

# INTERBANK NETWORKS IN THE SHADOWS OF THE FEDERAL RESERVE ACT

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# MOTIVATION

- ▶ Question
  - ▶ How does public liquidity provision (Fed windows, bailouts, etc.) affect banks' portfolios, interbank relations and potentially systemic risk?
- ▶ Challenge: No counterfactual.
- ▶ Strategy
  - ▶ Endogenous network model to obtain testable implications.
  - ▶ Confront the implications by comparing the banking system before and after credible public liquidity provision (the Federal Reserve Act of 1913).

# OUR FINDINGS

- ▶ The creation of the Federal Reserve System created a “shadow banking system,” and may have increased systemic risk through three channels.

1. **Changing banks’ portfolios:**

**Crowding out of private self-insurance.**

Both member and nonmember banks held less cash and deposits, and more loans.

2. **Changing the nature of the interbank system:**

**Crowding out of private interbank insurance.**

*More short-term borrowing*, both by members (directly from Fed) and nonmembers (indirectly from members), and *less interbank deposits*.

3. **Changing the anatomy of the interbank system:**

**Crowding out of private cross-regional insurance.**

More regionally concentrated networks and more reliance on the Fed to hedge against regional liquidity shocks.

## RELATED WORK

- ▶ Financial stability effects of the Fed's founding.
  - ▶ Miron (1986), Mankiw et al. (1987), Bernstein et al. (2010), Carlson and Wheelock (2018), Mitchener and Richardson (2019) and Calomiris et al. (2019).
- ▶ Financial stability effects of shadow banking.
  - ▶ Adrian and Shin (2009), Moreira and Savov (2017), Ordonez (2018), Begenau and Landvoigt (2019).
- ▶ Network reactions to government regulations.
  - ▶ Erol and Ordonez (2017), Anderson, Paddrik, and Wang (2019), Chang and Zhang (2021).

# HISTORICAL BACKGROUND

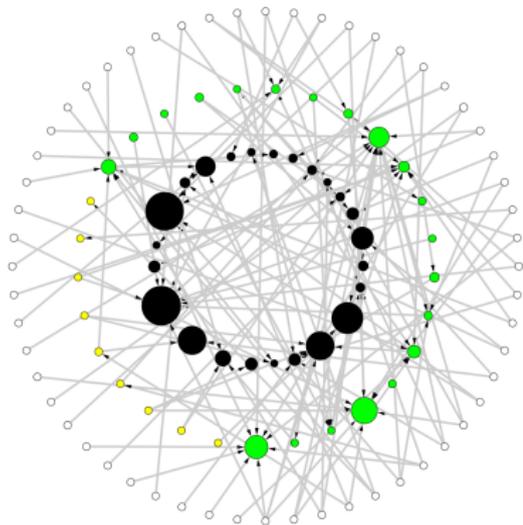
# INTERBANK SYSTEM BEFORE THE FED

- ▶ Branching restrictions made inter-regional payments difficult.
- ▶ An interbank (deposit) network developed to facilitate inter-regional payments and redistribute liquidity shocks across regions.
- ▶ The National Banking Act (1863) institutionalized the interbank system.
  - ▶ National Banks: Reserve pyramid with 3 tiers

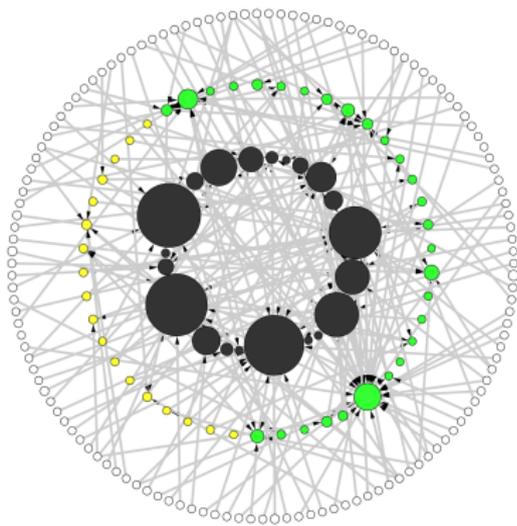
Tier Group	Reserve Ratio	
	Total	in deposits
Central Reserve City Banks	25%	0
Reserve City Banks	25%	1/2
Country Banks	15%	3/5

- ▶ State banks: Similar but with more relaxed regulations.
- ▶ **Important detail:** Part of reserves (e.g.  $15\% \times 3/5$ ) earned interest (2%).

# INTERBANK “DEPOSIT” NETWORKS IN 1862 AND 1867



(a) 1862



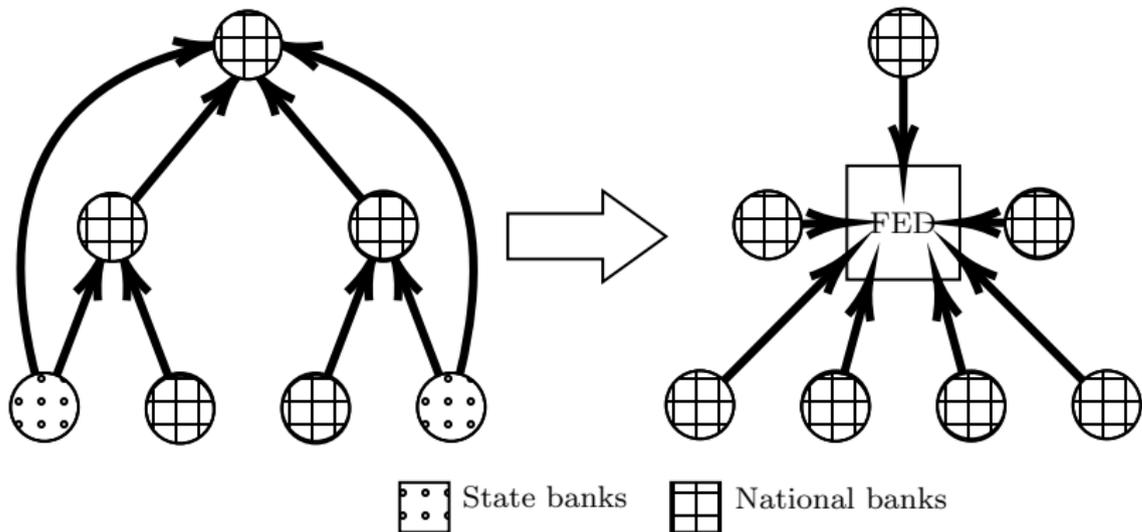
(b) 1867

●—NYC   ●—PHL   ●—PIT   ○—country banks  
|——| Log Size of Due-To Deposits

# FEDERAL RESERVE ACT (1913)

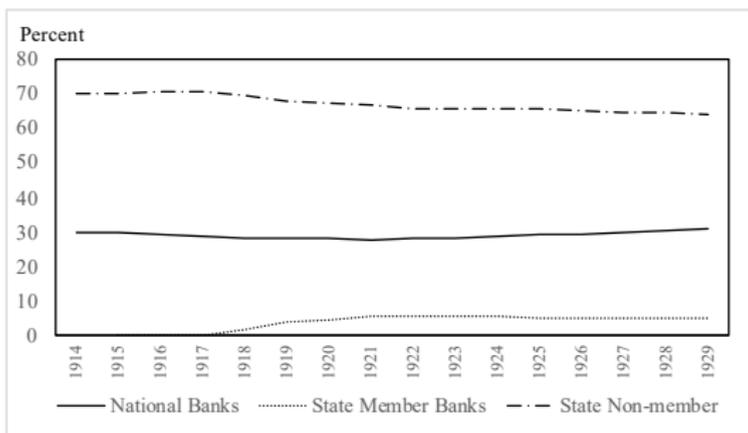
- ▶ The National Banking Era witnessed 5 major banking panics.
- ▶ The Fed was created to “*provide the nation with a safer, more flexible, and more stable monetary and financial system.*”
- ▶ How?
  1. Members allowed to access the discount window.
  2. Members not allowed to keep reserves as interbank deposits.
  3. Membership compulsory for national banks, voluntary for state banks.

