The Spatial Transmission of US Banking Panics

Marc Dordal i Carreras
Economics Department
HKUST

Seung Joo Lee
Saïd Business School
Oxford University

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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

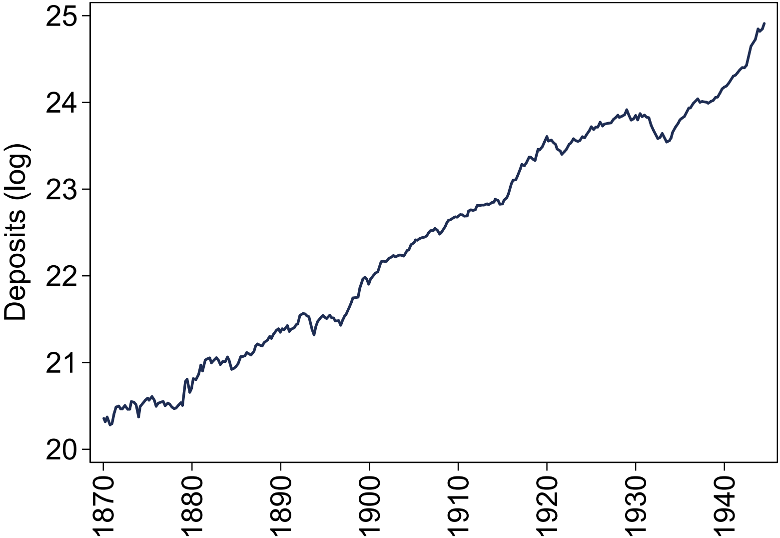
Data treatment

- Frequency
  - Convert to quarterly (Febraury $1^{st} = \text{Q1}$)
  - 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.
ALABAMA.	90 banks.	90 banks.	90 banks.	90 banks.	90 banks.
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



Data

Other data

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

Data — Panics

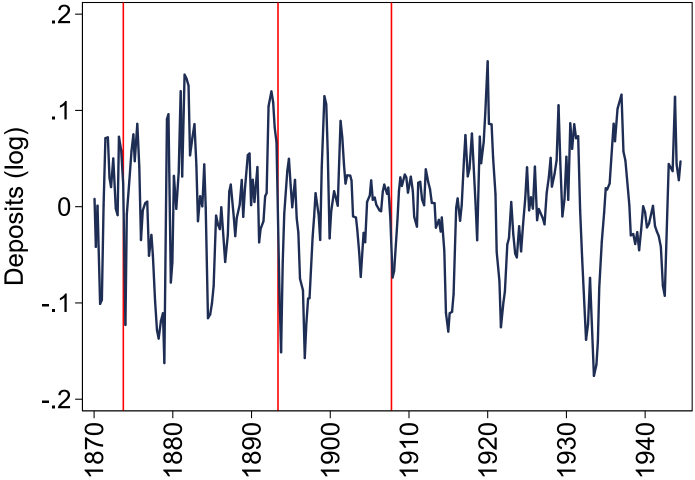
Date	Jalil (2015)	Origin
Sep 1873	All	Europe
May 1884	NY, PA, NJ	NY
Nov 1890	NY	
May 1893	All	All
Dec 1896	IL, MN, WI	IL
Dec 1899	MA, NY	MA
Jun 1901	NY	
Oct 1903	PA, MD	MD

