

The Spatial Transmission of US Banking Panics

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Introduction

Banking panics

- Common feature of the pre-WWII economy
- 1870-1940 average of a panic every four years

Research contributions

- Historical aspects
 - Severity and persistence
 - Geographical spillovers
 - Banking sector volatility
- General aspects
 - Novel model for interbank lending
 - Identification strategy for spatial spillovers
 - Optimal environment to study transmission of financial shocks

Literature

- Classification and dating of panics: Kemmerer (1910), Gorton (1988), Jalil (2015) and many others
- Banking system was unstable and prone to panics: Calomiris and Haber (2014)
- Importance of the correspondent network and pyramidal structure of reserves: Calomiris et al. (2015, 2016), Mitchener and Richardson (2019)
- Modeling sides: Farrokhi (2016), Carreras et al. (2022)

Banking sector data

- Balance sheets of National Banks
 - Data from Reports of the Comptroller of the Currency 1870-1945
 - 1880-1910 digitized by [Weber \(2000\)](#), the rest by authors
- Frequency of observation
 - 1870-1914: five observations per year
 - 1915-1945: irregular, three to six
- Geographical aggregation
 - Reserve cities (increasing across time)
- States and overseas possessions (minor changes, ex. Dakota)

Data

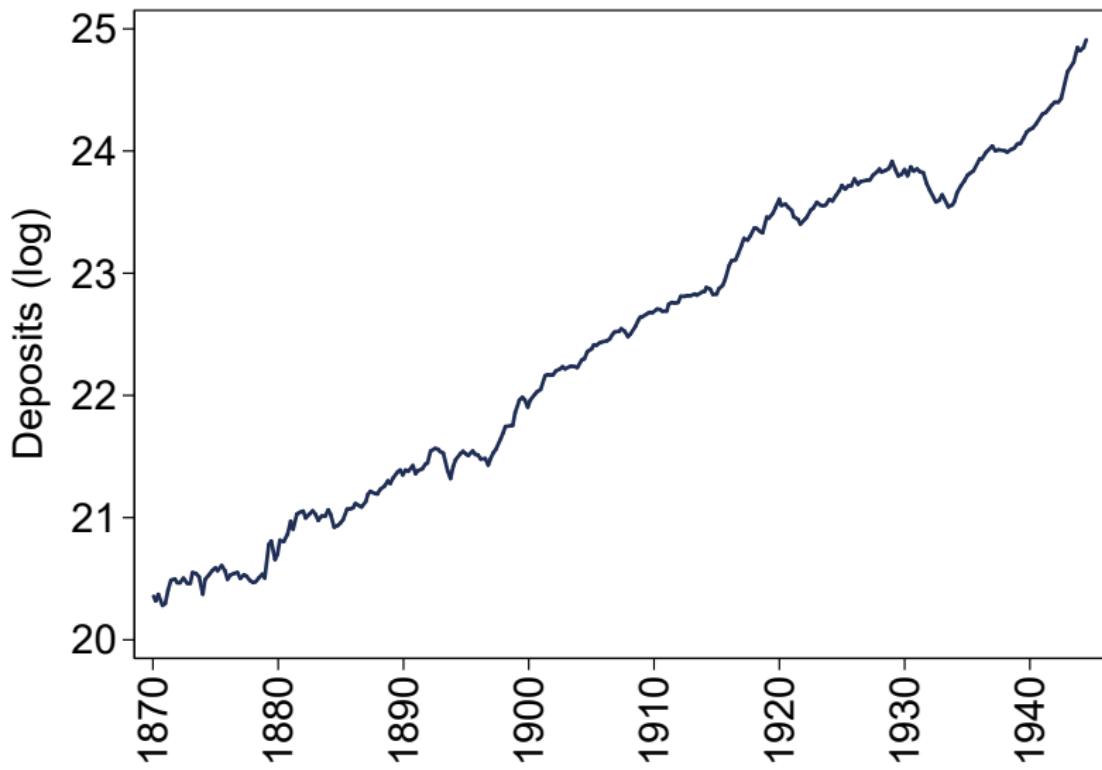
Data treatment

- Frequency
 - Convert to quarterly (February 1st = Q1)
 - If \exists two observations in same quarter
 - Pick one that is closest to mid-quarter
 - Pick one that is closest to panic
- Geographical aggregation
 - State aggregates only
 - Lower 48 States (except Hawaii and Alaska) + Washington DC
- Variables
 - Relatively constant categories, easy aggregation

