Empirical Network Contagion for U.S. Financial Institutions

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Motivation

- Explosion of research on financial networks since crisis
- Problem: lack of data
  - Literature predominantly theory
  - Empirics limited to subsector or single asset class
  - Simulations to fill in for missing data
  - Or top-down using non-network data (CoVaR, srisk, etc.)
- Network contagion: direct or indirect connections?
  - Fire sales: indirect connection through overlap in assets
 - Default spillovers: direct counter-party risk
  - Other?

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This paper: Empirical Default Spillovers

- Empirically estimate a measure of expected network default spillovers for entire US financial system 2002-2016
- Network model of Eisenberg and Noe (2001)
    1. Nodes are financial institutions; hold in- and out-of-network assets and liabilities
    2. Shocks to outside assets can cause a node to default
    3. Default of a node can trigger default of counter-parties
- Estimating default spillovers requires all bilateral contracts

This paper: Empirical Default Spillovers

- Glasserman and Young (2015): an **upper bound** on spillovers only requires **node-specific** data
  - Outside assets, ratio of inside liabilities to total liabilities, probability of default
- Check tightness of upper bound by creating worst network given empirical node-dependent data

Main Result: Network Spillovers Can Be Large

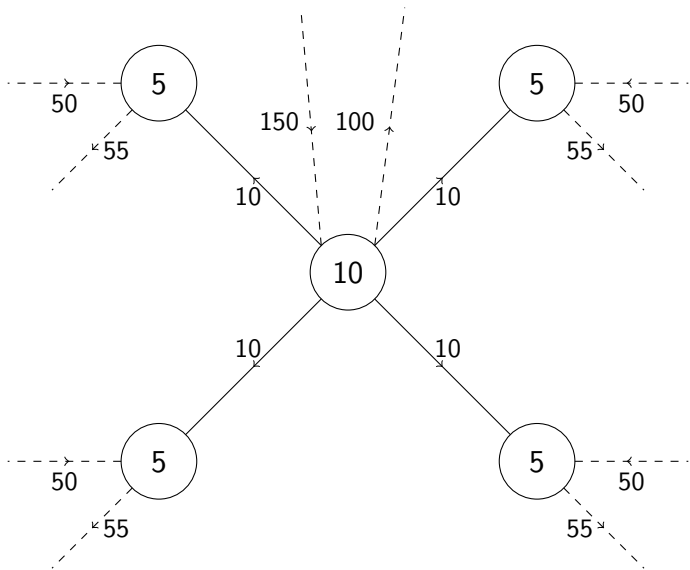Amplification of Expected Losses Due to Network Spillover Effects
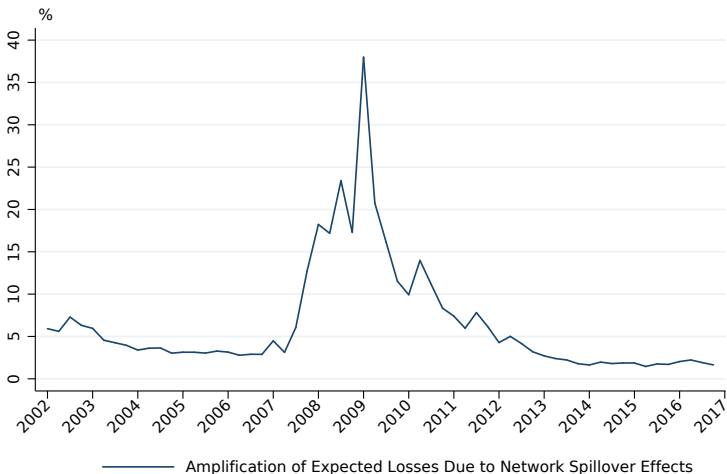
Outline of This Talk

1. Network model and upper bound on spillovers

2. Data and estimate of upper bound

3. Decompositions, robustness

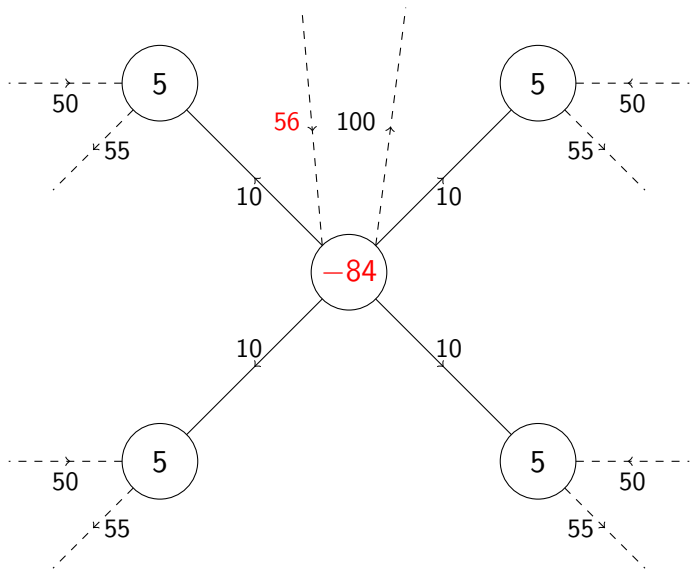4. Worst and best networks given empirical data