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	

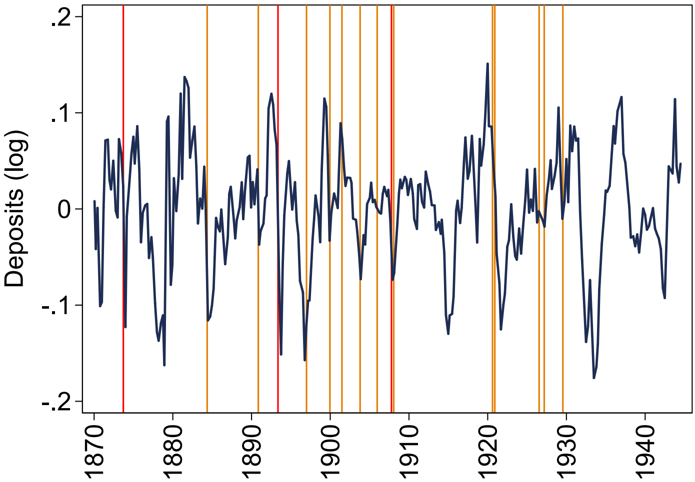
Data — Panics

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

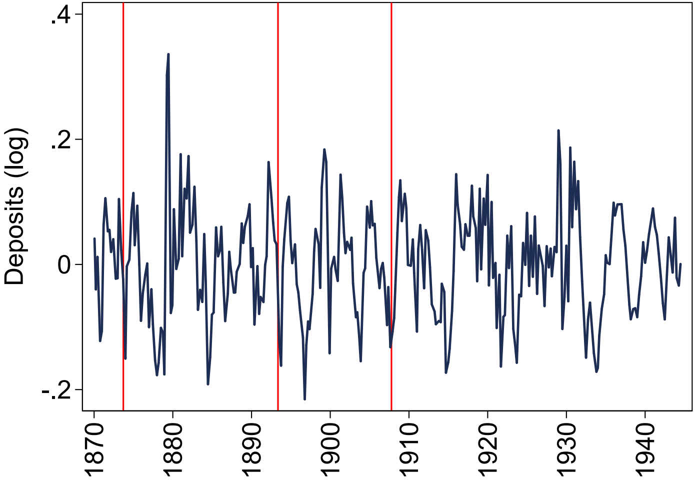
Data — United States Deposits



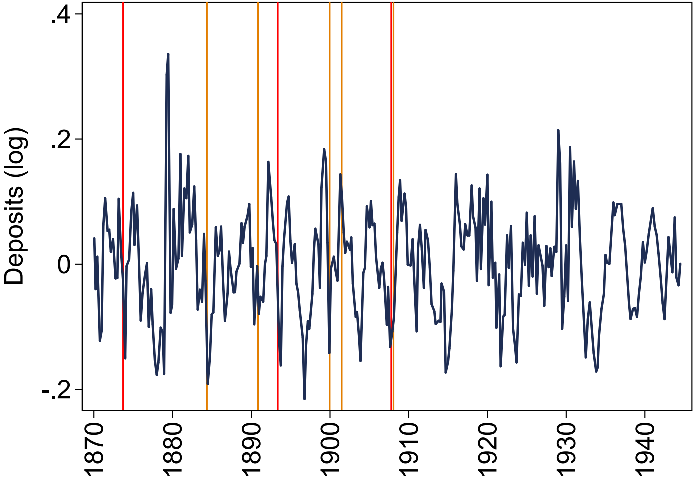
Data — United States Deposits



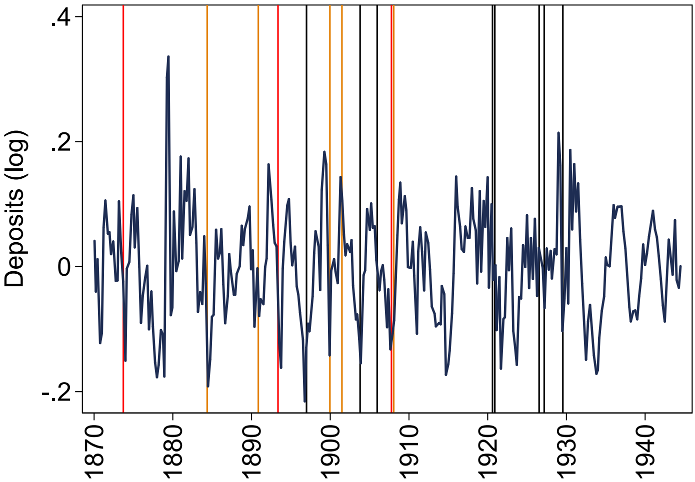
Data — New York Deposits



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, ...

Data — Panics

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)

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

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

$$Loan^S_{i,t}(\tau) \leq M_{i,t}(\tau)$$

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

The final producer solves:

$$\max_{\{Loan^S_{i,t}(\tau)\}} \int_0^1 \left(R^F_{i,t}(\tau) Loan^S_{i,t}(\tau) - R^I_{i,t}(\tau) M_{i,t}(\tau) \right) d\tau$$

where

1. $R^F_{i,t}(\tau)$: interest rate charged on loans
2. $R^I_{i,t}(\tau)$: interest rate charged on loanable funds

Model — Final Producer (i)

The first order condition is:

$$R^F_{i,t}(\tau) = R^I_{i,t}(\tau)$$

due to perfect competition

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

$$R^I_{i,t}(\tau) = \min_n \{R^I_{ni,t}(\tau)\}$$

the loanable funds come from the intermediate producer n

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

Model — Intermediate Producer (n)

Production function

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

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)