Data

| Resources. | OCT. 21, 1913. | JAN. 13, 1914. | MAR. 4, 1914. | JUNE 30, 1914. | SEPT. 12, 1914. |
|---------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | 90 banks. |
| ALABAMA. | | | | | |
| Loans and discounts.. | \$45,513,715.05 | \$42,849,992.35 | \$42,905,637.89 | \$43,582,574.87 | \$41,812,117.43 |
| Overdrafts..... | 396,119.39 | 288,816.63 | 238,160.73 | 104,561.68 | 111,129.33 |
| Bonds for circulation.. | 8,747,750.00 | 8,935,750.00 | 8,934,750.00 | 9,101,750.00 | 9,103,749.95 |
| Misc. securities..... | | | | | 4,861,281.14 |
| Bonds for deposits..... | 411,000.00 | 485,000.00 | 505,713.00 | 410,000.00 | 397,000.00 |
| Other b'ds for deposits.. | 496,153.75 | 500,655.64 | 476,900.75 | 274,500.00 | 418,500.00 |
| U. S. bonds on hand.. | 9,000.00 | 9,000.00 | 9,000.00 | 9,000.00 | 10,000.00 |
| Premiums on bonds.. | 91,245.71 | 78,576.04 | 77,412.29 | 70,094.79 | 63,521.91 |
| Bonds, securities, etc.. | 3,348,927.54 | 3,358,970.02 | 3,308,569.78 | 3,363,852.16 | 2,321,201.77 |
| Stocks..... | | | | 143,858.49 | 179,144.71 |
| Banking house, etc.. | 2,173,798.88 | 2,169,921.91 | 2,169,114.21 | 2,190,582.18 | 2,196,334.97 |
| Real estate, etc..... | 322,342.75 | 311,914.19 | 322,095.64 | 333,964.56 | 333,918.44 |
| Due from nat'l banks.. | 4,195,515.45 | 4,300,854.48 | 3,666,789.64 | 2,169,436.13 | 1,727,789.62 |
| Due from State banks.. | 1,714,335.10 | 1,660,222.11 | 1,303,238.00 | 976,877.10 | 845,832.72 |
| Due from res've agts.. | 6,959,955.73 | 7,374,465.51 | 6,348,607.03 | ,403,111.15 | 3,215,822.55 |
| Cash items..... | 308,028.93 | 262,611.25 | 239,394.00 | 187,521.17 | 238,991.11 |
| Clear'g-house exch'gs.. | 324,608.67 | 250,191.01 | 311,139.61 | 270,994.99 | 179,617.99 |
| Bills of other banks.. | 889,950.00 | 1,124,469.00 | 978,233.00 | 964,975.00 | 1,535,034.00 |
| Fractional currency.. | 29,160.00 | 41,041.08 | 45,683.69 | 45,333.69 | 42,625.33 |
| Specie..... | 2,852,883.16 | 3,248,435.06 | 3,002,017.36 | 3,043,383.10 | 2,852,801.47 |
| Legal-tender notes.. | 662,485.00 | 709,896.00 | 531,574.00 | 459,927.00 | 341,739.00 |
| 5% fund with Treas.. | 424,287.50 | 429,037.50 | 413,137.50 | 434,437.50 | 561,766.50 |
| Due from U. S. Treas.. | 33,700.00 | 39,750.00 | 14,902.00 | 21,625.00 | 5,350.00 |
| Total..... | 79,904,962.61 | 78,429,569.78 | 75,802,070.12 | 72,563,370.56 | 73,355,269.94 |

Data — United States Deposits



Other data

- Euclidean distance between States (each state's most populated city)
- State neighborhood (common border), binary variable

