Bank Networks and Systemic Risk:

Micro-evidence before and after the National Banking Acts of 1863-1864

Mark Paddrik[1] Haelim Park[1] Jessie Jiaxu Wang[2]

[1]Office of Financial Research, U.S. Treasury

[2]W. P. Carey School of Business, Arizona State University

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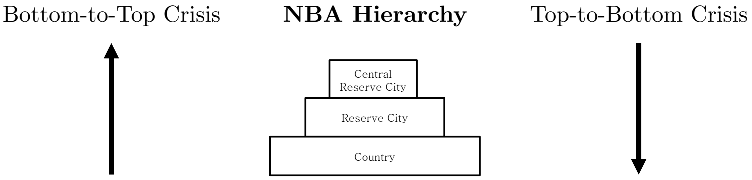
Motivation

- The financial system is becoming more and more interconnected.
  - Systemically Important Financial Institutions
  - Credit Default Swaps
- The interconnectedness of financial institutions is considered as a threat to financial stability.
- The lack of micro-level linkage data makes it difficult to evaluate how the structure of financial networks affect systemic risk.

Research Questions and Answers

- How does network structure impact financial stability?
  - We look at the National Banking Acts of 1863-1864 which instituted a reserve requirements system.
  - How did the structure of bank networks affect the occurrence of systemic crises?



- Preliminary Answers
  - An decrease in the vulnerability of top-to-bottom shocks during economic expansion, but an increase during economic recessions.
  - An increase in the vulnerability of bottom-to-top shocks generally.

This paper

1. Constructing a new dataset showing bank networks through interbank deposits.
2. Providing quantitative analysis showing how bank networks affected systemic liquidity crises (Allen and Gale 2000 JPE, Eisenberg, Noe 2001 MS, Acemoglu, Ozdaglar, Tahbaz-Salehi 2015 AER).
3. Showing how bank networks transmitted financial shocks through contagion.

Contributions

1. Exogenous financial networks and systemic risk
   - vs. Eisenberg, Noe 2001 MS; Acemoglu, Ozdaglar, Tahbaz-Salehi 2015 AER; Elliott, Golub, Jackson, 2014 AER
   - These papers provide theoretical framework.

2. Discussion on systemic risk during National Banking Era
   - vs. Calomiris, Gorton 1991; Sprague 1910; Kemmerer 1910; Bernstein, Hughson, Weidenmier 2010 JFE; Mankiw, Miron, Weil 1987 AER; Miron 1986 AER; Gorton, Tallman 2014; Wicker 2000
   - These papers debate whether the structure of bank networks caused the bottom-top vs. top-bottom crises.

Outline

1. Background
2. Data and empirical findings
3. Model
4. Quantitative analysis on systemic risk
5. Conclusion

National Banking Acts of 1863 - 1864

- Reason: financing the Civil War, create federally chartered banks, uniform currency
- Create a set of regulations
  - reserve requirements via a tiered system
  - capital requirements, lending limits, prohibiting mortgage loans
  - federal banknote backed by government bonds
  - annual examinations for national banks
- However, federal charters were not popular, so the revision (1864) raised taxes on state bank notes 2%→10% ⇒ most converted

The Tiered Correspondent Banking System

- Before NBA: (Weber 2003, JME)
  - interbank liability network: correspondent/notes redeeming
  - shaped by trade patterns: customer base, transportation
  - core-periphery structure
- After NBA: pyramid reserve requirements

Tier	Banks	Location	Reserve ratio	Deposit in up-tiers	Cash in vault
1	Central reserve city	NYC	25%	0	1
2	Reserve city	Phila, Pitt	25%	1/2	1/2
3	Country banks	others	15%	3/5	2/5

- Reshape the interbank network: correspondent/notes redeeming + satisfying reserve requirements

Data Type & Sources

Construct bank networks for 1862 (pre) and 1867 (post) using:

1. *Bank Balance Sheets*
2. *Inter-Bank Deposits*

Sources:

1. *Reports of the Several Banks and Savings Institutions of Pennsylvania*
   - State banks: balance sheet, list of correspondents (1862, 1867)
2. *PA Bank Examiner's Reports at the National Archives*
   - National banks: balance sheets and reserve agents (1867)
   - regulatory data from annual bank examinations

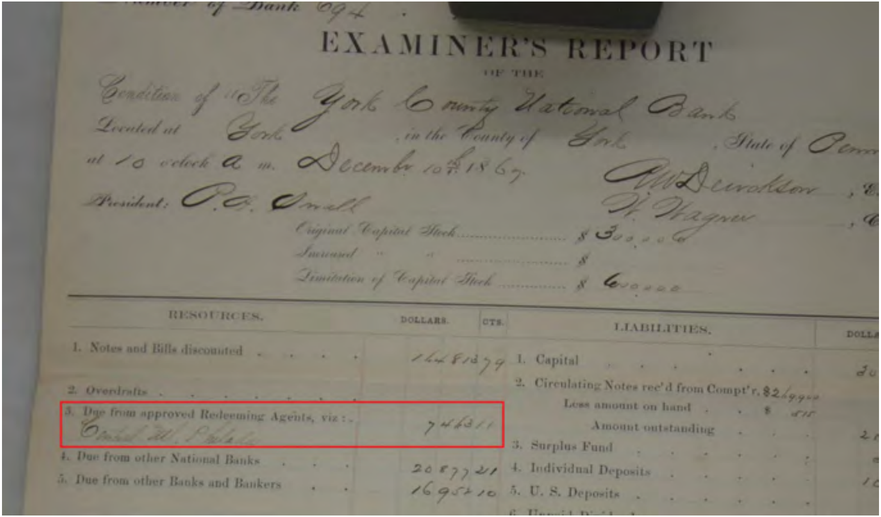
Data Sources: York County Bank (State)

Due-to for York County Bank in 1862

Bank of Chambersburg	$1,306 03
Bank of Gettysburg	3,136 53
Bank of Commerce, New York	687 98
Bank of Northern Liberties	622 14
Carlisle Deposit Bank	2,067 94
Exchange Bank, Pittsburg	637 09
Franklin Bank, Baltimore	6,725 03
Girard Bank	680 17
Hanover Savings Fund Society	667 19
Jay Cooke & Co	1,860 60
Lancaster County Bank	72 94
Mechanics' Bank, Harrisburg	2,242 00
Shrewsbury Savings Institution	253 24
Western Bank, Philadelphia	4,320 18
Western Bank, Baltimore	4,695 69
York Bank	6,913 85
	36,888 60

Data Sources: York National County Bank

Due-from approved agent Central bank of Philadelphia $7463.11 in 1867



EXAMINER'S REPORT

OF THE

Condition of "The York County National Bank

Located at York, in the County of York, State of Penn

at 10 o'clock a. m. December 10th 1867.

President:

Original Capital Stock .... $ 300,000

Increased " " .... $

Limitation of Capital Stock .... $ 600,000

RESOURCES. DOLLARS. CTS.

1. Notes and Bills discounted 164813 79

2. Overdrafts . . . .

3. Due from approved Redeeming Agents, viz: Central N. Phila 7463 11

4. Due from other National Banks . . . 20877 21

5. Due from other Banks and Bankers . . 16952 10

LIABILITIES. DOLLA

1. Capital . . . .

2. Circulating Notes rec'd from Compt'r. $269,9

Less amount on hand . . $ 815

Amount outstanding . . . .