# INTENDED CONSEQUENCE OF THE FED

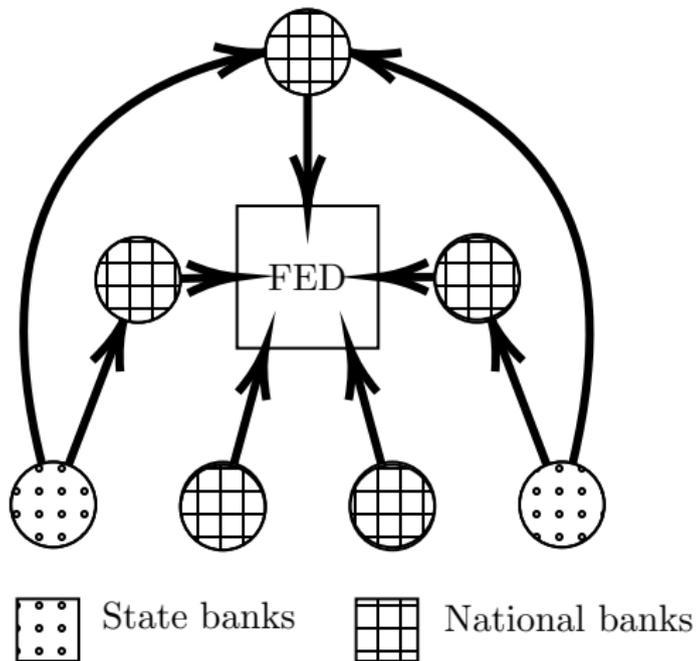


# FAILURE TO ATTRACT MEMBERS

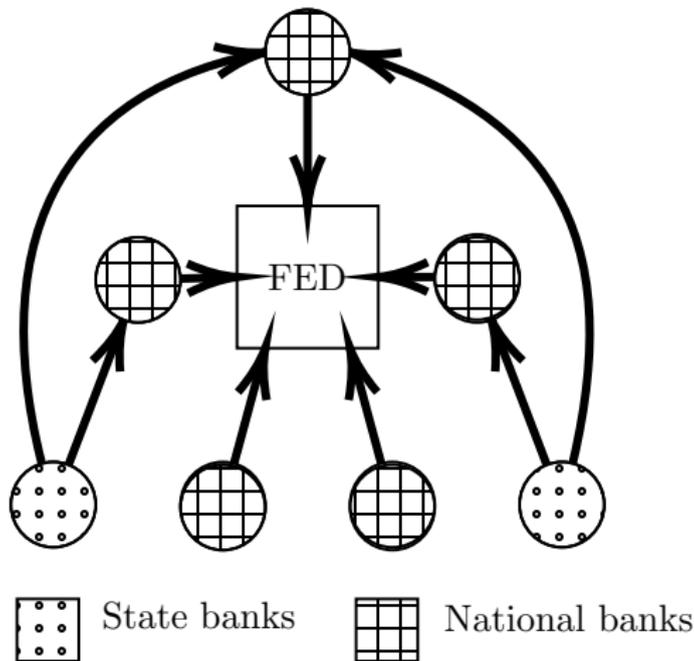
- ▶ Most state banks chose **NOT** to join:
  - ▶ Members subject to more restrictive regulations.
  - ▶ Members not allowed to hold interbank deposits to meet reserve requirements (so they lose 2% interest on those reserves).
  - ▶ Non-members could still access the Fed's discount window indirectly by borrowing from their member city correspondents.



# SUCCESS AT STABILIZING MEMBERS



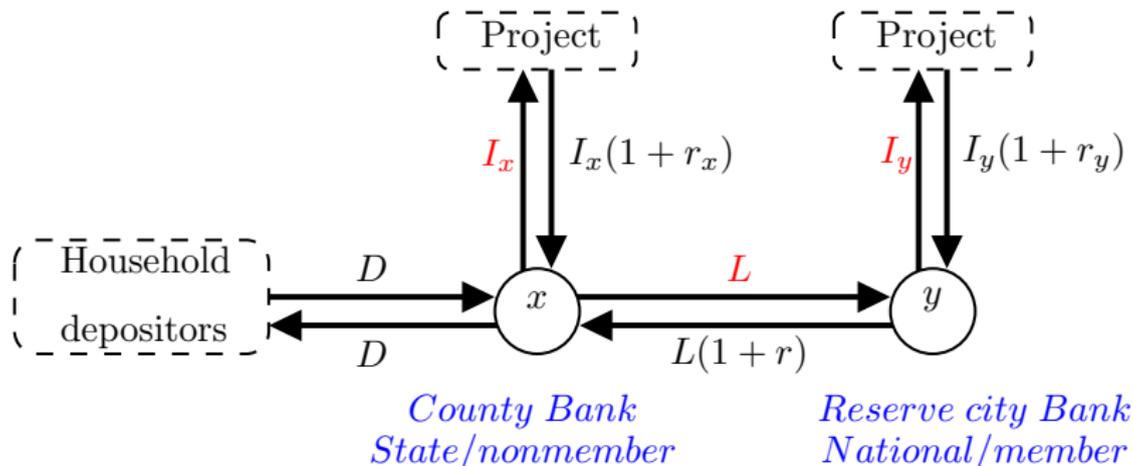
## SUCCESS AT STABILIZING MEMBERS



But, how did state/nonmembers change connections and portfolios?

# MODEL

# ENVIRONMENT



- ▶  $x$ 's cash reserves:  $\Phi_x = D - I_x - L$ .
- ▶  $y$ 's cash reserves:  $\Phi_y = L - I_y \geq \phi L$   
(subject to reserve requirements  $\phi$ .)

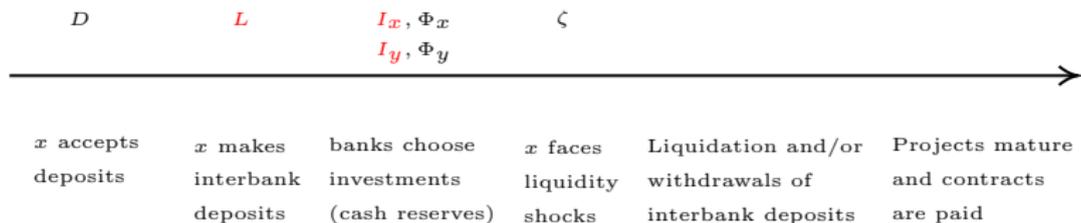
# SHOCKS AND TIMING

- ▶ Liquidity shock  $\zeta$  to  $x$ , after investments, before maturity.
  - ▶  $\zeta = 0$  with probability  $1 - \alpha$ ,
  - ▶  $\zeta \sim U[0, Z]$  with probability  $\alpha$ .
- ▶ Projects can be liquidated to cover  $\zeta$ .
  - ▶ Liquidation implies full investment recovery (**No DD bank-run**).
  - ▶ Liquidation cannot be partial (**Diversification motives**).