Data — Panics

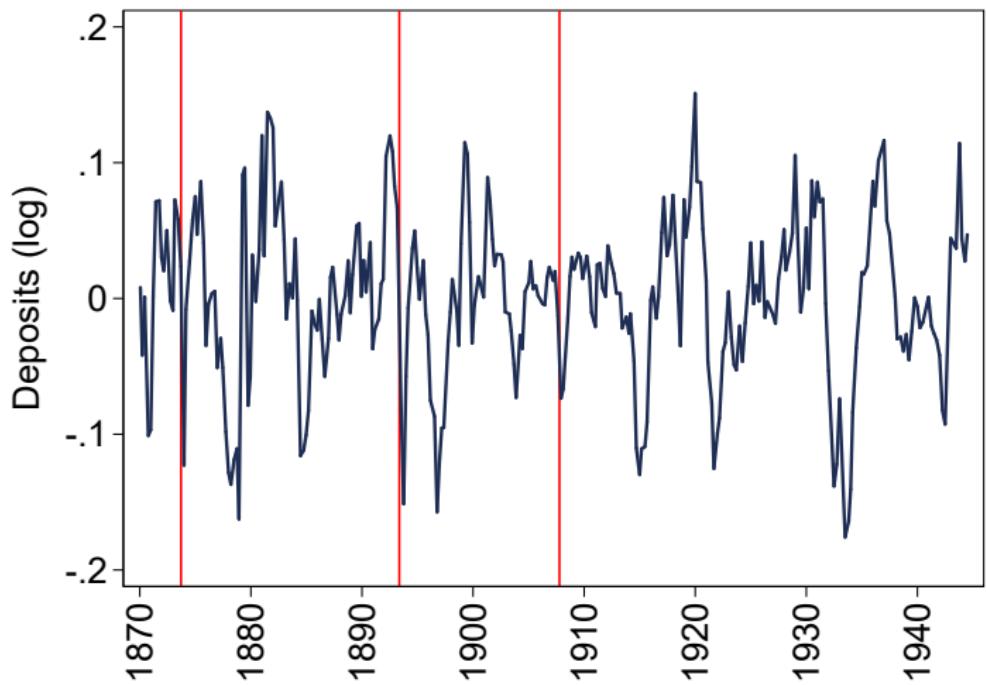
| Date | Jalil (2015) | Origin |
|----------|--------------|--------|
| Sep 1873 | All | Europe |
| May 1884 | NY, PA, NJ | NY |
| Nov 1890 | NY | |
| May 1893 | All | All |
| Dec 1896 | IL, MN, WI | IL |
| Dec 1899 | MA, NY | MA |
| Jun 1901 | NY | |
| Oct 1903 | PA, MD | MD |

| Date | Jalil (2015) | Origin |
|----------|--------------|--------|
| Dec 1905 | IL | |
| Oct 1907 | All | NY |
| Jan 1908 | NY | |
| Aug 1920 | MA | |
| Nov 1920 | ND | |
| Jul 1926 | FL, GA | GA |
| Mar 1927 | FL | |
| Jul 1929 | FL | |