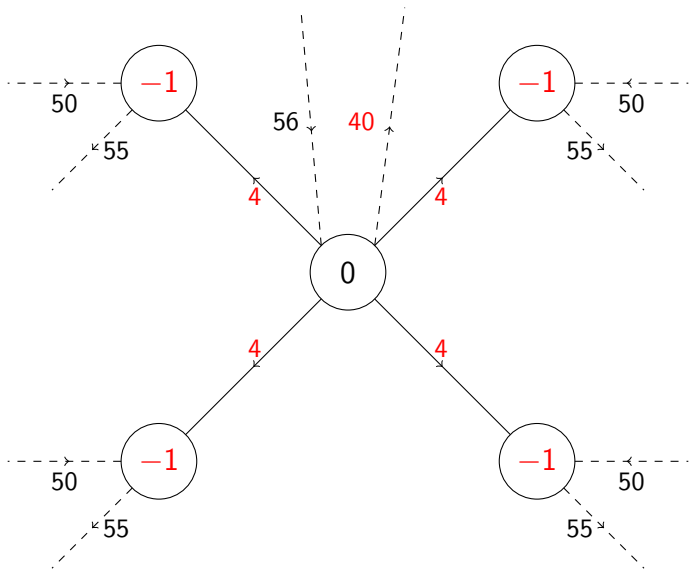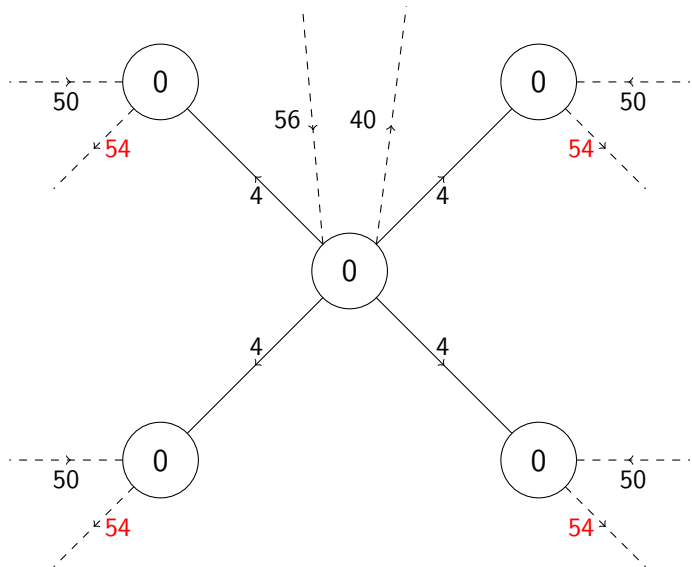Network model and upper bound on spillovers

