Empirical Network Contagion for U.S. Financial Institutions

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February 2020

Motivation

- Explosion of research on financial networks since crisis
- Problem: lack of data
  - Literature predominantly theory
  - Empirics mostly limited to few subsectors or asset classes
  - 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?

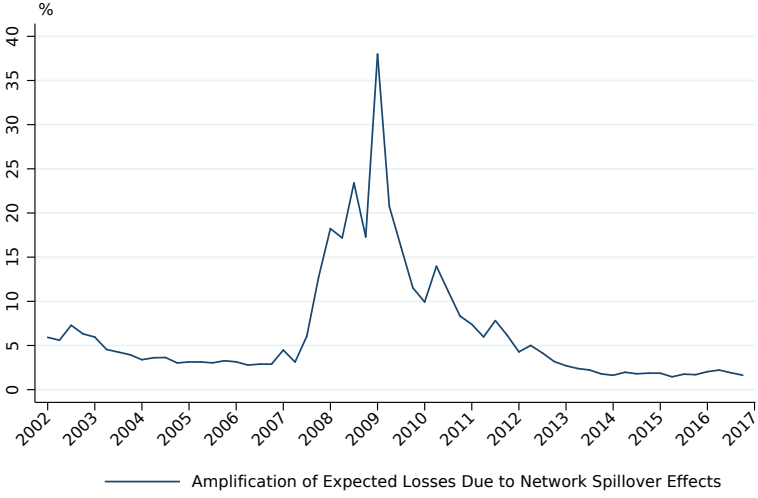
This paper: Empirical Default Spillovers

- 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 —the only shocks in the model— can cause a node to default
  3. Default of a node can trigger default of counter-parties
- Estimating default spillovers requires all bilateral net positions

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: Default Spillovers Can Be Large

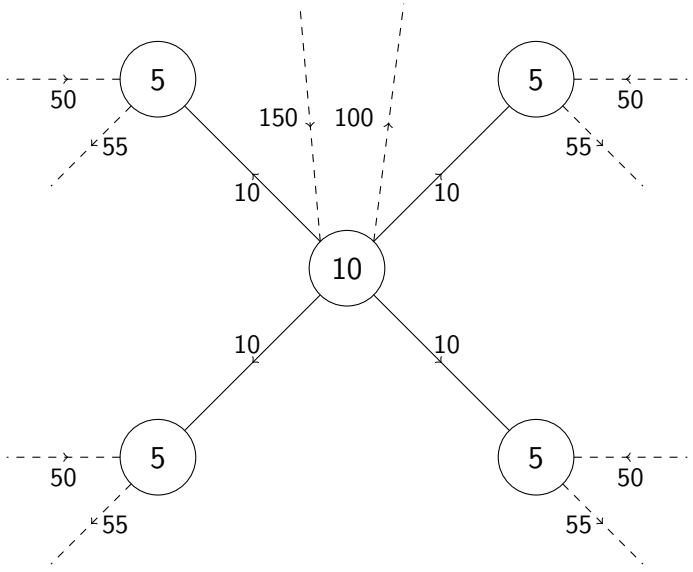


Outline of This Talk

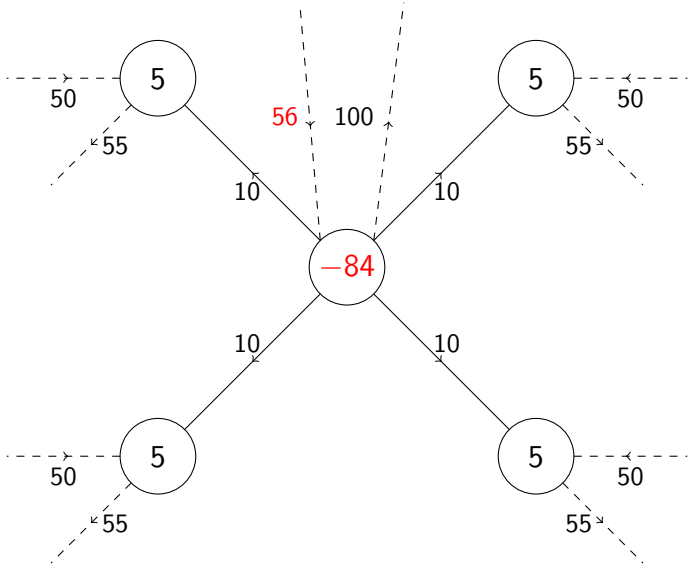
1. Network model and upper bound on spillovers
2. Data and estimate of upper bound
3. Decompositions, robustness
4. Worst and best networks given empirical data

