: Summary of Deposits (SOD), FDIC

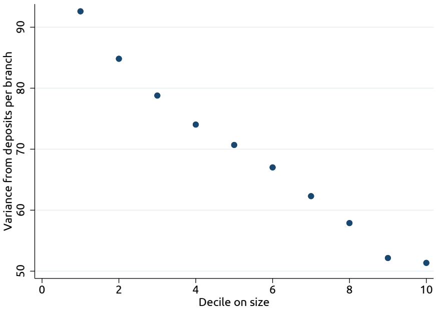
Deposits Variance Decomposition by Bank Size

Back

(a) Number of branches



(b) Deposits per branch

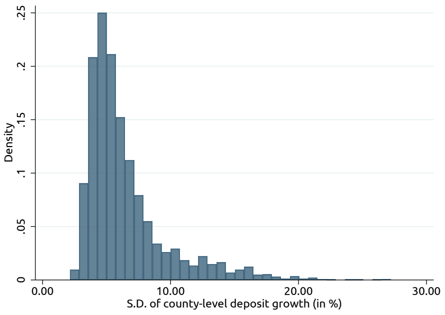


- Decomposition: 48% & 66% explained by extensive & intensive margins, respectively
- Fraction of deposit variance explained by the extensive margin is increasing in bank size

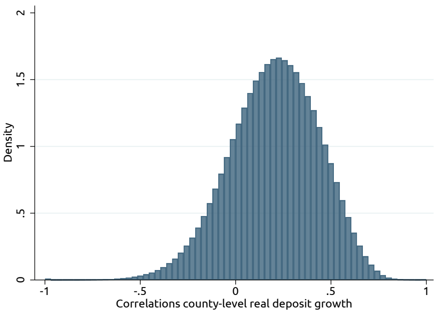
Motivating Facts: County-level Deposit Growth

Back

County-level deposit growth variation



Correlations between counties



Deposit growth volatile, imperfectly correlated $\Rightarrow$ Scope for diversification

Motivating Facts: Deposit Risk Back

- ω_{ij}^{τ}: Bank j's weight on county i at time τ:

$$\omega_{ij}^{\tau} = \frac{D_{ij}^{\tau}}{\sum_i D_{ij}^{\tau}}$$

- $\Delta \ln D_{it}$: Log change in total (real) deposits in county i for year t
- $\Delta \ln D_{jt}^{\tau}$: Bank j's weighted deposit growth

$$\Delta \ln D_{jt}^{\tau} = \sum_i \omega_{ij}^{\tau} (\Delta \ln D_{it})$$

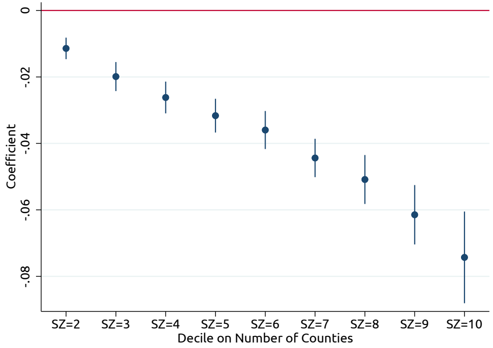
- σ_j^{τ}: Bank j's exposure to deposit risk at time τ

$$\sigma_j^{\tau} = sd \left(\Delta \ln D_{jt}^{\tau} \right)$$

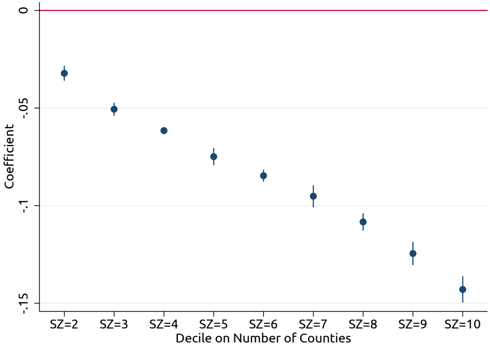
Motivating Facts: Loan Origination Risk by Size Back