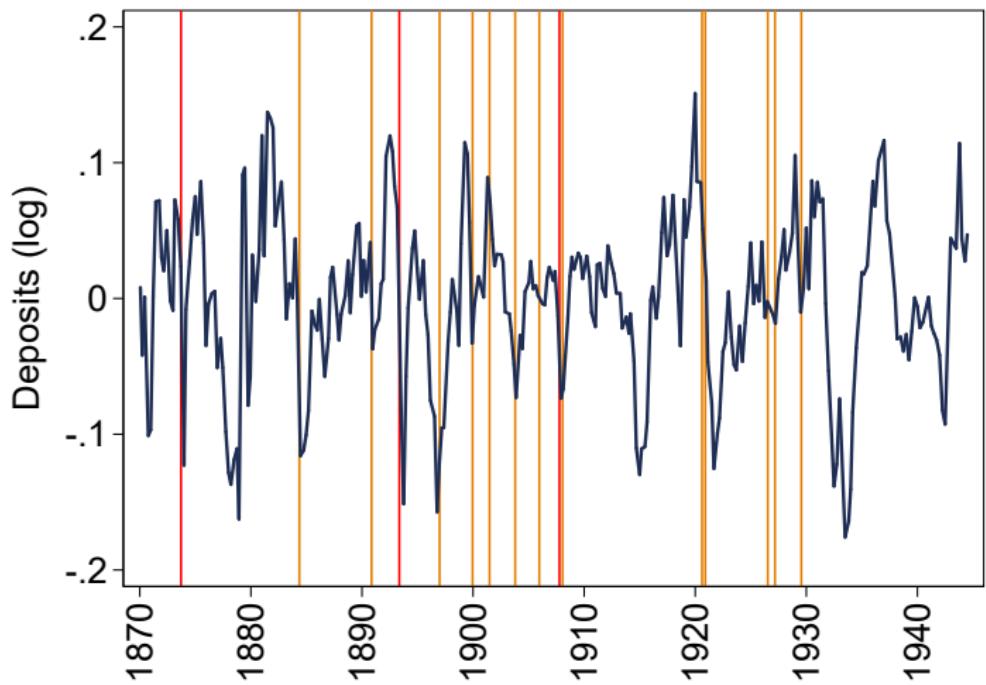
Data — Panics

| Panic, Start | Panic, End | Reporting Date | Time to Start | Time to End |
|--------------|------------|----------------|---------------|-------------|
| 18sep1873 | 30sep1873 | 26dec1873 | 99 | 87 |
| 13may1884 | 31may1884 | 20jun1884 | 38 | 20 |
| 10nov1890 | 22nov1890 | 19dec1890 | 39 | 27 |
| 13may1893 | 19aug1893 | 12jul1893 | 60 | 0 |
| 26dec1896 | 26dec1896 | 09mar1897 | 73 | 73 |
| 16dec1899 | 31dec1899 | 13feb1900 | 59 | 44 |
| 27jun1901 | 06jul1901 | 15jul1901 | 18 | 9 |
| 18oct1903 | 24oct1903 | 17nov1903 | 30 | 24 |
| 12oct1907 | 30nov1907 | 03dec1907 | 52 | 3 |
| 25jan1908 | 01feb1908 | 14feb1908 | 20 | 13 |
| 12aug1920 | 02oct1920 | 08sep1920 | 27 | 0 |
| 27nov1920 | 19feb1921 | 29dec1920 | 32 | 0 |
| 14jul1926 | 21aug1926 | 31dec1926 | 170 | 132 |
| 08mar1927 | 26mar1927 | 23mar1927 | 15 | 0 |
| 20jul1929 | 07sep1929 | 04oct1929 | 76 | 27 |
| | | Median | 38.5 | 22 |