A Simple Example

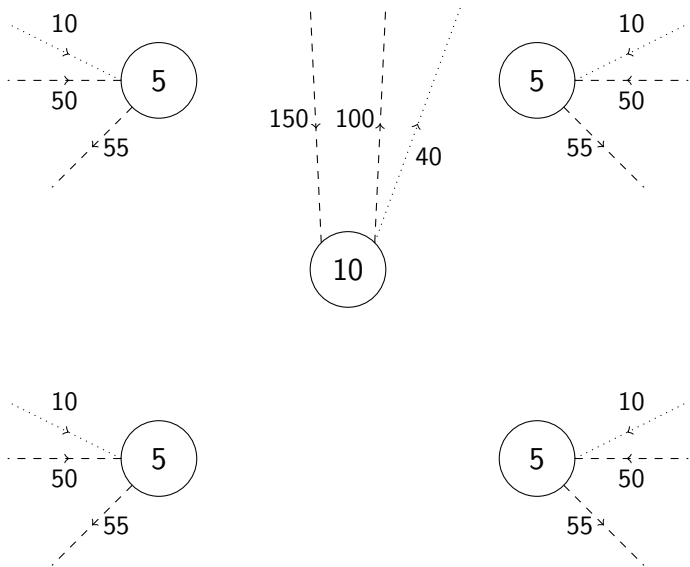# A Simple Example: Losses

A Simple Example: Losses After Shock
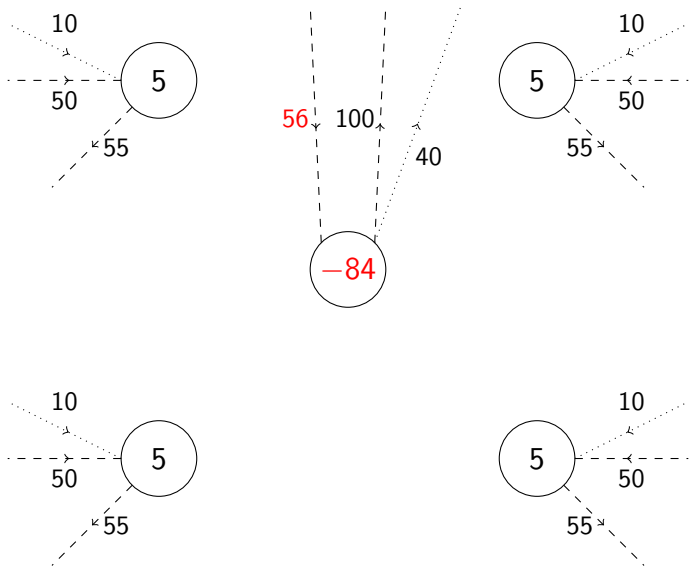
A Simple Example: Default Contagion

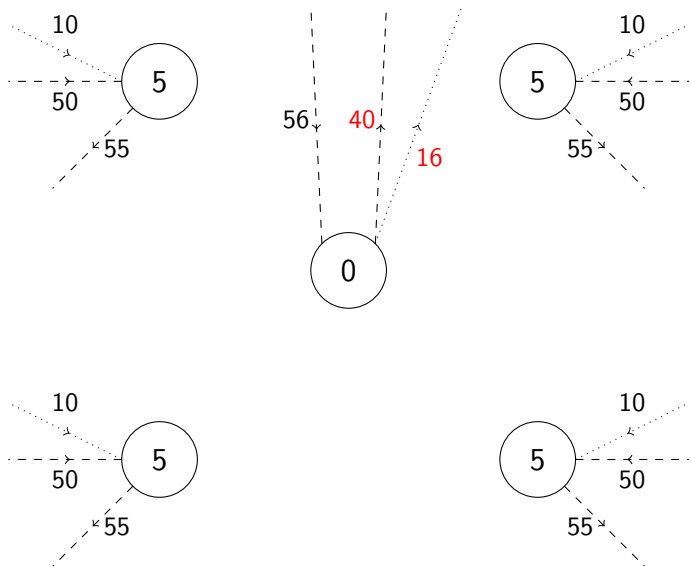Total asset value loss = 10 (direct equity loss) + 88 (payment shortfalls)

The Disconnected Network: Losses
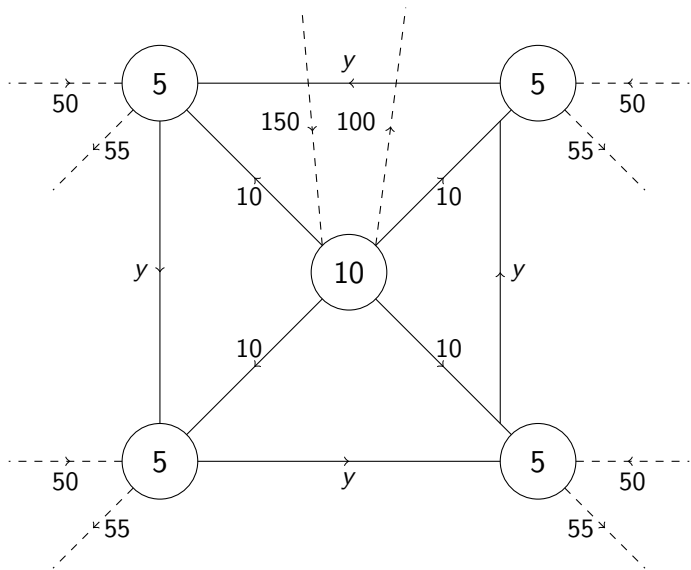
The Disconnected Network

The Disconnected Network: No Contagion

Total asset value loss = 10 (direct equity loss) + 84 (payment shortfalls)

A Fixed Point Example

Default Spillovers and an Upper Bound

- Want to measure $R = \mathbb{E}[Loss_{\text{actual}}]/\mathbb{E}[Loss_{\text{disconnected}}]$
- Instead, find bound B

$$R \leq B = 1 + \frac{1}{(1 - \beta^+)} \frac{\sum_{i \in S} \delta_i c_i}{\sum_{i \in S} c_i}$$

where

δ_i : probability of default for i

c_i : dollar value of outside assets for i

β^+ : $\beta^+ = \max\limits_{i \in S} \beta_i$

β_i : i's in-network liabilities relative to total liabilities

S : Set of nodes in network

Default Spillovers and an Upper Bound

- Define the *Network Vulnerability Index* NVI $= B - 1$
- Decomposition of NVI

$$\text{NVI} = \underbrace{\frac{1}{1 - \beta^+}}_{\substack{\text{Connectivity} \\ \text{multiplier}}} \times \underbrace{\frac{\sum_{i \in S} \delta_i c_i}{\sum_{i \in S} c_i}}_{\substack{\text{Avg default} \\ \text{prob}}}$$