- Similar analysis on originations of small business loans and mortgages

Small Business Loans



Mortgages



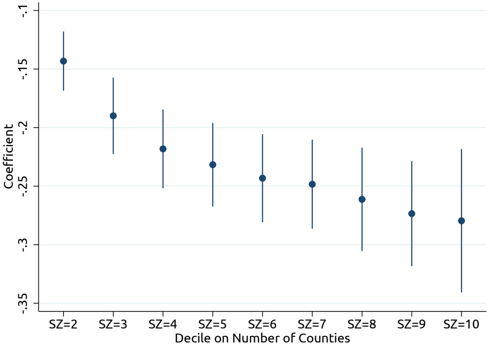
Source: Community Reinvestment Act (CRA) and Home Mortgage Disclosure Act (HMDA)

Motivating Facts: Credit Risk by Size

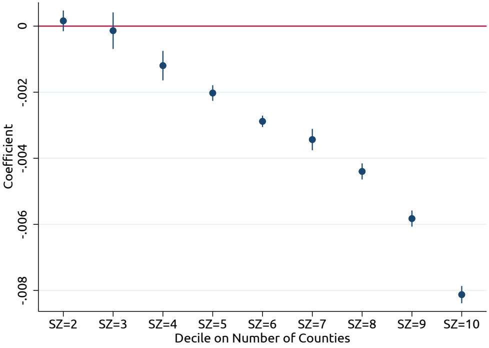
Back

- Similar analysis using delinquency rates on mortgage loans & nonfarm personal income

Delinquency Rates



Personal Income (Nonfarm)



Source: Consumer Financial Protection Bureau (CFPB) and BEA

Economy-wide Deposit Assembly Firms

- Their problem is

$$\max_{D_i} \left(R - R^D\right) D - \int_0^1 \left(R - R_i^D\right) D_i di$$

$$\text{s.t. } D = \left(\int_0^1 \phi_i D_i^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}}$$

- Firm's demand

$$\frac{R - R_i^D}{R - R^D} = \phi_i \left(\frac{D_i}{D}\right)^{-\frac{1}{\theta}}$$

Back

County-wide Deposit Assembly Firms Back

- Let J_i be the number of banks operating in county i. Assembly's firm problem

$$\max_{D_{ij}} \left(R - R_i^D\right) D_i - \sum_{j=1}^{J_i} \left(R - R_{ij}^D\right) D_{ij}$$

$$\text{s.t. } D_i = \left(\sum_{j=1}^{J_i} \psi_{ij} D_{ij}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

- Firm's demand

$$\frac{R - R_{ij}^D}{R - R_i^D} = \psi_{ij} \left(\frac{D_{ij}}{D_i} \right)^{-\frac{1}{\eta}}$$

Bank j's Problem: Optimal Wholesale Funding Back

- The optimality condition on wholesale funding implies

$$H_j = \frac{z - \omega_j \left(\mathbb{E} \int_{i \in M_j} \mathcal{D}_{ij} di + E_j \right)}{\omega_j + v_j}$$

Data Imputation

- Ratewatch dataset does not cover universe of bank-county pairs
  - On average, 67% of value of deposits and 59% of total bank-county pairs
- Imput missing rates

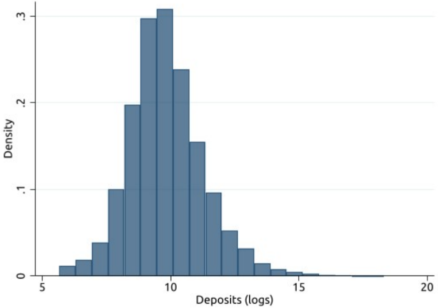
$$R_{ijt} = \beta_0 + \alpha_i + \alpha_t + \mathbf{\Gamma}'_B \mathbf{X}^B_{jt} + \mathbf{\Gamma}'_C \mathbf{X}^C_{it} + \beta_F \mathbf{1}^F_{ij} + \epsilon_{ijt},$$

  where α_i are county FE, α_t are year FE, $\mathbf{X}^B_{jt}$ and $\mathbf{X}^C_{it}$ are a battery of bank- and county-level characteristics, and $\mathbf{1}^F_{ij} = 1$ if bank j has follower branches in county i
- R^2 of the panel regression is $\approx 70\%$
- Imputed dataset: $\approx 3,000$ counties and $\approx 6,200$ banks