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

First-order conditions

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

As $z_{ni,t}(\tau)$ is random, $R^I_{ni,t}(\tau)$ becomes a random draw
$\longrightarrow$ 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

$$R^F_{i,t}(\tau) = \min_n \left\{ R^I_{ni,t}(\tau) \right\} \sim W\left(\Phi_{i,t}^{-\frac{1}{\kappa}}, \kappa \right)$$

where

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

$\longrightarrow$ We use the property that minimum of Weibull distributions $\sim$ Weibull

Model — Lending Demand

Demand for lending in state i is given by

$$Loan^D_{i,t}(\tau) = R^F_i(\tau)^{-\beta}\varepsilon_{i,t} \qquad \forall i$$

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

Total lending demand in period t is then

$$Loan^D_{i,t} = \int_0^1 Loan^D_{i,t}(\tau)d\tau = \underbrace{\left[\int_0^1 R^F_i(\tau)^{-\beta}d\tau\right]}_{=\mathbb{E}\left(R^F_i(\tau)^{-\beta}\right)}\varepsilon_{i,t} \qquad \forall i$$

by applying the Law of large number (LLN)

Model — Lending Demand

Final expression

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

- Lending in each State is linked to deposits in all states

- **Problem**: non-linear relationship

$\longrightarrow$ Approximation needed

Model — Lending Demand

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

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

where

$$\mu_i = \frac{\beta}{\kappa}\left(\frac{T_{ni}^{\frac{1}{\kappa}}}{\sum_{n=1}^{N} T_{ni}^{\frac{1}{\kappa}}}\right)\sum_{n=1}^{N}\hat{T}_{ni} = \frac{\beta}{\kappa}\left(\frac{T_{ni}}{\bar{T}}\right)^{\frac{1}{\kappa}}\sum_{n=1}^{N}\hat{T}_{ni}$$

and

$$\tilde{T}_{ni} = \beta(\alpha-\gamma)\left(\frac{T_{ni}}{\bar{T}}\right)^{\frac{1}{\kappa}}$$

Model — Lending Demand

Assume T_{ni} takes the following form:

$$\tilde{T}_{ni} = \beta(\alpha - \gamma)\left(\frac{T_{ni}}{\bar{T}}\right)^{\frac{1}{\kappa}}$$

$$= \lambda_1 + \lambda_2 \log\left(\underbrace{Distance_{ni}}_{\text{Distance between state } i \text{ and } n}\right) + \lambda_3 Neighbor_{ni} + \lambda_4 Own_n$$

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

Model — Lending Demand

Then

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

where

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

$$X_{i,t}^{2} = \sum_{n=1}^{N} \log\left(Distance_{ni}\right) \cdot \log\left(D_{n,t}\right) \qquad X_{i,t}^{4} = \sum_{n=1}^{N} Own_{n} \cdot \log\left(D_{n,t}\right)$$

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

Model — Deposits Supply

Deposits supply is given by

$$\log\left(D_{n,t}\right) = c_n + \log\left(D_{n,t-1}\right) + \phi Panic_{n,t} + \upsilon_{n,t} \tag{3}$$

- Precise specification is not important
- $Cov(\upsilon_{n,t}, \epsilon_{i,t}) \neq 0, \quad \forall n, i$
- $Cov(\upsilon_{n,t}, Panic_{n,t}) = 0, \quad \forall n$

$\longrightarrow$ Going back to the exogeneity of panics

Combining equations (2) and (3)

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

where

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

$$F^2_{i,t} = \sum_{n=1}^{N} \log\left(Distance_{ni}\right) \cdot Panic_{n,t} \qquad F^4_{i,t} = \sum_{n=1}^{N} Own_{n} \cdot Panic_{n,t}$$

Estimation — Reduced Form

Jordà (2005) **Local Projections**:

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

where

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

$$F_{i,t}^{2} = \sum_{n=1}^{N} \log\left(Distance_{ni}\right) \cdot Panic_{n,t} \qquad F_{i,t}^{4} = \sum_{n=1}^{N} Own_{n} \cdot Panic_{n,t}$$

Estimation — Reduced Form

Dependent variables

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

Standard errors

- Driscoll-kraay:

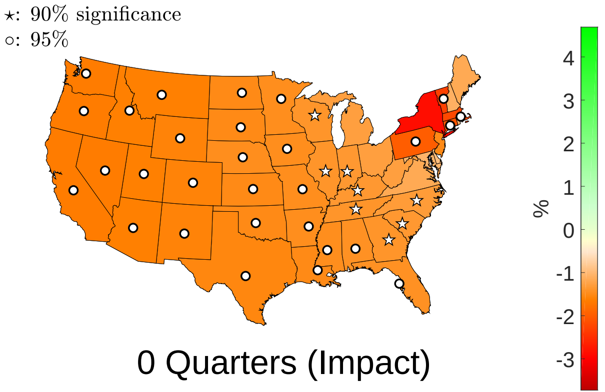
  Spatial correlation, heteroskedasticity and auto-correlation (4 lags)

- Alternatives: heteroskedasticity-consistent (HC), Newey-West

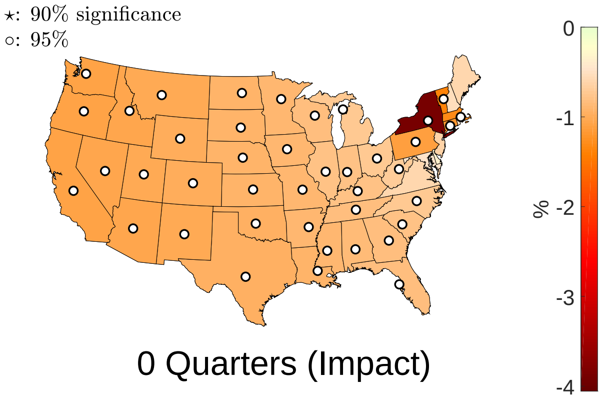
Results (predicted spatial spillover)

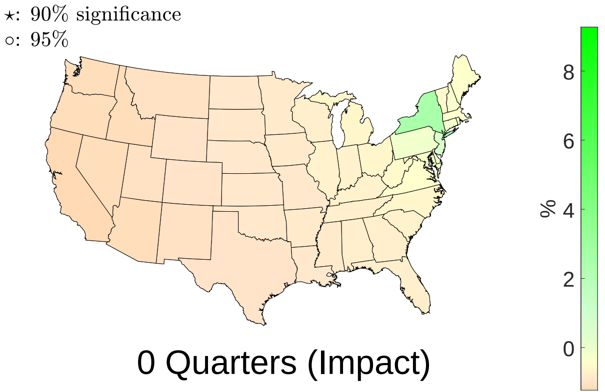
1. Estimate equation (4) for all h, obtain $\left\{\hat{\theta}_{j,h}\right\}_{j=1}^{4}$
2. Assume $\exists$panic in New York state, generate $\left\{F_{i,t}^{j}\right\}_{j=1}^{4}$ for all i
3. $\sum_{j=1}^{4}\hat{\theta}_{j,h}F_{i,t}^{j}$ is the predicted response at horizon h for State i

Results— Deposits

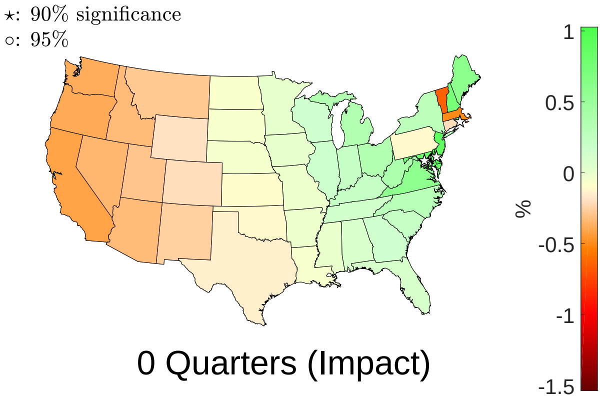


Results— Loans

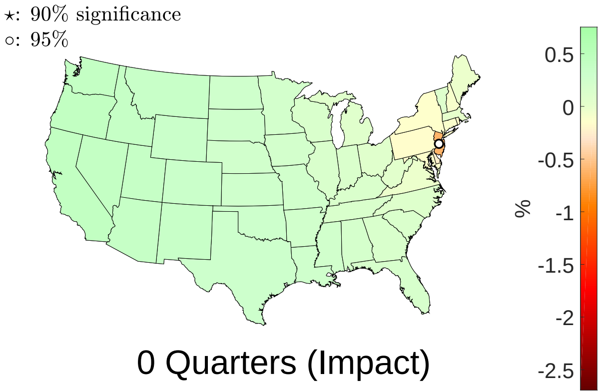



⋆: 90% significance
○: 95%
0 Quarters (Impact)
%
8
6
4
2
0

Results— Average Capital



Results— Number of Banks



0 Quarters (Impact)

Conclusions

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