- Node *contagion index*: maximum shortfall that a node can pass on to network
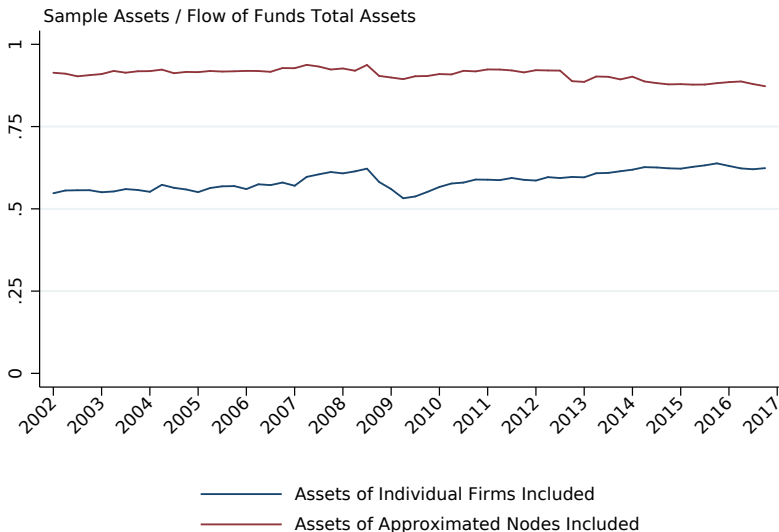
$$\text{contagion index} = w_i \beta_i \lambda_i$$

where $\lambda_i = \frac{c_i}{w_i}$ is the leverage of i's outside assets.

Data and estimate of upper bound

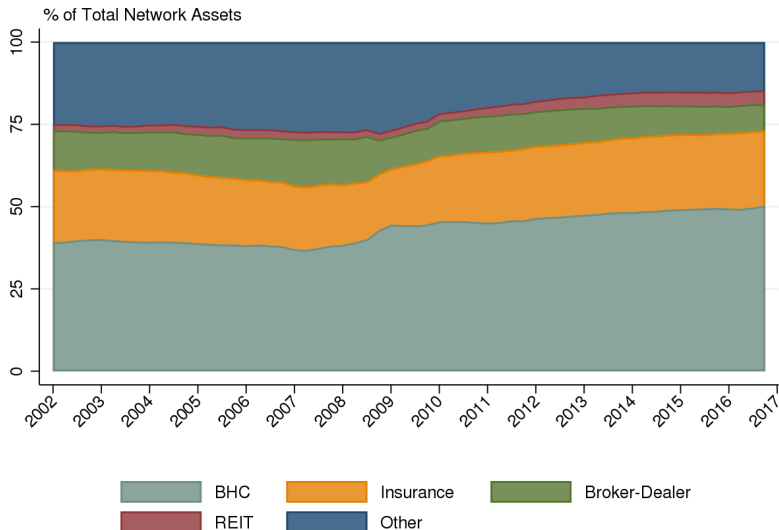# Data Sources

- Bank holding companies: Y-9C
- Insured Deposits: Call Report
- Broker-dealers: Focus Report (aggregated by tier 1-10, etc)
- Hedge Funds: HFR (not yet done, sub-universe)
- Other traded firms: Moody's Analytics
- Other firms and aggregates: Financial Accounts of U.S. (FOF)
- Probabilities of default: Moody's Analytics (KMV)
- Time of bankruptcy: Moody's Default and Recovery Database

Coverage is Large

Sample Assets / Flow of Funds Total Assets
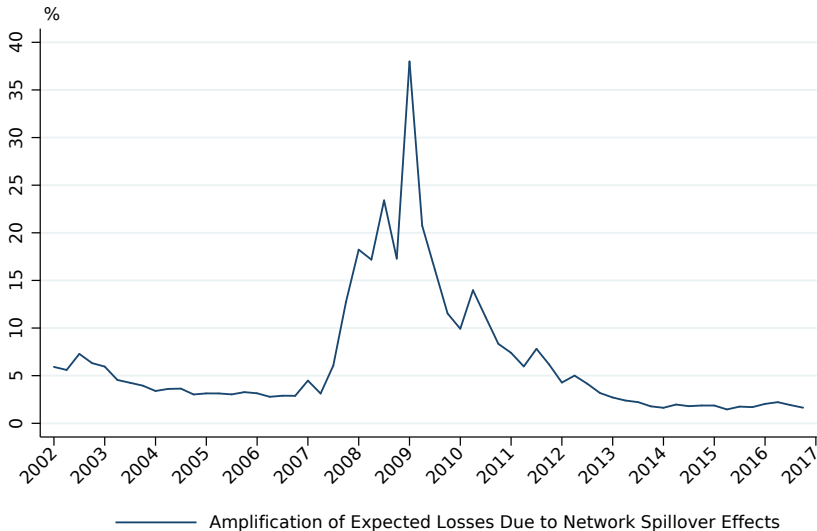
Assets of Individual Firms Included
Assets of Approximated Nodes Included