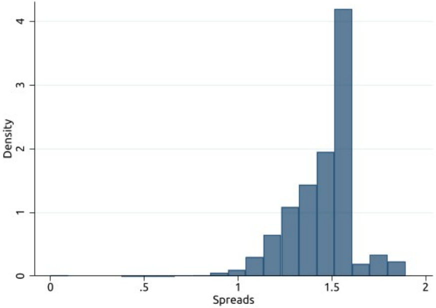
Distributions of Deposits and Rates

Back

Distribution of D_{ij}



Distribution of $R - R_{ij}^D$



Source: Ratewatch and Summary of Deposits (FDIC)

Imputing Rates (pre-2011)

$$R - R^D = \xi \left[\sum_i \left(\mathbb{E}\left[\phi_i^\theta\right] \left(\mathbb{E}\left[D_i\right]\right)^{\theta-1} \right)^{\frac{1}{\theta}} \Lambda_i \right]^{\gamma \frac{\theta}{1-\theta}}$$

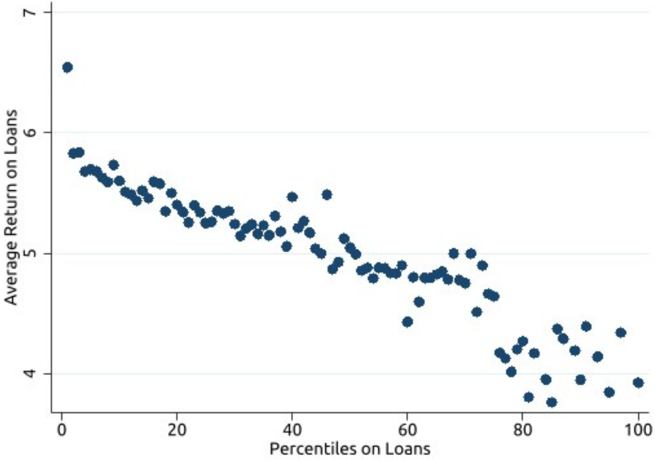
$$R - R_i^D = \left(\frac{\mathbb{E}\left[\phi_i^\theta\right]}{\mathbb{E}\left[D_i\right]} \right)^{\frac{1}{\theta}} \xi^{\frac{1}{\gamma\theta}} \left(R - R^D\right)^{1-\frac{1}{\gamma\theta}}$$

$$R - R_{ij}^D = \psi_{ij} \left(\frac{\left(\sum_{j=1}^{J_i} \psi_{ij} \mathbb{E}\left[D_{ij}\right]^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}}{\mathbb{E}\left[D_{ij}\right]} \right)^{\frac{1}{\eta}} \left(R - R_i^D\right)$$

Assume

- $\psi_{ij} = 1/N_i$, with N_i number of banks in county i
- $\mathbb{E}\left[\phi_i^\theta\right]$ is the same in the post-2011 period
- $\mathbb{E}\left[D_{ij}\right]$ approximated by time series average

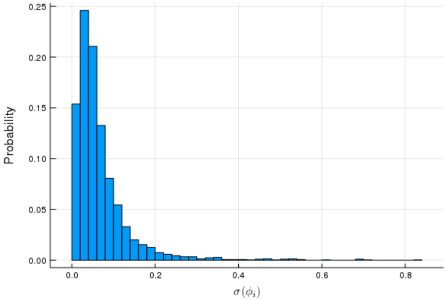
Lending Rates and Size



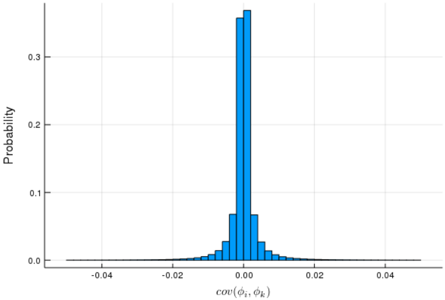
- Banks with higher L_j are associated with lower average returns

Deposit Demand Shocks Back

Histogram of $\sigma(\phi_i)$



Histogram of Cov(ϕ_i, ϕ_k)



Solution Algorithm

Back

- Iterate over $R - R_{ij}^D$ with the following algorithm
  1. Given an initial guess $\{R - R_{ij}^D\}^0$, compute $R - R_i^D$ and $R - R^D$
  2. Combine HH's FOC and demand functions to compute

$$\mathbb{E}\left[D_{ij}\right] = \psi_{ij}^{\eta}\left(R - R_{ij}^D\right)^{-\eta}\left(R - R_i^D\right)^{\eta-\theta}\left(R - R^D\right)^{\theta-\frac{1}{\gamma}}\mathbb{E}\left[\phi_i^{\theta}\right]\xi^{\frac{1}{\gamma}}$$