3. Surplus Fund . . . . . .

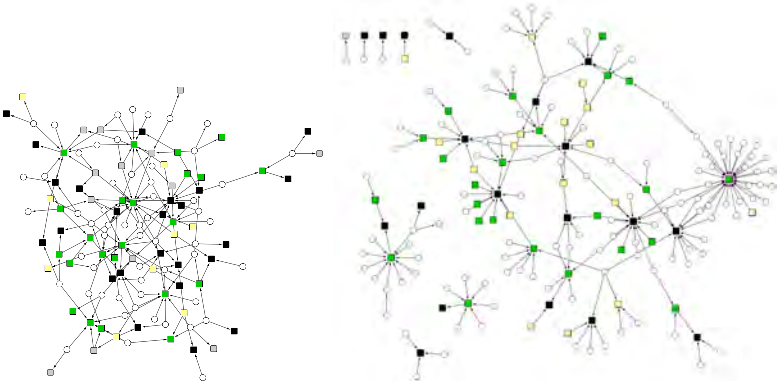
4. Individual Deposits . . . . .

5. U. S. Deposits . . . . . .

Descriptive Balance Sheet Statistics

Against Total Major Interbank Deposits			
	Philadelphia	**Pittsburgh**	**Country Banks**
Year = 1862	Mean	Mean	Mean
New York City	0.339	0.682	0.258
Philadelphia	0.076	0.213	0.541
Pittsburgh	0.003	0.001	0.017
Other PA	0.237	0.049	0.125
Other U.S.	0.345	0.054	0.058
Year = 1867	Mean	Mean	Mean
New York City	1.000	0.757	0.300
Philadelphia	-	0.155	0.526
Pittsburgh	-	0.087	0.106
Other PA	-	-	0.035
Other U.S.	-	-	0.034