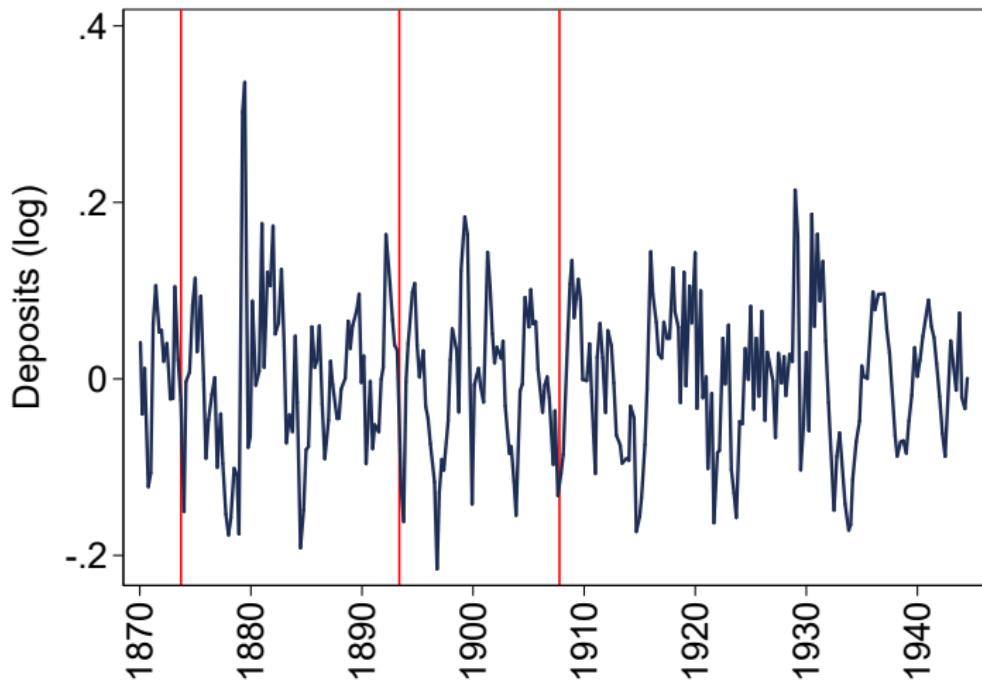
Data — United States Deposits



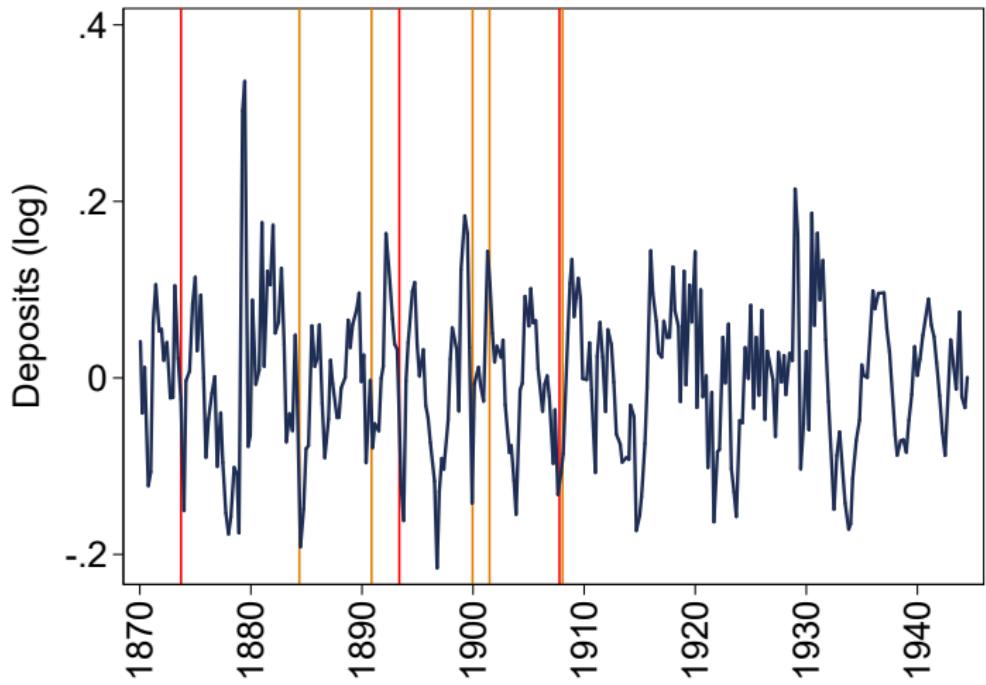
Data — United States Deposits



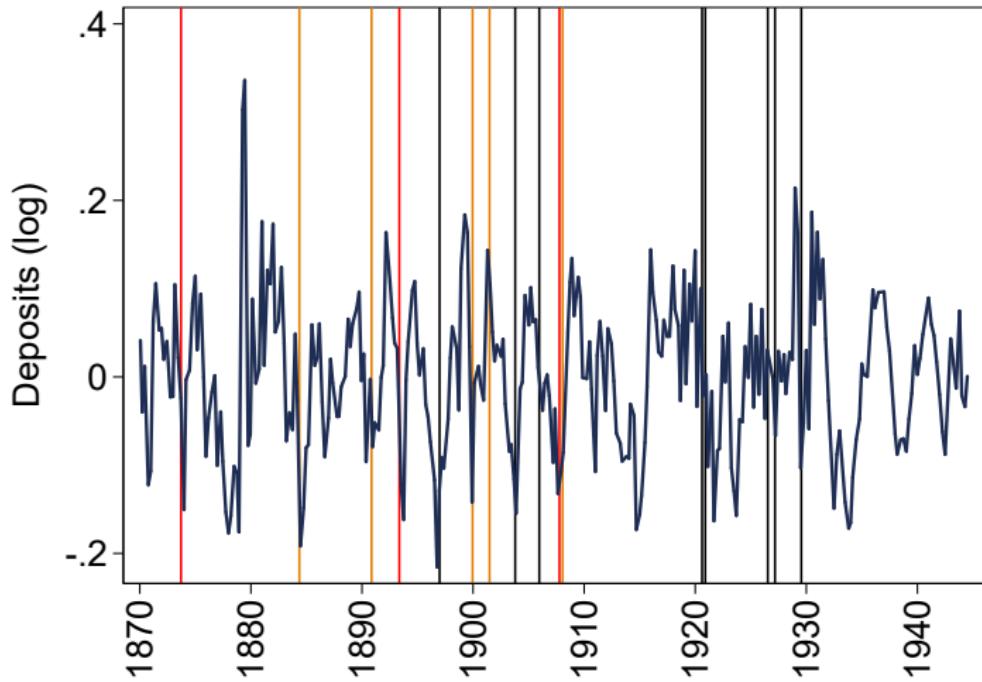
Data — New York Deposits



Data — New York Deposits



Data — New York Deposits



Panic exogeneity

Big Question

Is panic exogenous or correlated with business cycles?