  3. Use banks' optimality conditions to compute H_j and $\mathbb{E}[L_j]$
  4. Compute MC_{ij}, s_{ij} and MKP_{ij}
  5. Compute new spreads, $\{R - R_{ij}^D\}^1$, using optimal spreads equation
  6. Calculate distance $\|\{R - R_{ij}^D\}^1 - \{R - R_{ij}^D\}^0\|$ and update spreads

Extension: Local Lending

- Local lending
  1. Changes the curvature in lending technology
  2. Lack of diversification has a larger effects on county-level lending
- Timing assumption
  1. Bank chooses $R - R_{ij}^{D}$, then shocks are realized
  2. Bank allocates lending to each county $\{L_{ij}\}$

Local Lending (Cont.) Back

- Bank j's 2-stage problem

$$\max_{\{R-R^D_{ij}\}} \mathbb{E}\left[Rev_j\left(L_j\right) - \left(R + \frac{\nu_j}{2}\right) H_j - \sum_k \left(R^D_{kj} + k_{kj}\right) \mathcal{D}_{kj} \Lambda_{kj}\right]$$

$$Rev_j\left(L_j\right) = \max_{\{L_{kj}\}} \sum_k \left(R + z - \frac{omega_j}{2} L_{kj}\right) L_{kj} \Lambda_{kj}$$

$$\text{s.t. } L_j = \sum_k L_{kj} \Lambda_{kj}$$

- Optimal pricing similar to baseline (and similar analysis follows)

$$R - R^D_{ij} = \frac{(\eta - \theta)\, s_{ij} - \eta}{1 + (\eta - \theta)\, s_{ij} - \eta} \times \left[k_{ij} - z + \hat{\omega}_j \mathbb{E}\left[L_j\right] \left(1 + d_j \sum_k \omega^D_{kj} \frac{\rho_{ik}\sigma_i\sigma_k}{\mu_i \mu_k}\right)\right]$$

with $\omega_j = \frac{\omega_j}{\left(\sum_k \Lambda_{kj}\right)}$

Microfoundation for CES Demand System

- Heterogeneous depositors making independent discrete decisions *a la* Verboven (1995)
- Unit measure of ex-ante identical depositors $\ell \in [0,1]$, each with random i.i.d. preference $\zeta_{\ell ij}$ for depositing funds at ij branch (follows Gumbel distribution)

$$F(\boldsymbol{\zeta}) = \exp\left[-\sum_{i=1}^{N}\left(\sum_{j=1}^{N_i} e^{-(1+\bar{\eta})\zeta_{ij}}\right)^{\frac{1+\bar{\theta}}{1+\bar{\eta}}}\right]$$

- Depositor values deposit services, but faces an opportunity cost $y_\ell = d_{\ell ij}\left(R - R_{ij}^{D}\right)$
- Interpretation
  - $\bar{\eta}$: rises the correlation of draws within a location (higher within-location substitution)
  - $\bar{\theta}$: lower overall variance of draws across all banks (higher across-location rate competition)

Microfoundation for CES Demand System

- After drawing ζ, depositor chooses ij that solves

$$\max_{ij} \{\ln d_{\ell ij} + \zeta_{ij}\} = \max_{ij} \left\{\ln y_\ell - \ln\left(R - R^D_{ij}\right) + \zeta_{ij}\right\}$$

- Depositor's optimization yields

$$Prob_\ell\left(R^D_{ij}, R^D_{-ij}\right) = \underbrace{\frac{\left(R - R^D_{ij}\right)^{-(1+\bar{\eta})}}{\sum_{j=1}^{N_i}\left(R - R^D_{ij}\right)^{-(1+\bar{\eta})}}}_{Prob_\ell(\text{Choose bank } j|\text{ Choose location } i)} \underbrace{\frac{\left(\sum_{j=1}^{N_i}\left(R - R^D_{ij}\right)^{-(1+\bar{\eta})}\right)^{\frac{1+\bar{\theta}}{1+\bar{\eta}}}}{\sum_{i=1}^{N}\left(\sum_{j=1}^{N_i}\left(R - R^D_{ij}\right)^{-(1+\bar{\eta})}\right)^{\frac{1+\bar{\theta}}{1+\bar{\eta}}}}}_{Prob_\ell(\text{Choose location } i\text{ })}$$