Distribution of Assets: BHC dominate

% of Total Network Assets

Legend: BHC, Insurance, Broker-Dealer, REIT, Other

Classification of BHC Assets

BHC Assets Inside Financial System (%)		BHC Assets Outside Financial System (%)	
Repos and Fed Funds	31.93	Loans	60.25
Interest Bearing Deposits	28.53	Agency MBS	13.82
Private Label ABS	6.60	State, Treasury, and Agency Debt	7.37
Goodwill	5.70	Other Securities	4.61
Other Trading Assets	4.83	Interest Bearing Deposits	3.62
Derivatives	3.67	Noninterest Bearing Deposits	1.48
Private Label MBS	1.92	Goodwill	1.34
Other MBS	1.05	Other Trading Assets	1.14
Other	15.77	Other	6.37
% of BHC Assets	19.06	% of BHC Assets	80.94

Classification of BHC Liabilities

BHC Liabilities Inside Financial System (%)		BHC Liabilities Outside Financial System (%)	
Uninsured Domestic Deposits	61.42	Insured Domestic Deposits	62.78
Repos and Fed Funds	10.73	Foreign Deposits	17.38
Longer Term Debt	9.67	Longer Term Debt	8.08
Trading Liabilities	4.38	Short Term Debt	3.27
Short Term Debt	3.92	Subordinated Debt	2.62
Derivatives	2.96	Other	5.87
Other	6.92		
% of BHC Liabilities	45.51	% of BHC Liabilities	54.49

Main Result: NVI

Amplification of Expected Losses Due to Network Spillover Effects

Decompositions, robustness

Both Components are Important

% per year

Legend:
— Asset-Weighted Default Probability (left axis)
— Connectivity Multiplier (right axis)

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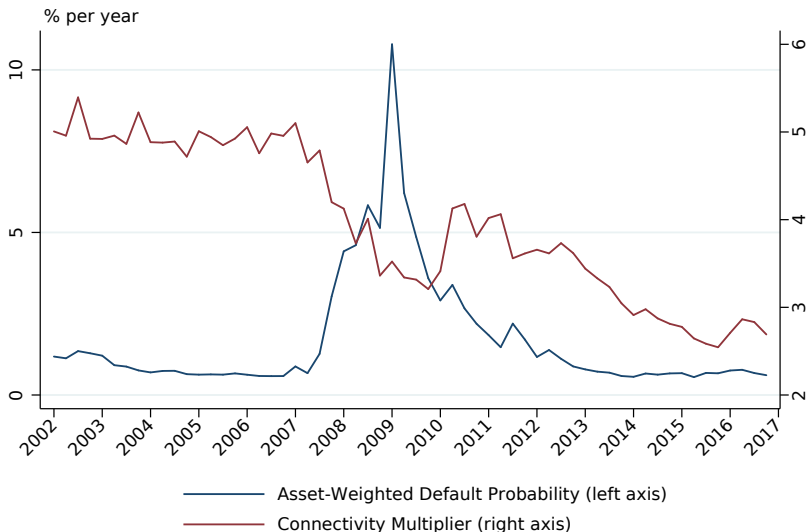
Broker-Dealers Drive Connectivity

Inside Liabilities/Total Liabilities
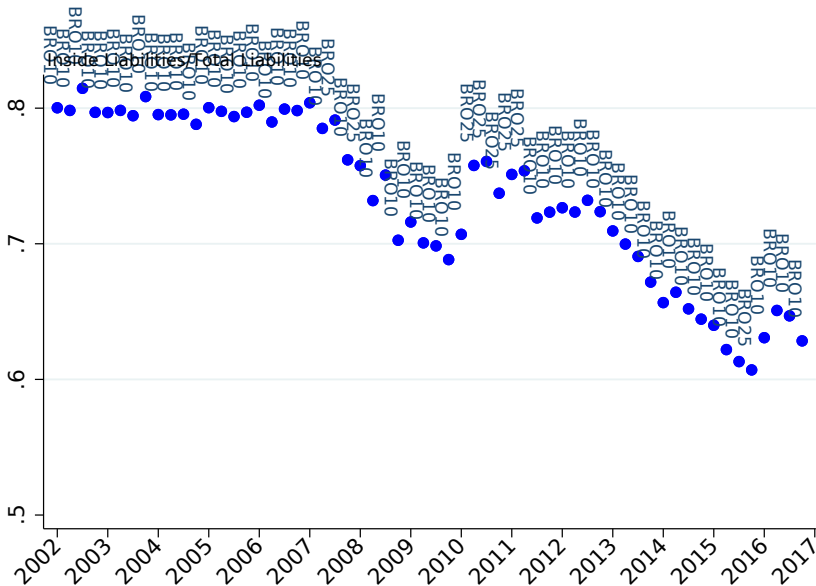
Ignoring Sectors Underestimates NVI
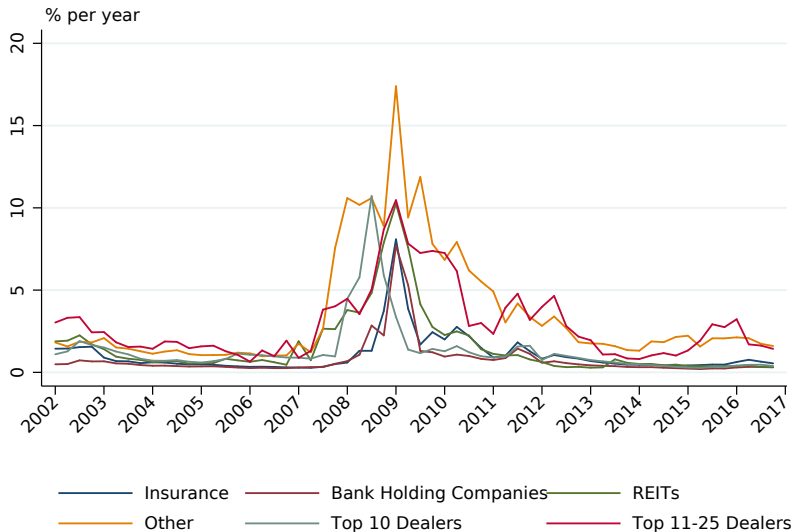
'Other' Firm Category, Top Firms by Assets