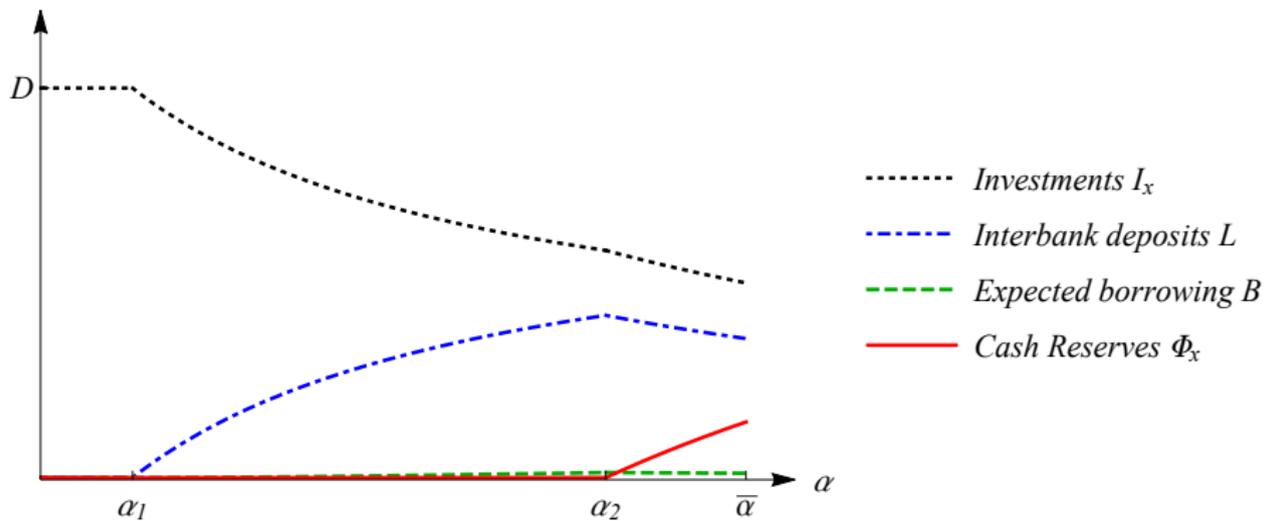
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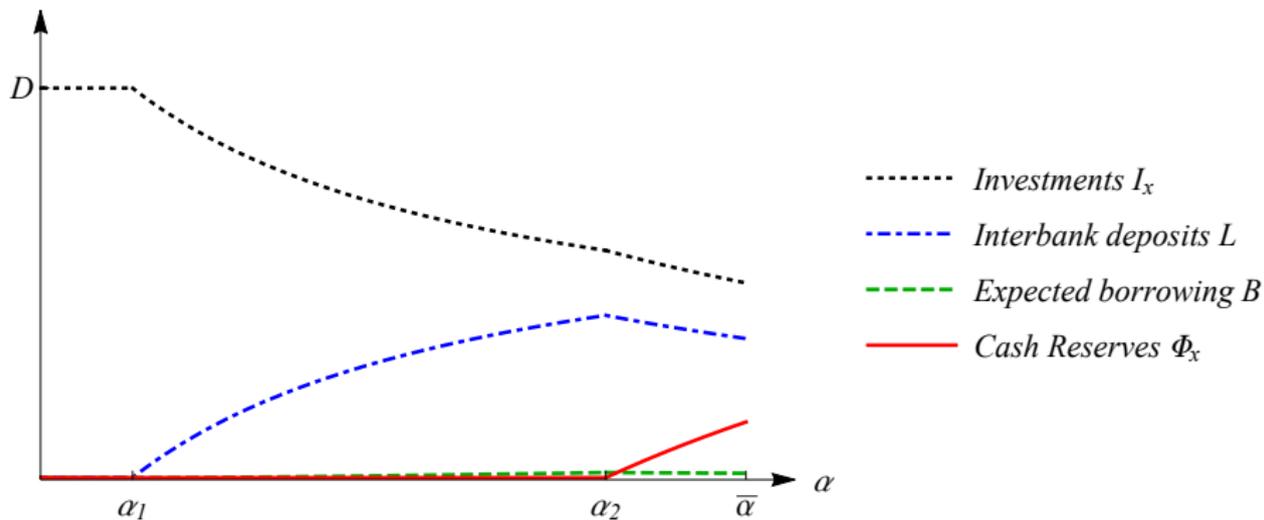
## Timeline



# OPTIMAL PORTFOLIO



# OPTIMAL PORTFOLIO

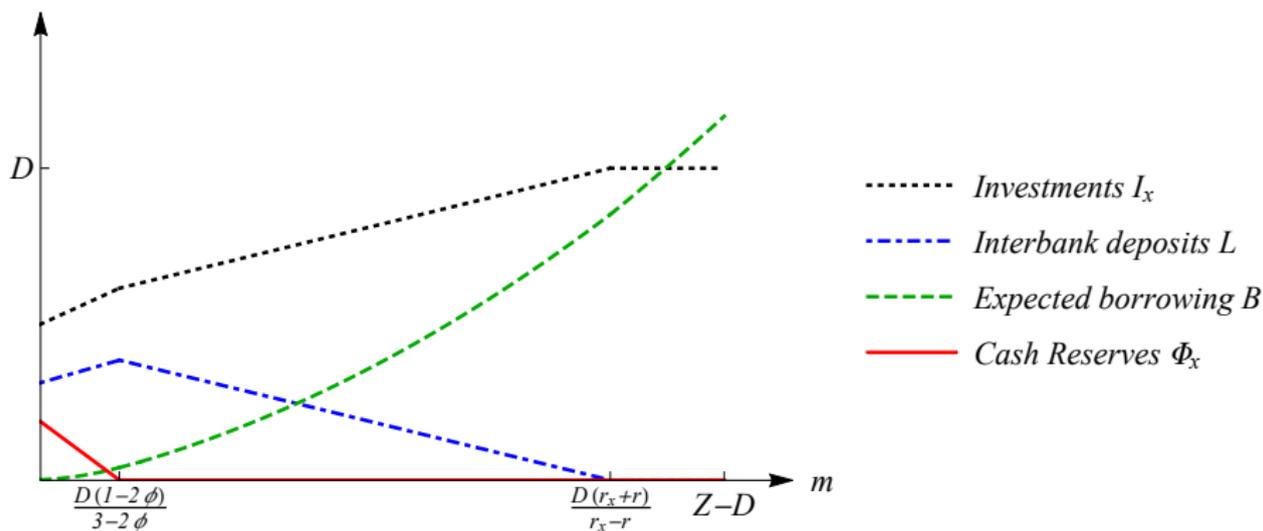


Add banks with heterogeneous link costs (s.t.,  $r - c_i$ ), links increase with  $\alpha$

# PUBLIC LIQUIDITY PROVISION

- ▶ Central bank (the Fed) provides  $m$  to  $y$  through a discount window.
- ▶  $x$  can borrow  $m$  from  $y$ , and  $y$  has no incentive to withhold  $m$  from  $x$ .
- ▶ Effectively,  $\zeta$  becomes  $\max\{0, \zeta - m\}$ .