- Aggregate $D_{ij} = \int Prob_\ell\left(R^D_{ij}, R^D_{-ij}\right) d_{\ell ij} dF\left(y\right) = Prob_\ell\left(R^D_{ij}, R^D_{-ij}\right) \frac{Y}{R - R^D_{ij}}$

Microfoundation for CES Demand System Back

- Define indexes

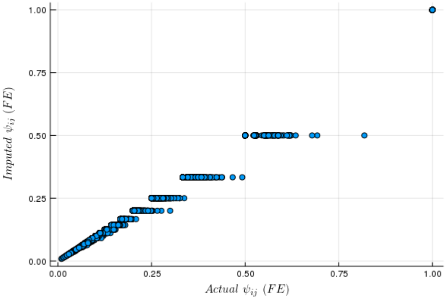
$$R - R_i^D \equiv \left[\sum_{j=1}^{N_i} \left(R - R_{ij}^D \right)^{-(1+\bar{\eta})} \right]^{\frac{-1}{1+\bar{\eta}}} \quad \text{and} \quad R - R^D \equiv \left[\sum_{i=1}^{N} \left(R - R_i^D \right)^{-\left(1+\bar{\theta}\right)} \right]^{\frac{-1}{1+\bar{\theta}}}$$

- Note that $D \times (R - R^D) = \sum_i \sum_j D_{ij} \left(R - R_{ij}^D \right) = Y$
- Substituting for Y and using the indexes,

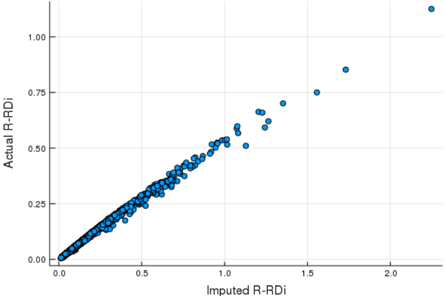
$$D_{ij} = \left(\frac{R - R_{ij}^D}{R - R_i^D} \right)^{-\eta} \left(\frac{R - R_i^D}{R - R^D} \right)^{-\theta} D, \quad \text{with } \eta = \bar{\eta} + 2, \ \theta = \bar{\theta} + 2$$

Imputing Rates (Cont.) Back

Actual vs Imputed ψ_{ij}



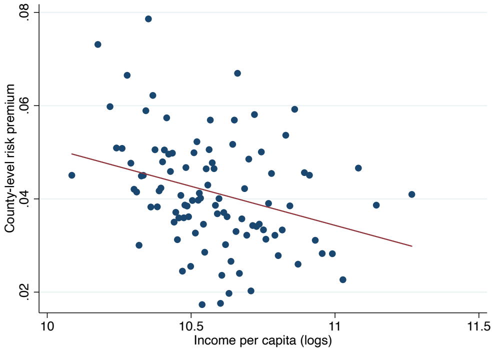
Actual vs Imputed $R - R^D_{ij}$



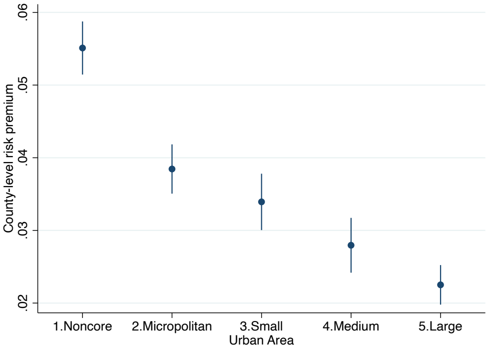
Risk Premium and Per-Capita Income

Back

Per Capita Income (Nonfarm)