- Causes of panics relatively disconnected from the business cycle (e.g., Jalil (2015))
- Common triggers: mismanagement, misappropriation of funds
- Why?: Small and medium banks, unit office, no deposit insurance, lack of diversification, pyramidal structure of reserves, ...

Excerpts from Jalil (2015):

- 1884 Panic

"On May 14, the Metropolitan Bank closed its doors following a serious run. Rumors had been circulating that its president had misappropriated funds for speculative purposes. The suspension of the Metropolitan Bank, an institution holding reserves from banks throughout the nation, led to the intervention of the New York Clearing House."

- 1896 Panic

"The failure of The National Bank of Illinois set off a banking panic in December 1896. According to the Chronicle, the bank had loaned an amount that surpassed its "combined capital, surplus and undivided profits" to one corporation and a large additional sum to a relative of one of the officers of the bank."

Data — Panics

Granger causality test (exogeneity test)

$$Panic_{i,t} = \sum_{l=1}^4 \left[\beta_l^D \Delta Deposit_{i,t-l} + \beta_l^L \Delta Loan_{i,t-l} + \beta_l^B \Delta \underbrace{Bank_{i,t-l}}_{\text{Number of banks}} \right] + \mu_i + s_t + \varepsilon_{i,t}$$

Joint test, $H_0: \beta_l^D = \beta_l^L = \beta_l^B = 0 \quad \forall l$

| | 1 | 2 | 3 | 4 |
|-----------------------|------|-------|-------|-------|
| Joint F-test, p-value | *** | *** | H_0 | H_0 |
| R-squared | 0.4% | 1.88% | 0.06% | 0.95% |
| All panics | X | X | | |
| Minor panics | | | X | X |
| Indiv. fix effects | | X | | X |
| Seasonal dummies | | X | | X |

Claim: no rejection when using the regional series

Model (similar to Carreras et al. (2022))

Objective: Model interbank loans and transmission of deposit shocks

Main components: N regions

- N final loan producers, supplying lending to local demands
- N intermediate producers
 - Accept local deposits
 - Create loanable funds, distribute through interbank loans
- N Deposit supplies and loan demands. Local and exogenous.
- Time is continuous within a quarter
 - Quarters indexed by t
 - Continuous partition (unit interval) indexed by τ

Model — Final Producer (i)

Production function

$$Loan_{i,t}^S(\tau) \leq M_{i,t}(\tau)$$

where $M_{i,t}(\tau)$ represents loanable funds.

The final producer solves:

$$\max_{\{Loan_{i,t}^S(\tau)\}} \int_0^1 \left(R_{i,t}^F(\tau) Loan_{i,t}^S(\tau) - R_{i,t}^I(\tau) M_{i,t}(\tau) \right) d\tau$$

where

- ① $R_{i,t}^F(\tau)$: interest rate charged on loans
- ② $R_{i,t}^I(\tau)$: interest rate charged on loanable funds

Model — Final Producer (i)

The first order condition is:

$$R_{i,t}^F(\tau) = R_{i,t}^I(\tau)$$

due to perfect competition

Loanable funds are an homogeneous good (money), obtained at lowest rate every period: for n such that

$$R_{i,t}^I(\tau) = \min_n \{R_{ni,t}^I(\tau)\}$$

the loanable funds come from the intermediate producer n

$$M_{i,t}(\tau) = M_{ni,t}(\tau), \quad n = \arg \min \left\{ R_{ni,t}^I(\tau) \right\}$$

Model — Intermediate Producer (n)

Production function

$$\sum_{i=1}^N \int_0^1 z_{ni,t}(\tau) M_{ni,t}(\tau) d\tau = (D_{n,t})^\alpha, \quad 0 < \alpha < 1 \quad (1)$$

where $z_{ni,t}(\tau)$ represents technology, $M_{ni,t}$ loanable funds for final producer i and $D_{n,t}$ local deposits at the beginning of the period.