# OPTIMAL PORTFOLIO WHEN $\alpha = \bar{\alpha}$



## ► Public liquidity provision

1. Increases shadow investment  $I_x$ .
2. Reduces shadow private liquidity holdings ( $\Phi_x + L$ ).
3. Increases shadow expected short-term borrowing ( $B$ ).

# FINANCIAL RISKS

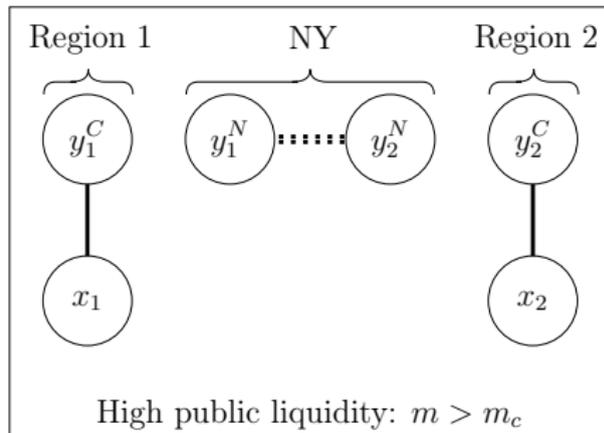
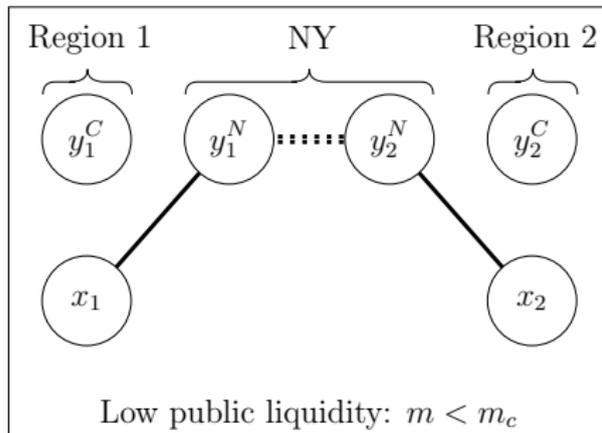
- ▶ Assume  $m$  is random, with  $m^* = \mathbb{E}[m]$ ... (previous results hold with  $m^*$ ).
- ▶ Risk category I: **What is liquidated**  
**Direct:**  $I_x$  liquidated. **Contagion:**  $I_y$  liquidated. **Systemic:** Both.
- ▶ Risk category II: **The need and use of public liquidity**  
**Fragility:** Probability of liquidation (given  $m$ ).  
**Vulnerability:** Probability of liquidation (in the counterfactual  $m = 0$ )
- ▶ As  $m^*$  increases:
  - ▶ All notions of fragility decrease.
  - ▶ Direct vulnerability increases **Shadow banks become “too big to fail”**.
  - ▶ Contagion and systemic vulnerability first increase and then decrease.

# NETWORKS

- ▶ Consider banks state/non-member banks  $x_1$  and  $x_2$  in different regions.
  - ▶  $x_1$  faces  $\zeta_1$ ,  $x_2$  faces  $\zeta_2$ .
  - ▶ Negatively correlated.
    - ▶  $\zeta_1 = 0$  and  $\zeta_2 \sim U[0, Z]$ , with probability  $\theta = \frac{\alpha}{2}$ .
    - ▶  $\zeta_1 \sim U[0, Z]$  and  $\zeta_2 = 0$ , with probability  $\theta = \frac{\alpha}{2}$ .
    - ▶  $\zeta_1$  and  $\zeta_2 = 0$ , with probability  $1 - 2\theta = 1 - \alpha$ .
- ⇒ no systemic risk
- ⇒ incentives of coinsurance
- ⇒ no competition for public liquidity
- 
- ▶ If pairs are isolated, same analysis with a lower shock probability.

## ENDOGENOUS NETWORK

- ▶ Now assume  $x_i$  can either connect to a NY correspondent or connect to a correspondent in the closer reserve city.
- ▶ If both connect to NY, NY correspondents provide liquidity coinsurance. But connecting to NY has a cost of geographical distance.



Public liquidity provision crowds out private cross-regional insurance

## MODEL: SUMMARY

Three effects of increasing public liquidity provision,  $m$ .

1. *Less self insurance.*

Less cash and deposit buffers, more loans.

2. *Less interbank insurance.*

Replacement of diversification with short-term borrowing.

3. *Less cross-regional insurance.*

Regional concentration and dissipated core.

**Now we show that these changes were observed in the data!**

# EMPIRICAL EVIDENCE

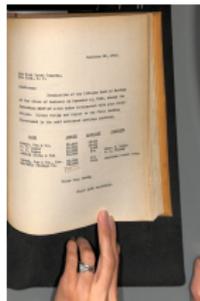
# BANK LEVEL DATA

- ▶ Virginia State Bank Examination Reports for 1911 and 1922
  - ▶ Balance sheets along with detailed information on interbank deposit and short-term borrowing networks.

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Interbank Deposits    Short-term Borrowing    Collateral for Borrowing

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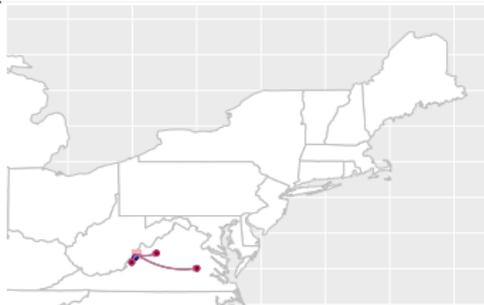
# EXAMPLE: BANK OF WARM SPRINGS

Bank of Warm Springs in Warm Springs

1911



1922



Correspondents	Town	State	Duefrom	Borrowed Money
Chase National Bank	New York	NY	809.28	10000
National Exchange Bank	Baltimore	MD	2459.28	5000
Covington National Bank	Covington	VA	509.07	5000
Bath County National Bank	Hot Springs	VA	237.61	

Correspondents	Town	State	Duefrom	Borrowed Money
Covington National Bank	Covington	VA	2562.25	21500
Bath County National Bank	Hot Springs	VA	1376.53	
Merchants National Bank	Richmond	VA	2129.64	25000
National Valley Bank	Staunton	VA	1091.03	15000

# SUMMARIZING OUR DATA

	Banks	Respondent	Total Links	Mean
Panel A: All Banks				
Year 1911				
Due-from	200	200	933	4.7
Borrowing	200	59	87	1.5
Year 1922				
Due-from	315	315	1025	3.3
Borrowing	315	160	252	1.6
Panel B: Banks both in 1911 and 1922				
Year 1911				
Due-from	146	146	635	4.3
Borrowing	146	37	55	1.5
Year 1922				
Due-from	146	146	581	4.0
Borrowing	146	82	133	1.6