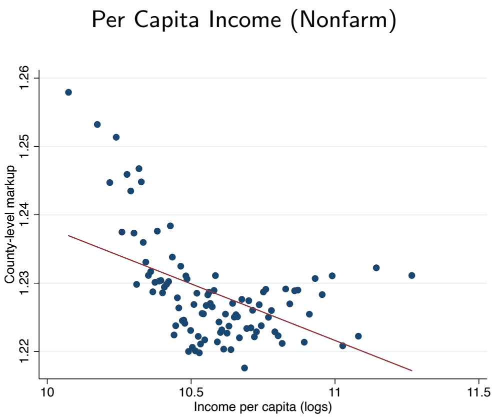
Urban vs Rural

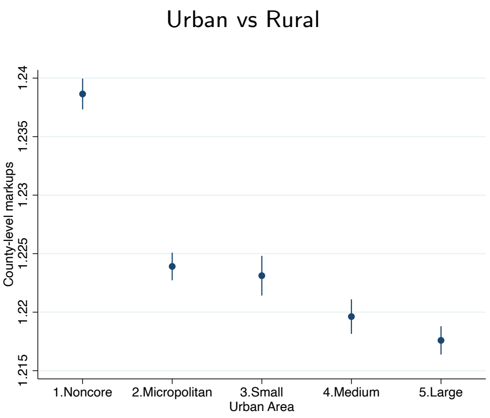


- Risk premium higher for counties with lower per capita income

Markups and Per-Capita Income

Back

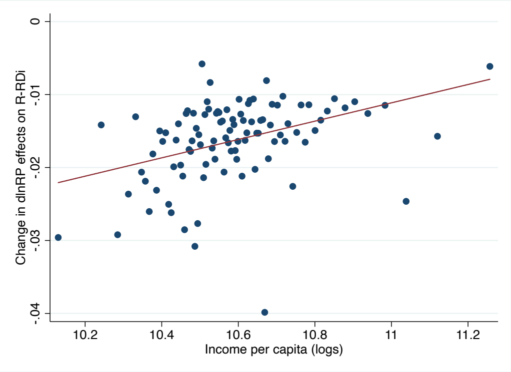




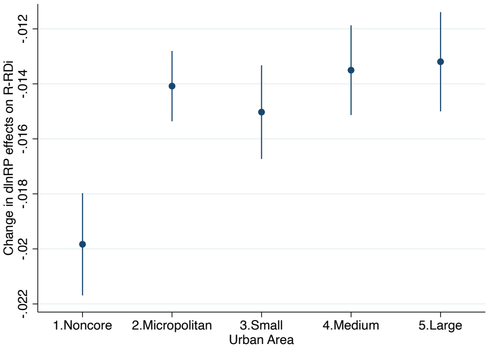
Diversification Gains by County Characteristics

Back

Per Capita Income (Nonfarm)



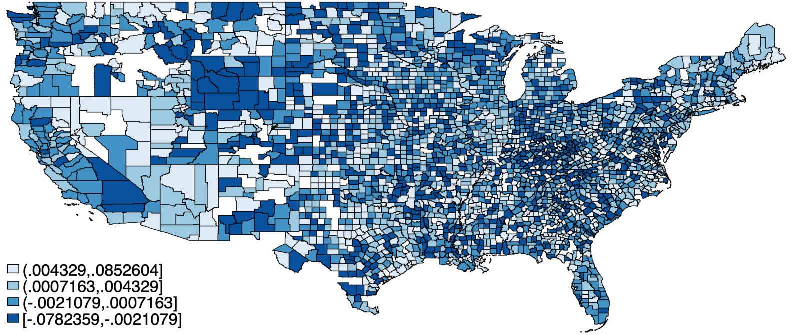
Urban vs Rural



- Counties with lower income per capita, and rural areas, exhibit larger drop in spreads through a reduction in risk premium

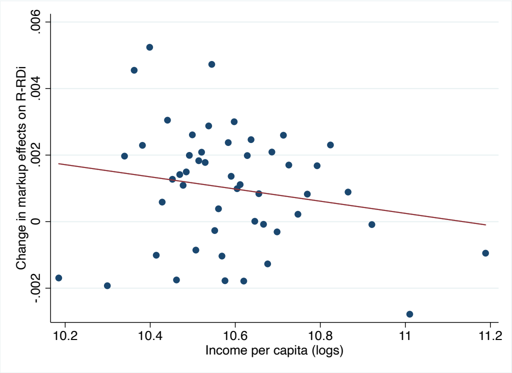
Markup Changes Back

- Pre/post comparison of county-level effects of markups



Markup Changes and County Characteristics Back

Per Capita Income (Nonfarm)



Urban vs Rural