Productivity

- $z_{ni,t}(\tau)$ is Weibull distributed $\sim W\left(T_{ni}^{-\frac{1}{\kappa}}, \kappa\right)$
- $T_{ni}^{-\frac{1}{\kappa}}$: scale parameter, κ : shape parameter
- Captures costs associated to trading with different States (trade costs, agency problems, imperfect information, etc)
- Different costs within the continuum (random draws)

Model — Intermediate Producer (n)

Solves the following problem, subject to (1)

$$\max_{\{M_{ni,t}(\tau)\}} \sum_{i=1}^N \int_0^1 R_{ni,t}^I(\tau) M_{ni,t}(\tau) d\tau - \underbrace{\rho D_{n,t}^\gamma}_{\text{Cost of loanable funds}}, \quad 0 < \gamma \leq 1$$

First-order conditions

$$R_{ni,t}^I(\tau) = \underbrace{z_{ni,t}(\tau)}_{\text{Random draw}} \left(\frac{\rho\gamma}{\alpha} \right) D_{n,t}^{-(\alpha-\gamma)}$$

As $z_{ni,t}(\tau)$ is random, $R_{ni,t}^I(\tau)$ becomes a random draw

→ We use the property that minimum of Weibull distributions \sim Weibull

Model — Intermediate Producer (n)

The distribution of (final) loan rates in State i is given by

$$R_{i,t}^F(\tau) = \min_n \left\{ R_{ni,t}^I(\tau) \right\} \sim W \left(\Phi_{i,t}^{-\frac{1}{\kappa}}, \kappa \right)$$

where

$$\Phi_{i,t} = \left(\frac{\rho\gamma}{\alpha} \right)^{-\kappa} \left(\sum_{n=1}^N T_{ni}^{\frac{1}{\kappa}} D_{n,t}^{(\alpha-\gamma)} \right)^\kappa$$

→ We use the property that minimum of Weibull distributions \sim Weibull

Model — Lending Demand

Demand for lending in state i is given by

$$Loan_{i,t}^D(\tau) = R_i^F(\tau)^{-\beta} \varepsilon_{i,t} \quad \forall i$$

where $\varepsilon_{i,t}$ is a **demand shifter** for period t

Total lending demand in period t is then

$$\begin{aligned} Loan_{i,t}^D &= \int_0^1 Loan_{i,t}^D(\tau) d\tau = \underbrace{\left[\int_0^1 R_i^F(\tau)^{-\beta} d\tau \right]}_{= \mathbb{E}(R_i^F(\tau)^{-\beta})} \varepsilon_{i,t} \quad \forall i \end{aligned}$$

by applying the Law of large number (LLN)

Model — Lending Demand

Final expression

$$\text{Loan}_{i,t}^D = \left[\sum_{n=1}^N T_{ni}^{\frac{1}{\kappa}} D_{n,t}^{(\alpha-\gamma)} \right]^{\beta} \left(\frac{\alpha}{\rho\gamma} \right)^{\beta} \Gamma \left(1 - \frac{\beta}{\kappa} \right) \varepsilon_{i,t} \quad \forall i$$

- Lending in each State is linked to deposits in all states
- **Problem:** non-linear relationship
→ Approximation needed

Model — Lending Demand

Log-linear approximation around equal deposit size (across n)

$$\log(Loan_{i,t}) = \mu_i + \sum_{n=1}^N \tilde{T}_{ni} \log(D_{n,t}) + \epsilon_{i,t} \quad \forall i$$

where

$$\mu_i = \frac{\beta}{\kappa} \sum_{n=1}^N \left(\frac{T_{ni}^{\frac{1}{\kappa}}}{\sum_{n'=1}^N T_{n'i}^{\frac{1}{\kappa}}} \right) \hat{T}_{ni} = \frac{\beta}{\kappa} \sum_{n=1}^N \left(\frac{T_{ni}}{\bar{T}} \right)^{\frac{1}{\kappa}} \hat{T}_{ni}$$

and

$$\tilde{T}_{ni} = \beta(\alpha - \gamma) \left(\frac{T_{ni}}{\bar{T}} \right)^{\frac{1}{\kappa}}, \text{ where } \bar{T} \equiv \left(\sum_{n=1}^N T_{ni}^{\frac{1}{\kappa}} \right)^\kappa$$