**Borrow more and deposit in less counterparties.**

# I. BALANCE SHEET BEFORE AND AFTER THE FED

	1911	1922	Difference
Cash to assets	0.048	0.032	-0.016***
	(0.029)	(0.034)	(0.004)
Duefroms to assets	0.129	0.077	-0.052***
	(0.077)	(0.0509)	(0.007)
Equity to liabilities	0.243	0.191	-0.052***
	(0.088)	(0.077)	(0.009)
Deposits to liabilities	0.704	0.736	0.032**
	(0.133)	(0.132)	(0.016)
Duetos to liabilities	0.017	0.014	-0.004
	(0.083)	(0.070)	(0.009)
Borrowing to liabilities	0.033	0.056	0.022**
	(0.062)	(0.078)	(0.008)
Obs.	146	146	146

## II. EFFECT OF BORROWING ON BALANCE SHEETS

	none	1911 and 1922	1911 only	1922 only	Difference		
	(1)	(2)	(3)	(4)	(2) - (1)	(3) - (1)	(4) - (1)
Cash to assets	0.045	0.025	0.029	0.025	-0.019**	-0.016	-0.020**
	(0.055)	(0.014)	(0.012)	(0.011)	(0.007)	(0.010)	(0.007)
Duefroms to assets	0.101	0.077	0.084	0.053	-0.024*	-0.017	-0.048**
	(0.053)	(0.049)	(0.048)	(0.039)	(0.011)	(0.014)	(0.010)
Loans to assets	0.695	0.806	0.760	0.787	0.110***	0.065	0.092***
	(0.161)	(0.107)	(0.082)	(0.135)	(0.030)	(0.040)	(0.027)
Equity to liabilities	0.184	0.191	0.195	0.195	0.007	0.011	0.011
	(0.064)	(0.107)	(0.072)	(0.068)	(0.017)	(0.023)	(0.016)
Deposits to liabilities	0.802	0.683	0.798	0.692	-0.119***	-0.004	-0.111***
	(0.065)	(0.156)	(0.073)	(0.142)	(0.027)	(0.036)	(0.024)
Duetos to liabilities	0.025	0.002	0.029	0.006	-0.023	0.005	-0.018
	(0.108)	(0.004)	(0.102)	(0.017)	(0.016)	(0.021)	(0.014)
Borrowing to liabilities	0	0.110	0	0.088	0.110***	0.000	0.088***
	(0)	(0.087)	(0)	(0.066)	(0.013)	(0.017)	(0.011)
Obs.	47	35	15	49			

## II. EFFECT OF BORROWING ON BALANCE SHEETS

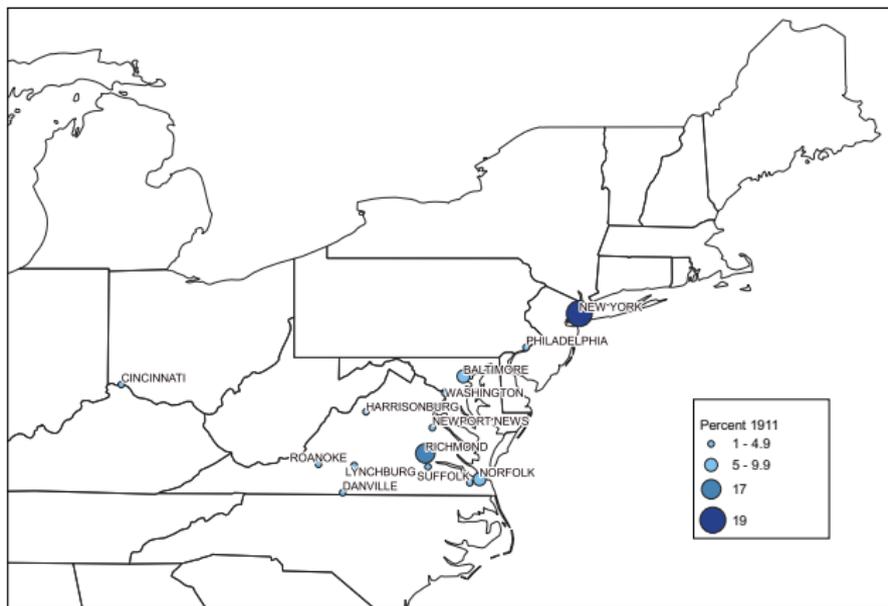
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	(1)	(2)	(3)	(4)	(2) - (1)	(3) - (1)	(4) - (1)
Cash to assets	0.045 (0.055)	0.025 (0.014)	0.029 (0.012)	0.025 (0.011)	-0.019** (0.007)	-0.016 (0.010)	-0.020** (0.007)
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Duetos to liabilities	0.025 (0.108)	0.002 (0.004)	0.029 (0.102)	0.006 (0.017)	-0.023 (0.016)	0.005 (0.021)	-0.018 (0.014)
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### III. EXPOSURE TO THE LARGEST COUNTERPARTY

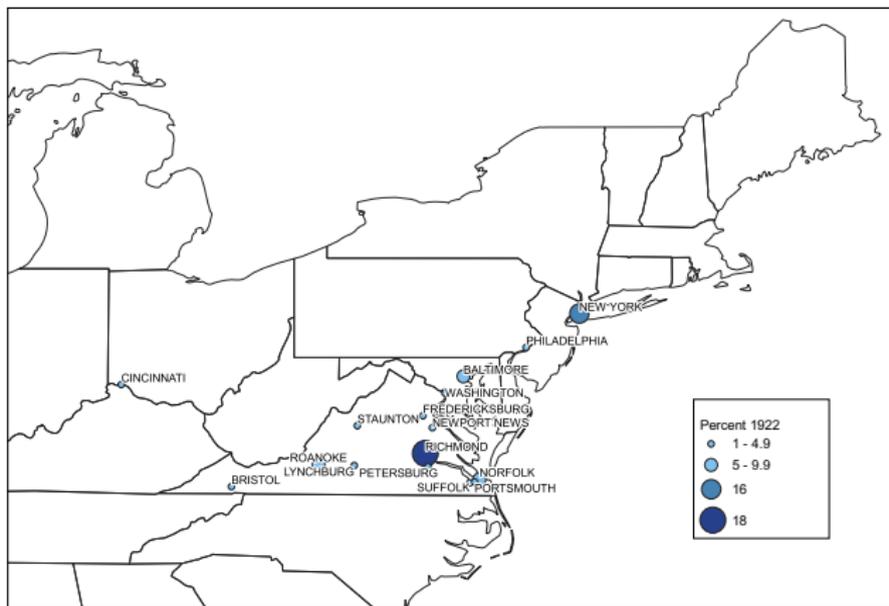
Duefrom in largest counterparty	Existing - Across years			Across banks		
	1911	1922	Difference	Existing	New	Difference
to total duefroms	0.663 (0.232)	0.655 (0.217)	-0.007 (0.026)	0.655 (0.217)	0.776 (0.208)	0.121*** (0.024)
to total assets	0.084 (0.062)	0.050 (0.036)	-0.034*** (0.006)	0.050 (0.036)	0.078 (0.069)	0.028*** (0.007)
Respondent Bank	146	146		146	169	
Correspondent Bank	65	56		56	74	
Obs.	146	146		146	169	