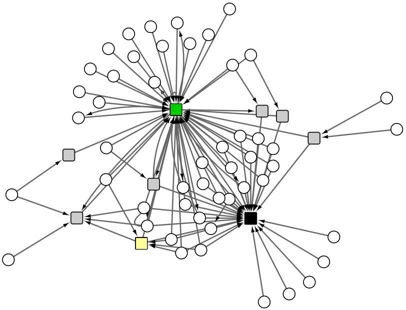
Empirical Correspondent Networks: Banks



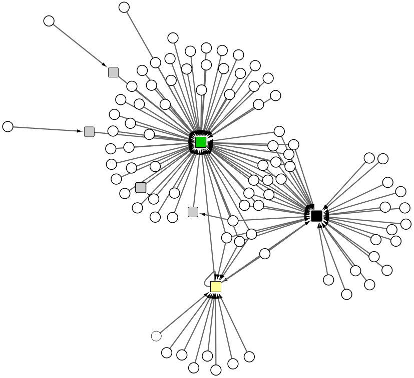
(a) 1862 (b) 1867

NYC PHI PIT local hubs country banks

Empirical Correspondent Networks: City



(c) 1862



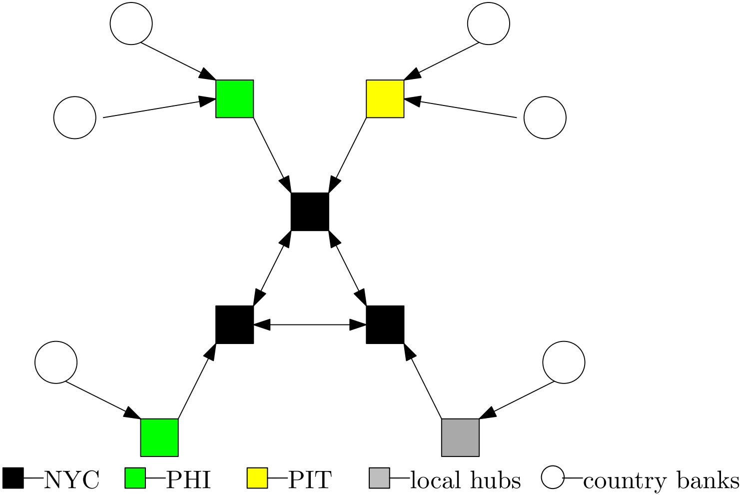
(d) 1867

Summary of Network Patterns

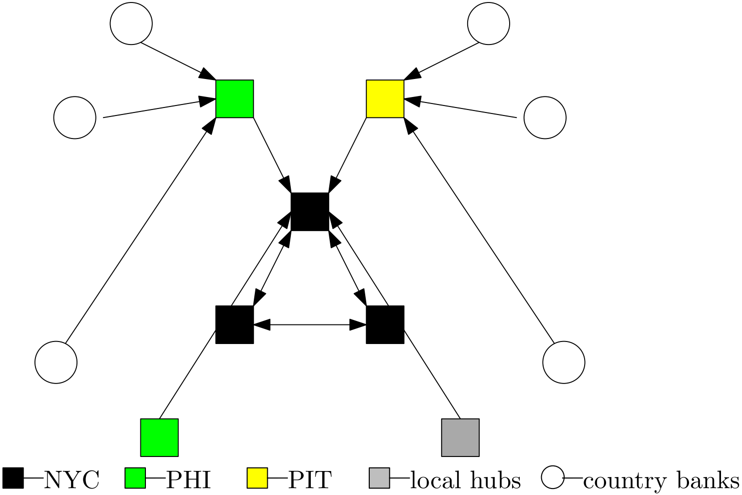
	Bank		City	
Type Bank	1862	1867	1862	1867
	Betweenness Centrality			
New York	0.0264	**0.0365**	0.2864	**0.3572**
Philadelphia	0.0498	**0.0245**	0.7302	**0.7950**
Pittsburgh	0.0350	**0.0278**	0.0091	**0.1702**
Country	0.0212	**0.0131**	0.0033	**0.0007**

- Before NBA, PA was a financially mature state
  - local hubs severed as money markets, e.g. Harrisburg banks
- After NBA
  - number of correspondent banks (hubs) shrank
  - bank chain became shorter
  - a more concentrated 3-tier structure emerged

Correspondent Networks before NBA: stylized



Correspondent Networks after NBA: stylized



Model: setup

- Single good, 3-date, no discounting, n risk neutral banks, $i = \{1, 2, ..., n\}$.
- At $t = 0$, bank i has capital k_i, deposit d_i; invests in cash c_i, loans, and interbank deposit
- Return on loan
  - $t = 1$: random return e_i
  - $t = 2$: a fixed non-pledgeable long-term return A / liquidated for ξA at $t = 1$, $\xi < 1$.
- Interbank deposit
  - l_{ij}: bank i deposits to j, $l_{ij} \geq 0, l_{ii} = 0$
  - bank network: weighted, directed graph $L = [l_{ij}]$.

Model: bank's balance sheet at $t = 1$

- Bank i's balance sheet

Asset	**Liability**
Cash c_i	Capital k_i
Loans $e_i + \xi A$	Deposit d_i
Due-froms $\sum_{j \neq i} l_{ij}$	Due-tos $\sum_{j \neq i} l_{ji}$

- Bank i's total liability $d_i + \sum_{j \neq i} l_{ji}$

- Whether bank i is able to pay depends on cash buffer, loan returns, and the value of due-froms (Eisenberg, Noe 2001 MS; Acemoglu, Ozdaglar, Tahbaz-Salehi 2015 AER).

Model: payment system at $t = 1$, $s \xrightarrow{x_{is}} i \xrightarrow{x_{ji}} j$

- Let x_{is} be the repayment by bank s to bank i, $x_{is} \in [0, l_{is}]$.