Model — Lending Demand

Assume T_{ni} takes the following form:

$$\begin{aligned}\tilde{T}_{ni} &= \beta(\alpha - \gamma) \left(\frac{T_{ni}}{\bar{T}} \right)^{\frac{1}{\kappa}} \\ &= \lambda_1 + \lambda_2 \log \left(\underbrace{\text{Distance}_{ni}}_{\text{Distance between state } i \text{ and } n} \right) + \lambda_3 \text{Neighbor}_{ni} + \lambda_4 \text{Own}_n\end{aligned}$$

- Neighbor_{ni} : state n and i are neighbors (binary)
- Own_n : $n = i$ (binary)

Model — Lending Demand

Then

$$\log(Loan_{i,t}) = \mu_i + \sum_{j=1}^4 \lambda_j X_{i,t}^j + \epsilon_{i,t} \quad (2)$$

where

$$X_{i,t}^1 = \sum_{n=1}^N \log(D_{n,t})$$

$$X_{i,t}^3 = \sum_{n=1}^N Neighbor_{ni} \cdot \log(D_{n,t})$$

$$X_{i,t}^2 = \sum_{n=1}^N \log(Distance_{ni}) \cdot \log(D_{n,t})$$

$$X_{i,t}^4 = \sum_{n=1}^N Own_n \cdot \log(D_{n,t})$$

→ interactions between $D_{n,t}$ and geographic variables

Model — Deposits Supply

Deposits supply is given by

$$\log(D_{n,t}) = c_n + \log(D_{n,t-1}) + \phi Panic_{n,t} + v_{n,t} \quad (3)$$

- Precise specification is not important
 - $Cov(v_{n,t}, \epsilon_{i,t}) \neq 0, \quad \forall n, i$
 - $Cov(v_{n,t}, Panic_{n,t}) = 0, \quad \forall n$
- Going back to the exogeneity of panics

Model — Loans and Panics

Combining equations (2) and (3)

$$\log(Loan_{i,t}) = \eta_i + \sum_{j=1}^4 \theta_j F_{i,t}^j + \varepsilon_{i,t}$$

where

$$F_{i,t}^1 = \sum_{n=1}^N Panic_{n,t}$$

$$F_{i,t}^3 = \sum_{n=1}^N Neighbor_{ni} \cdot Panic_{n,t}$$

$$F_{i,t}^2 = \sum_{n=1}^N \log(Distance_{ni}) \cdot Panic_{n,t}$$

$$F_{i,t}^4 = \sum_{n=1}^N Own_n \cdot Panic_{n,t}$$

Estimation — Reduced Form

Jordà (2005) Local Projections:

$$\text{LHS}_{i,t+h} = \eta_{i,h} + s_{t,h} + \sum_{j=1}^4 \theta_{j,h} F_{i,t}^j + \sum_{l=1}^L \beta_{l,h} \text{cntrl}_{i,t-l} + \varepsilon_{i,t+h} \quad (4)$$

where

$$F_{i,t}^1 = \sum_{n=1}^N \text{Panic}_{n,t}$$

$$F_{i,t}^3 = \sum_{n=1}^N \text{Neighbor}_{ni} \cdot \text{Panic}_{n,t}$$

$$F_{i,t}^2 = \sum_{n=1}^N \log(\text{Distance}_{ni}) \cdot \text{Panic}_{n,t}$$

$$F_{i,t}^4 = \sum_{n=1}^N \text{Own}_n \cdot \text{Panic}_{n,t}$$

Estimation — Reduced Form

Dependent variables

{Banks Number, Average Capital, Deposits, Loans, Liquidity ratio}

Standard errors

- Driscoll-kraay:
Spatial correlation, heteroskedasticity and auto-correlation (4 lags)
- Alternatives: heteroskedasticity-consistent (HC), Newey-West

Results (predicted spatial spillover)

- ① Estimate equation (4) for all h , obtain $\left\{ \hat{\theta}_{j,h} \right\}_{j=1}^4$
- ② Assume \exists panic in New York state, generate $\left\{ F_{i,t}^j \right\}_{j=1}^4$ for all i
- ③ $\sum_{j=1}^4 \hat{\theta}_{j,h} F_{i,t}^j$ is the predicted response at horizon h for State i

Results— Deposits

Results— Loans

Results— Liquidity Ratio

Results— Average Capital

Results— Number of Banks

Conclusions

- Minor panics had a national scope
- Moderate impact and duration (~ 2 years)
- Rapid spatial transmission
- Burden of the crises shifted to the interior