**New banks' interbank deposits more concentrated in main counterparty.**

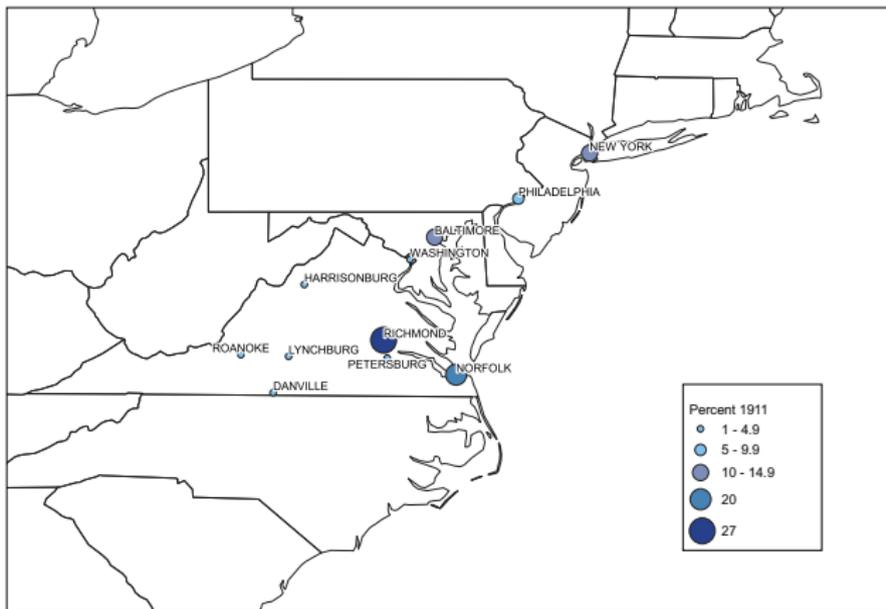
## IV. PAYMENT NETWORK: EXTENSIVE 1911



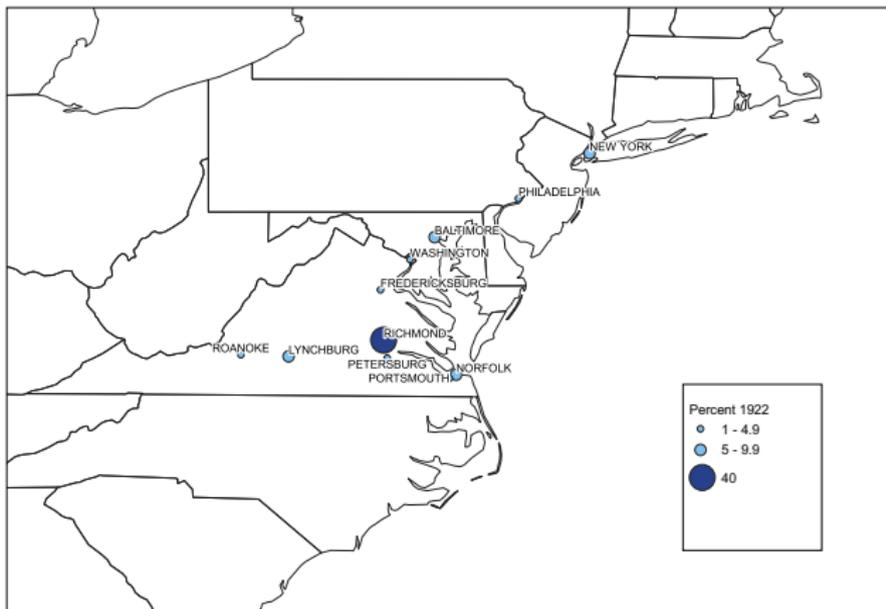
## IV. PAYMENT NETWORK: EXTENSIVE 1922



## IV. PAYMENT NETWORK: INTENSIVE 1911



## IV. PAYMENT NETWORK: INTENSIVE 1922

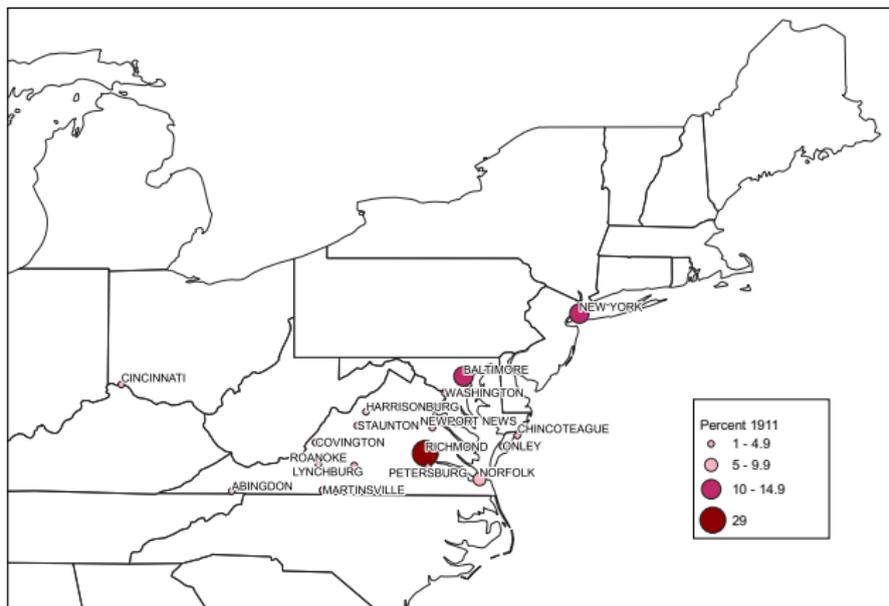


## IV. PAYMENT NETWORK: LOCATIONS

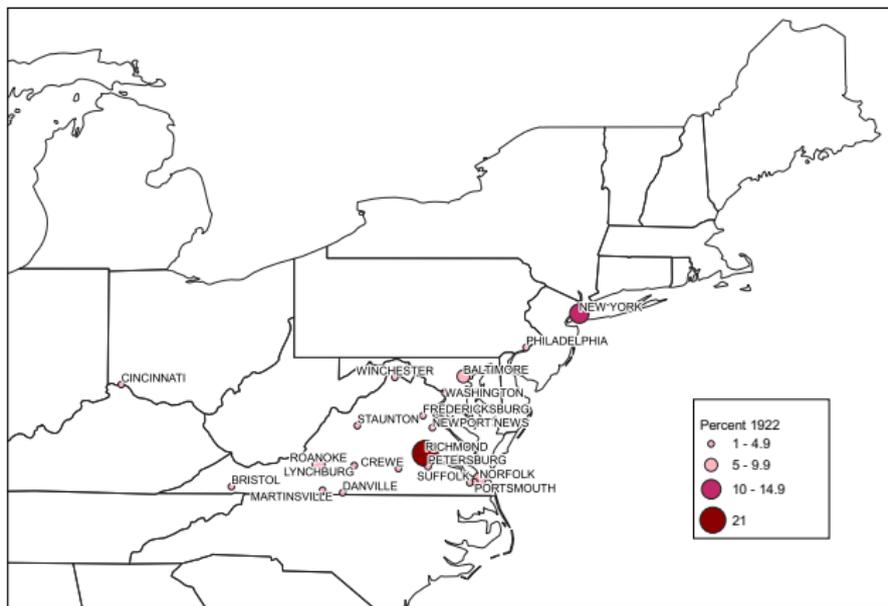
	Extensive Margin (Links)			Intensive Margin (Amount)		
	1911	1922	Difference	1911	1922	Difference
New York City	0.195 (0.184)	0.127 (0.167)	-0.068*** (0.016)	0.108 (0.163)	0.069 (0.140)	-0.038*** (0.014)
Baltimore	0.094 (0.180)	0.069 (0.166)	-0.025 (0.016)	0.110 (0.242)	0.0704 (0.198)	-0.04** (0.020)
Washington, DC	0.022 (0.0786)	0.017 (0.099)	-0.005 (0.008)	0.018 (0.075)	0.016 (0.108)	-0.002 (0.009)
Richmond	0.212 (0.200)	0.223 (0.277)	0.011 (0.022)	0.289 (0.326)	0.272 (0.346)	-0.017 (0.030)
Reserve Cities in Other States	0.024 (0.072)	0.034 (0.136)	0.010 (0.011)	0.026 (0.085)	0.040 (0.168)	0.015 (0.013)
Country Banks in VA	0.423 (0.279)	0.500 (0.345)	0.077** (0.029)	0.408 (0.368)	0.511 (0.406)	0.104*** (0.036)
Country Banks in Other States	0.027 (0.109)	0.028 (0.104)	0.001 (0.009)	0.031 (0.145)	0.017 (0.095)	-0.014 (0.011)
Obs.	200	315		200	315	