- Total cash flow of bank i with no liquidation:

$$h_i = c_i + i_i(1 + e_i) + \sum_{s \neq i} x_{is} - \mathbb{I}_i^l \xi_l i_i.$$

1. If $h_i \geq d_i + \sum_{k \neq i} l_{ki} \Rightarrow$ no liquidation $\mathbb{I}_i^l$=0
2. Otherwise, liquidate $\mathbb{I}_i^l$=1
   - if $h_i < d_i + \sum_{k \neq i} l_{ki}$ default on depositors, $x_{ji} = 0$
   - if $h_i \in [d_i, d_i + \sum_{k \neq i} l_{ki}]$,

$$x_{ji} = \frac{l_{ji}}{d_i + \sum_{k \neq i} l_{ki}} \left[\min \left\{ d_i + \sum_{k \neq i} l_{ki}, h_i \right\} \right]^+$$

Quantitative Analysis: measurement

- We obtain parameters (c, k, d, e, L) from the data
  1. (c, k, d, L) from bank balance sheet
  2. e from different scenarios of banking crises
- Shocks: two types of liquidity crises
  1. from NYC banks to outside NYC banks
  2. from country banks to reserve city banks
- Measures:

Systemic Risk	
1. Joint Probability of Liquidation	2. Joint Probability of Default
Contagion Risk	
3. Expected Percent of Bank Liquidations	4. Expected Percent of Bank Defaults
Expect Dollar Cost	
5. Expected Value of Liquidation Costs	6. Expected Value of Default Cost

Quantitative Analysis: top-to-bottom crises

"It was the suspension of cash payments and not bank runs nor bank failures through which the public in the rest of the country experienced the effects of banking panics." (Wicker, 2000)

- 4 out of 5 major banking panics began in NYC and spread to the rest of the country.
  - 1873: failure of Jay Cooke
  - 1884: failure of Grant and Ward
  - 1890: failure of Decker Howell and Co.
  - 1907: failure of knickerbocker trust

Quantitative Analysis: top-to-bottom crises - summary

- **Setup**: We do have general economic conditions we test over
  - Good Times: L return of $\bar{e} = 0\%$, $\sigma_e = 5\%$ for all banks
  - Bad Times: L return of $\bar{e} = 0\%$, $\sigma_e = 20\%$ for all banks
- **Shock**: increase σ_e for all NYC banks
- **Results**: After the NBA, systemic risk coming from NYC Banks
  - decreased when earnings and volatility of the economy was good
  - increased when earnings and volatility of the economy was bad

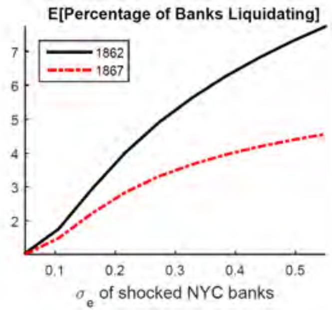
Quantitative Analysis: bottom-to-top crises

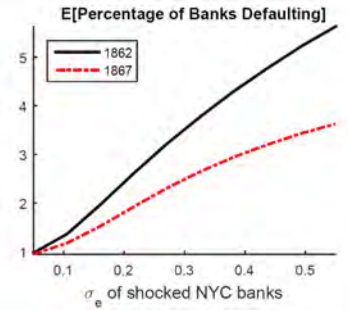
"A withdrawal of reserves by the bottom of the pyramid during a panic could thus result in a rapid depletion of reserves within the banking system." *(Bankers' Magazine 1907 July)*

- Due to agricultural cycles, country banks experience liquidity shortages in the spring and fall every year.
- 1893: bank suspensions occurred outside NYC, mainly in the South and West.

Quantitative Analysis: bottom-to-top crises - summary

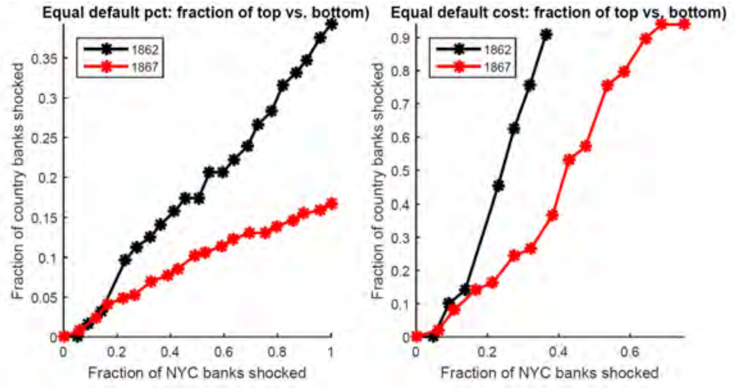
- **Shock**: increase σ_e for all country banks
- **Results**:After the NBA, the risk of a systemic shocks propagating from country banks increases.
  - However a comparable shock would still require a high degree of correlated shocks for a much larger number of country banks.