Other Financial Firm	Asset Weighting
Principal Financial Group Inc	0.22
Navient Corp	0.12
Blackrock Inc	0.07
Visa Inc	0.06
Oaktree Capital Group Llc	0.05
Santander Consumer Usa Hldgs	0.04
Kkr Co Lp	0.04
Nelnet Inc	0.03
Invesco Ltd	0.02
Blackstone Group Lp	0.02
Marsh Mclennan Cos	0.02
Springleaf Holdings Inc	0.02
Slm Corp	0.02

Individual Node Contagion Index

	Contagion Index	Financial Connectivity	Outside Assets	Net Worth
JP Morgan Chase Co	767.62	0.54	1683.01	254.40
Bank of America Corp	732.66	0.50	1727.24	266.84
Wells Fargo Co	624.17	0.45	1601.25	200.50
Citigroup	519.09	0.48	1297.92	226.14
Top 10 Dealers	418.97	0.63	774.12	107.39
U S Bank	164.01	0.45	415.33	47.93
Top 11-25 Dealers	121.74	0.52	292.91	56.78
Pnc Financial Services Group	104.62	0.39	316.84	46.85
Bank of NY Mellon Corp	91.46	0.52	216.21	39.58
Capital One Finance Company	80.22	0.28	332.25	47.51
BBT Corp	75.87	0.44	203.87	29.93
Suntrust Bank	73.89	0.44	193.30	23.62
Fifth Third Bank	56.52	0.49	131.46	16.23
State Street Corp	54.03	0.49	131.97	21.22
Keycorp	53.33	0.46	130.03	15.24
American Express Co	51.94	0.43	140.27	20.50
Citizens Financial Group	50.01	0.41	141.88	19.75