**These patterns were driven by entrants, not incumbents**

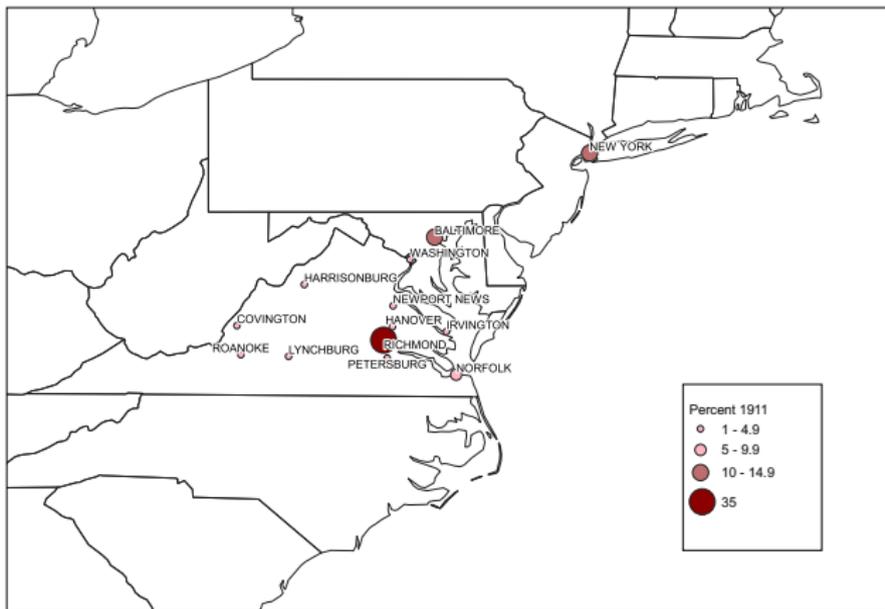
## IV. FUNDING NETWORK: EXTENSIVE 1911



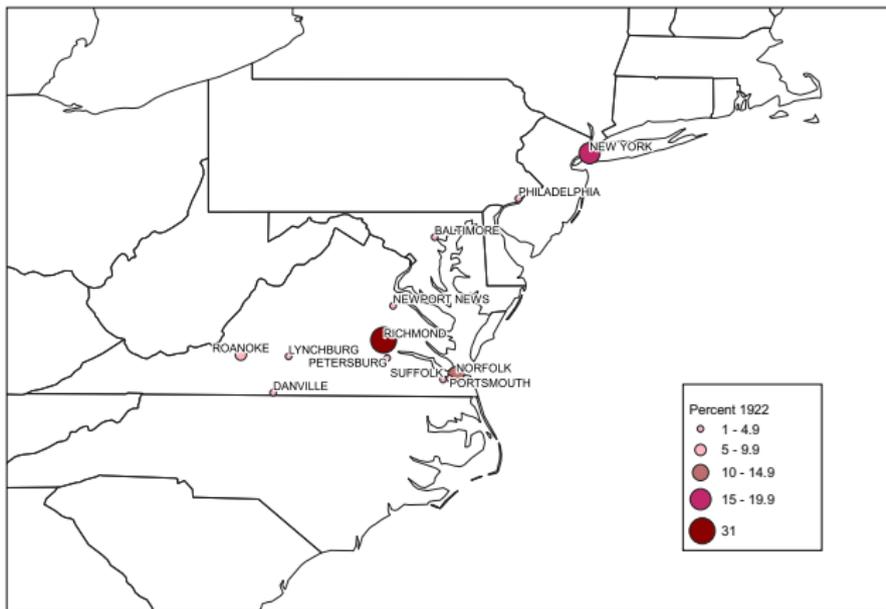
## IV. FUNDING NETWORK: EXTENSIVE 1922



## IV. FUNDING NETWORK: INTENSIVE 1911



## IV. FUNDING NETWORK: INTENSIVE 1922



## IV. FUNDING NETWORK: LOCATIONS

	Extensive Margin (Links)			Intensive Margin (Amount)		
	1911	1922	Difference	1911	1922	Difference
New York City	0.083 (0.225)	0.088 (0.225)	0.005 (0.032)	0.075 (0.216)	0.085 (0.227)	0.011 (0.030)
Baltimore	0.128 (0.303)	0.074 (0.235)	-0.054 (0.036)	0.132 (0.312)	0.071 (0.234)	-0.062* (0.036)
Washington, DC	0.020 (0.122)	0.017 (0.118)	-0.003 (0.017)	0.019 (0.119)	0.016 (0.117)	-0.003 (0.016)
<b>Richmond</b>	<b>0.363</b> (0.428)	<b>0.213</b> (0.351)	<b>-0.151***</b> (0.052)	<b>0.367</b> (0.438)	<b>0.211</b> (0.355)	<b>-0.156***</b> (0.052)
Reserve Cities in Other States	0.030 (0.137)	0.042 (0.177)	0.013 (0.023)	0.029 (0.137)	0.042 (0.175)	0.014 (0.022)
<b>Country Banks in VA</b>	<b>0.341</b> (0.422)	<b>0.536</b> (0.436)	<b>0.195***</b> (0.060)	<b>0.320</b> (0.419)	<b>0.505</b> (0.446)	<b>0.185***</b> (0.060)
Country Banks in Other States	0.034 (0.146)	0.031 (0.150)	-0.004 (0.021)	0.019 (0.116)	0.029 (0.147)	0.009 (0.019)
Obs.	59	160		59	160	

**These patterns were driven by entrants, not incumbents**

## IV. AVERAGE DISTANCE TO CORRESPONDENTS

	Payment Network			Funding Network		
	1911	1922	Difference	1911	1922	Difference
Longest Distance	293.5 (151.2)	213.9 (422.6)	-79.68** (31.08)	144.0 (146.1)	162.9 (573.9)	18.98 (75.7)
Mean Distance	131.6 (74.02)	114.7 (405.1)	-16.91 (28.95)	101.4 (101.3)	130.4 (568.5)	29.01 (74.55)
Total Distance	638.2 (686.1)	366.9 (556.8)	-271.31*** (55.17)	247.1 (292.2)	219.8 (597.3)	-27.29 (81.21)
Obs.	200	315		59	160	

# CONCLUSION

- ▶ The Fed was introduced to stabilize the financial system.
- ▶ While (arguably) successful in reducing volatility, it also created the first U.S. shadow banking system.
- ▶ This newly emerged shadow banking system was characterized by three elements usually correlated with systemic risk (and tail events!).
  1. Less aggregate private liquidity.  
→ insufficient private backstops to shocks.
  2. More reliance on short-term borrowing.  
→ dependence on the Fed's liquidity provision and new contagion challenges.
  3. More regionally concentrated networks.  
→ weakened cross-regional private interbank insurance.
- ▶ Moral of the paper: Stabilizing members with more public liquidity may make nonmembers larger, more reliant on others and more vulnerable!