Quantitative Analysis: comparing crisis impact

- The impact of the network structure change lead to an increase in the impact of a bottom-to-top crisis while decreasing that of top-to-bottom crisis.



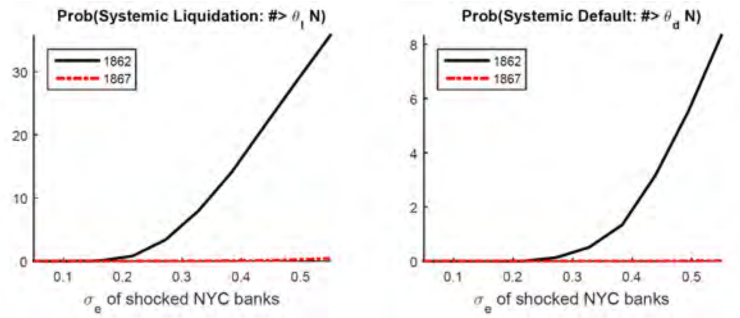
Conclusion

- We study the effect of a tiered network structure on systemic risk.
- NBA shaped the banking network into a more concentrated tiered structure.
- Simulations show that post-NBA network impact on systemic risk was:
  - An decrease in the vulnerability of top-to-bottom shocks during economic expansion.
  - An increase in the vulnerability of top-to-bottom shocks during economic recessions.
  - An increase in the vulnerability of bottom-to-top shocks generally.

Back-up Slides

Quantitative Analysis: top-to-bottom crises - good times

- Setup: L return of $\bar{e} = 0\%$, $\sigma_e = 5\%$ for all banks
- Shock: σ_e for all NYC banks



Quantitative Analysis: top-to-bottom crises - good times

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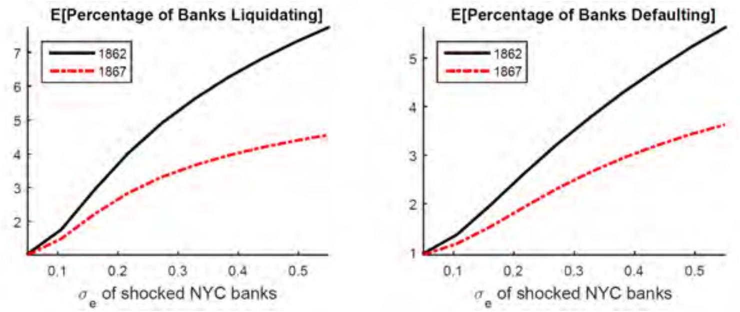

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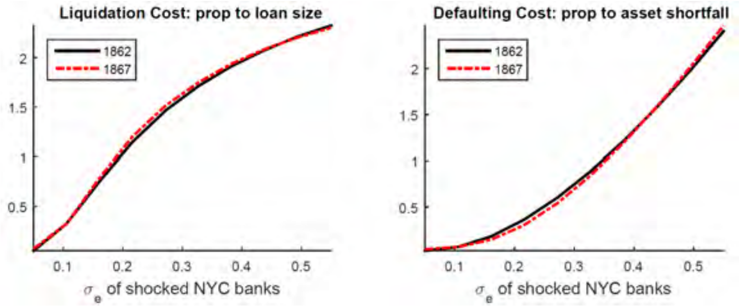