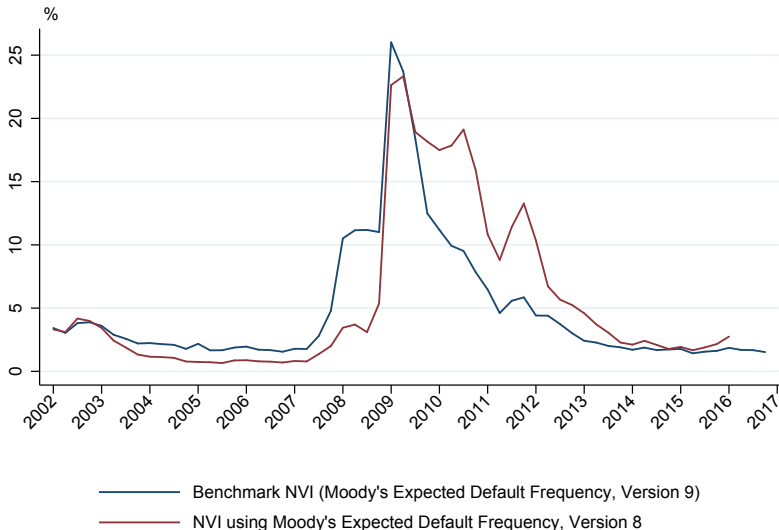# Robustness: Choices for Connectvity

(a)
%

(b)
Inside Liabilities/Total Liabilities
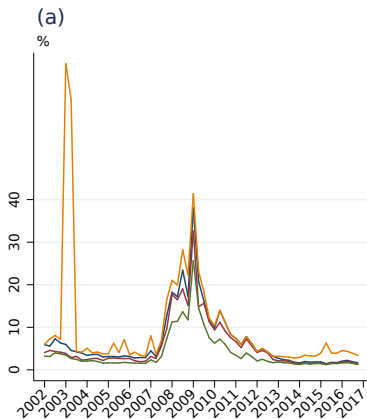
Benchmark NVI
Second Highest BHC Connectivity
Third Highest BHC Connectivity
Highest β, from Entire Sample
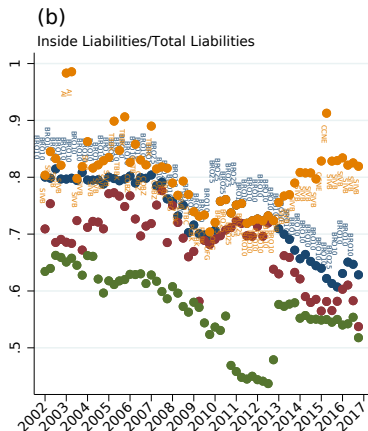
Benchmark BHC Connectivity (β^+)
Second Highest BHC Connectivity (β^+)
Third Highest BHC Connectivity (β^+)
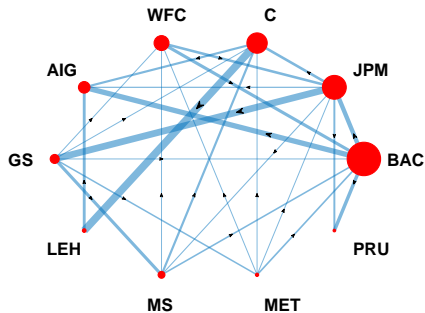Highest β, from Entire Sample (β^+)

Robustness: NVI using Pre- or Post-Crisis EDF

Benchmark NVI (Moody's Expected Default Frequency, Version 9)

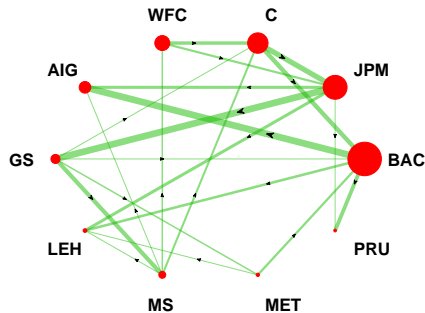NVI using Moody's Expected Default Frequency, Version 8

Worst and best networks given empirical data

Optimizing Network Spillovers

Maximum Amplification = 2.5%   Minimum Amplification = 0.2%

Conclusion

- First empirical estimate of network default spillovers for entire US financial system
- Large increase in spillovers during crisis
  - ▶ Probabilities of default spiked
  - ▶ Decreasing connectivity mitigated spillovers
- Spillovers outside banks are important
- Today
  - ▶ Vulnerability to spillovers is low
  - ▶ Low probabilities of default
  - ▶ Connectivity of broker-dealers and large BHC low, but increasing in other sub-sectors

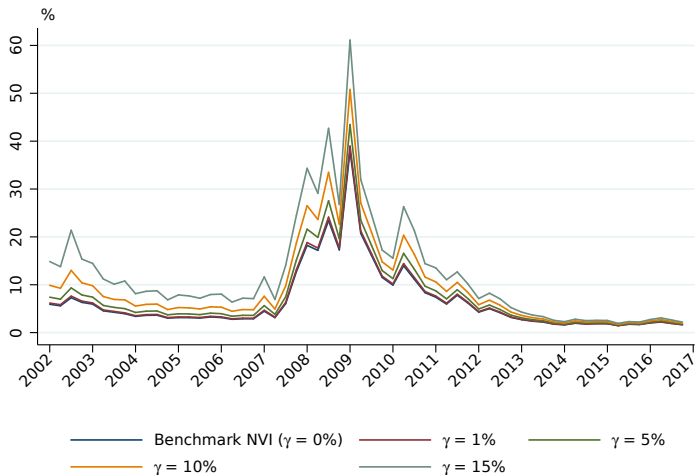# Empirical Network Contagion for U.S. Financial Institutions