# SUPPORTING SLIDES

# MODEL

( Project )      ( Project )



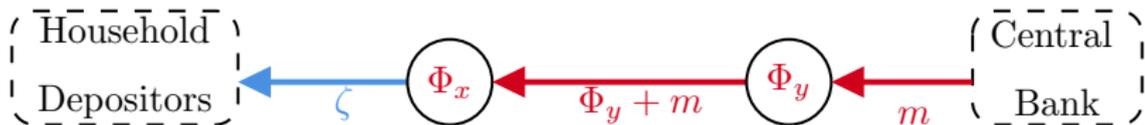
$x$  can use vault cash  $\Phi_x$ .

# MODEL



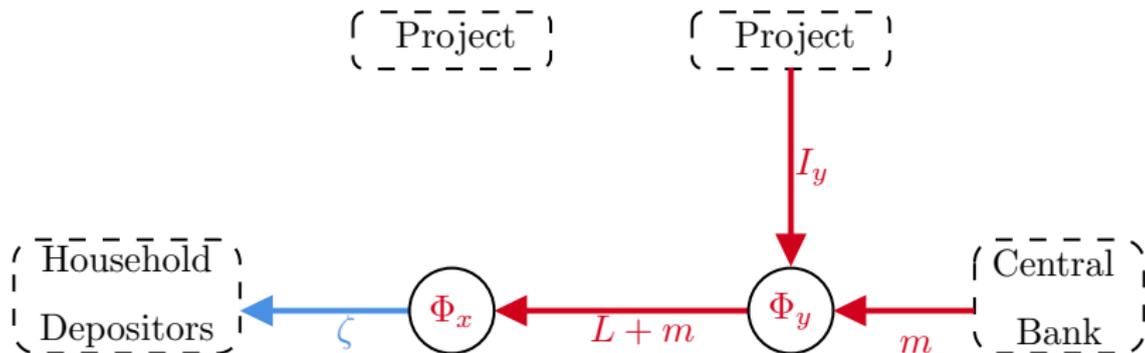
$x$  can use vault cash  $\Phi_x$ . If not sufficient, borrow short-term from  $y$ , at most  $\Phi_y$ .

# MODEL



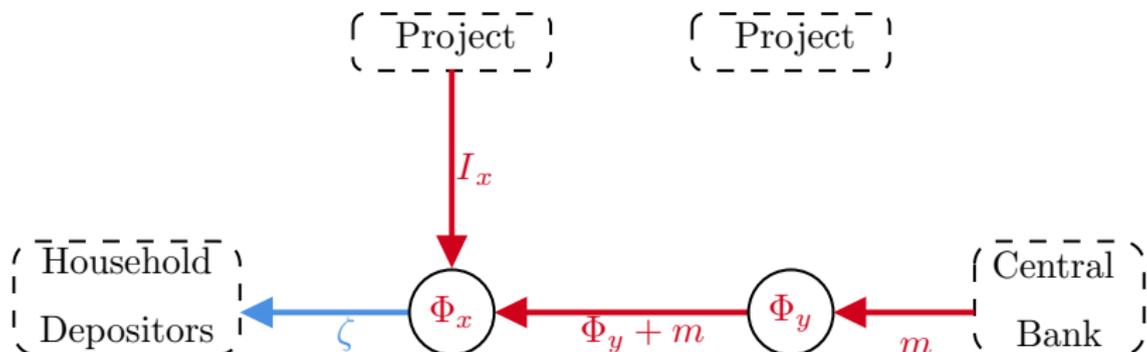
$x$  can use vault cash  $\Phi_x$ . If not sufficient, borrow short-term from  $y$ , at most  $\Phi_y$ . If not sufficient,  $y$  borrows short-term from the central bank, at most  $m$ . Then  $x$  borrows short-term from  $y$ .

# MODEL



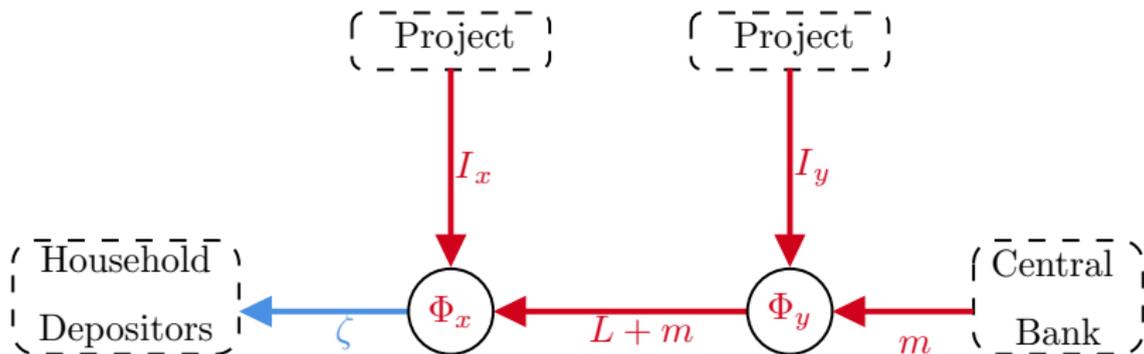
$x$  can use vault cash  $\Phi_x$ . If not sufficient, borrow short-term from  $y$ , at most  $\Phi_y$ . If not sufficient,  $y$  borrows short-term from the central bank, at most  $m$ . Then  $x$  borrows short-term from  $y$ . **If not sufficient, withdraw interbank deposits from from  $y$ , which makes  $y$  liquidate project.**

# MODEL



$x$  can use vault cash  $\Phi_x$ . If not sufficient, borrow short-term from  $y$ , at most  $\Phi_y$ . If not sufficient,  $y$  borrows short-term from the central bank, at most  $m$ . Then  $x$  borrows short-term from  $y$ . If not sufficient, withdraw interbank deposits from from  $y$ , which makes  $y$  liquidate project, or liquidate own project.

# MODEL



$x$  can use vault cash  $\Phi_x$ . If not sufficient, borrow short-term from  $y$ , at most  $\Phi_y$ . If not sufficient,  $y$  borrows short-term from the central bank, at most  $m$ . Then  $x$  borrows short-term from  $y$ . If not sufficient, withdraw interbank deposits from from  $y$ , which makes  $y$  liquidate project, or liquidate own project. **If neither suffice, do both.**