Quantitative Analysis: top-to-bottom crises - bad times

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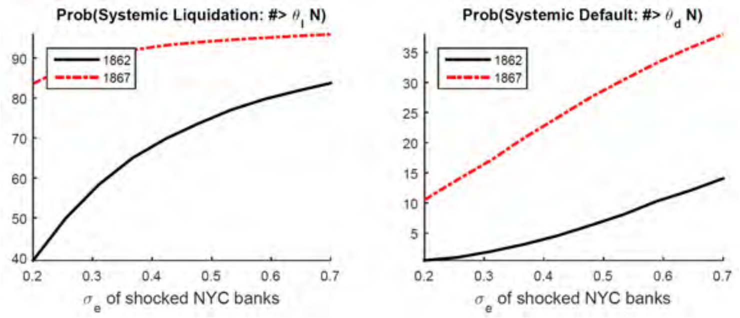
- Shock: σ_e for all NYC banks



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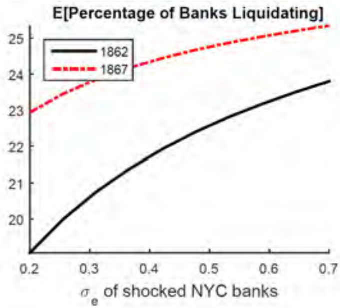

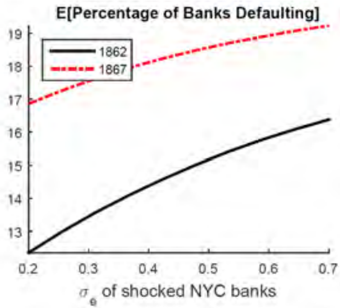

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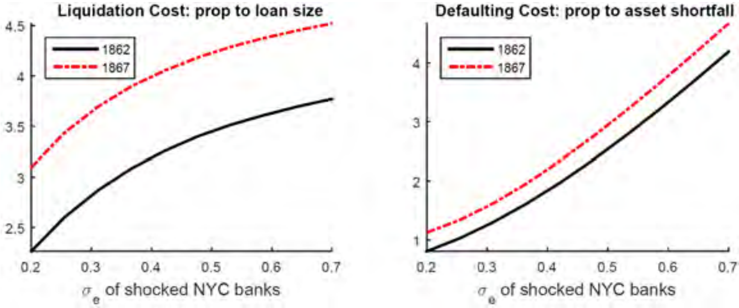

Quantitative Analysis: bottom-to-top crises

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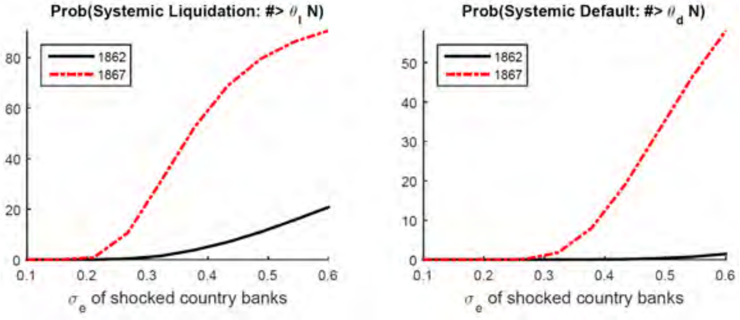
- Shock: σ_e for all country banks



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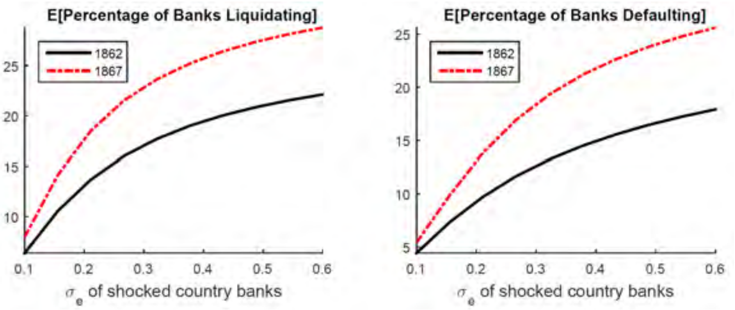

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