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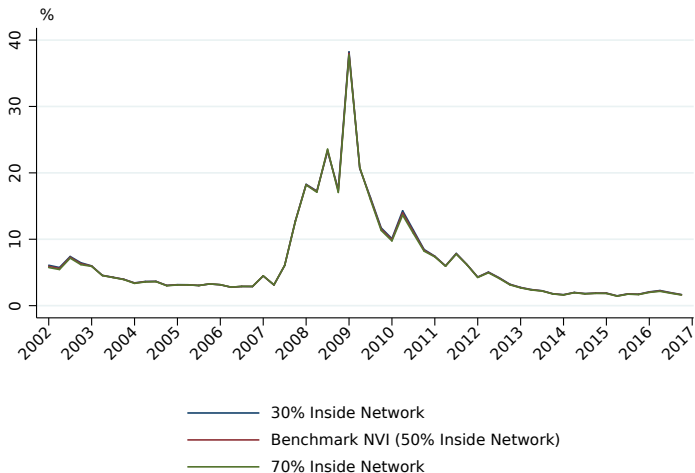Federal Reserve Bank of New York and Federal Reserve Bank of New York
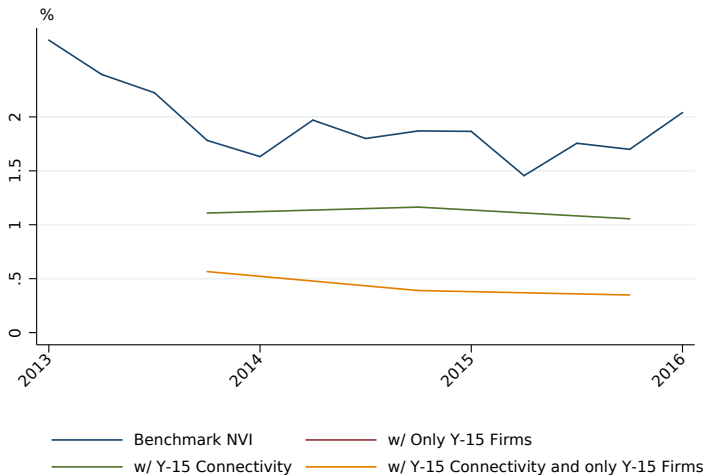
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Appendix: Additional Robustness

Additional Costs to Bankruptcy, γ

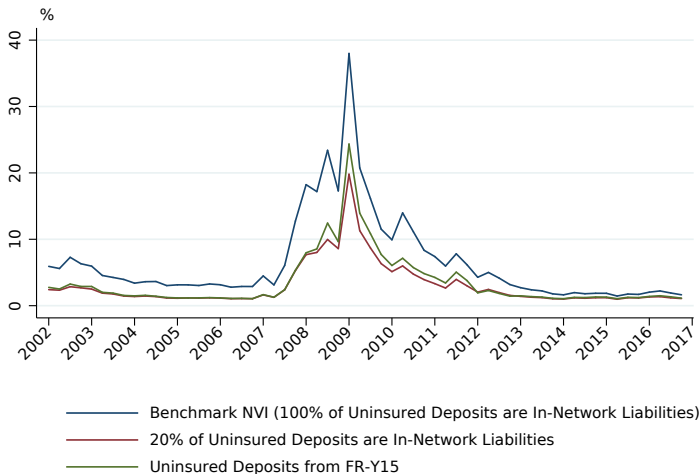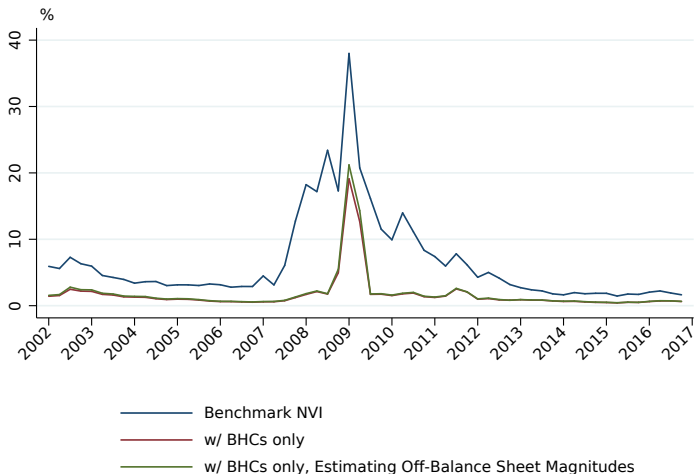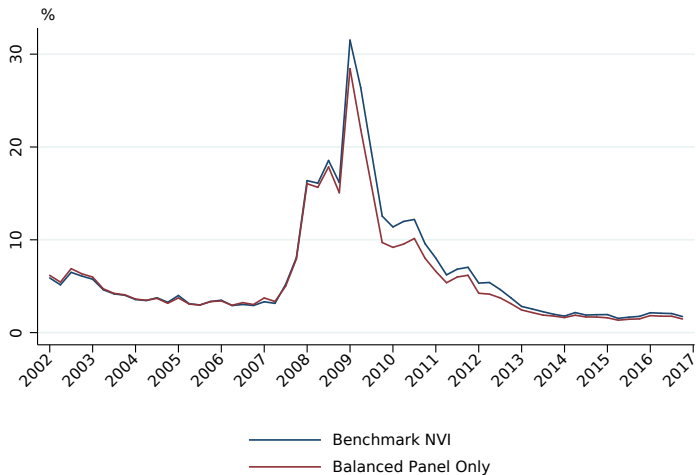# Different Classifications of Hard-To-Classify Assets and Liabilities

Using FR-Y15 Data

Classification of Uninsured Deposits

Benchmark NVI (100% of Uninsured Deposits are In-Network Liabilities)

20% of Uninsured Deposits are In-Network Liabilities

Uninsured Deposits from FR-Y15

Extrapolating FR-Y15 Off-Balance Sheet Items

Balanced FR-Y9C Panel

Fixed, High Default Probability

Legend:
- Benchmark NVI
- with Default Prob Fixed at 6%