Network model and upper bound on spillovers

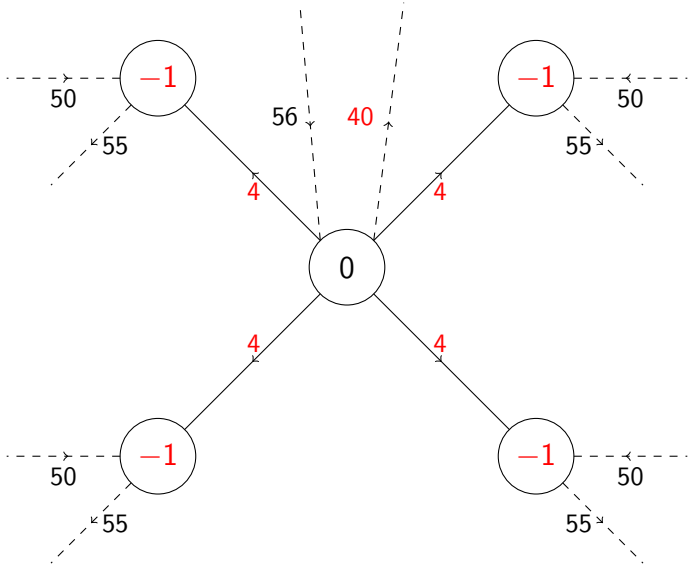
A Simple Example



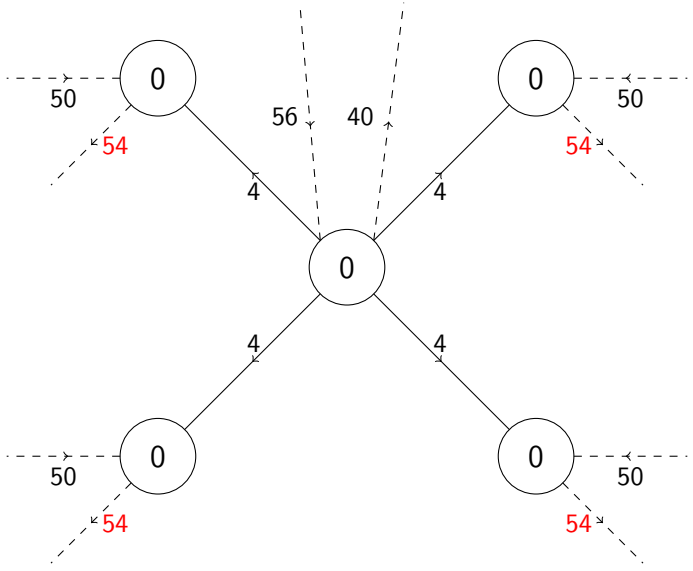
A Simple Example: Losses



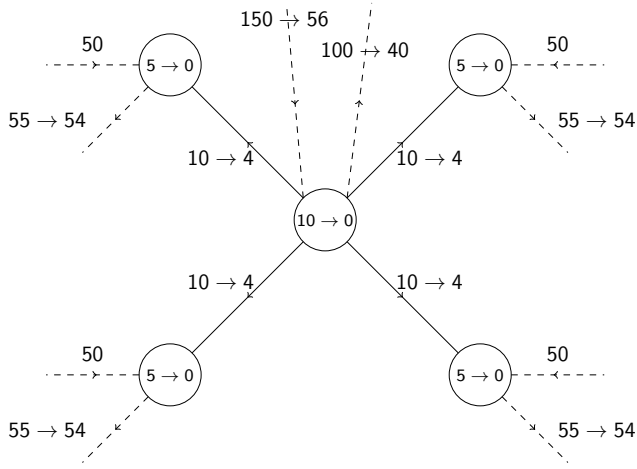
A Simple Example: Transmission



A Simple Example: Amplification



A Simple Example: Tallying Losses

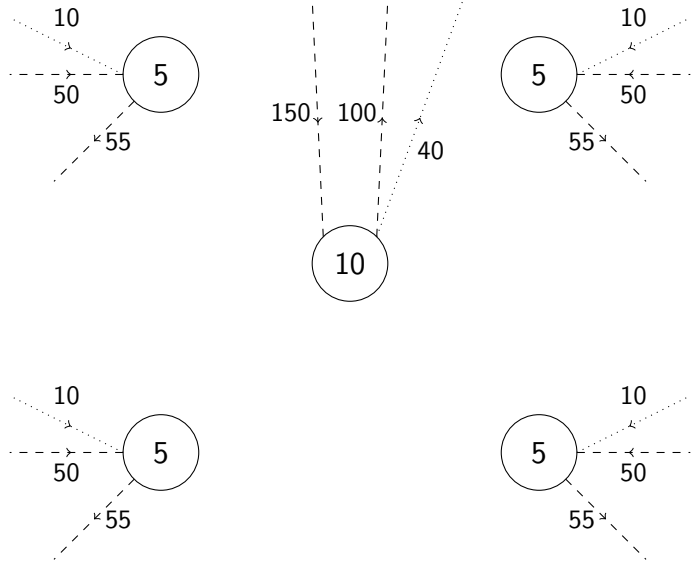


Asset losses = (150-56) for central node + (100-40) for top outside node +

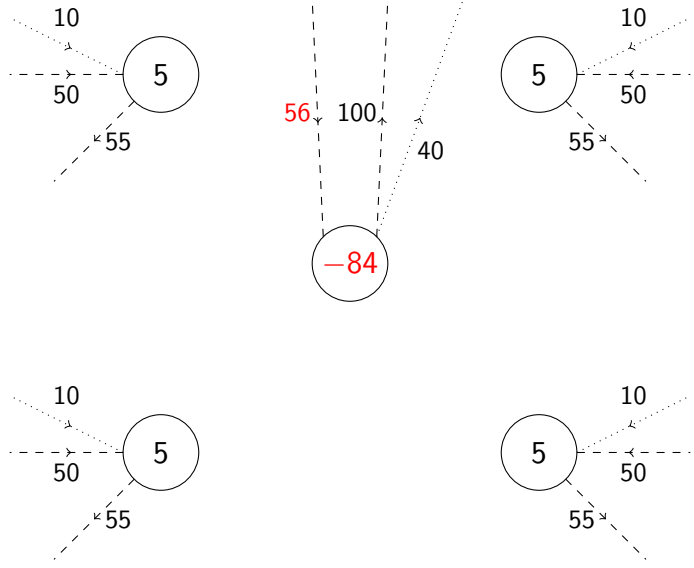
+ 4 × (10-4) for peripheral nodes + 4× (55-54) for other outside nodes

= 182

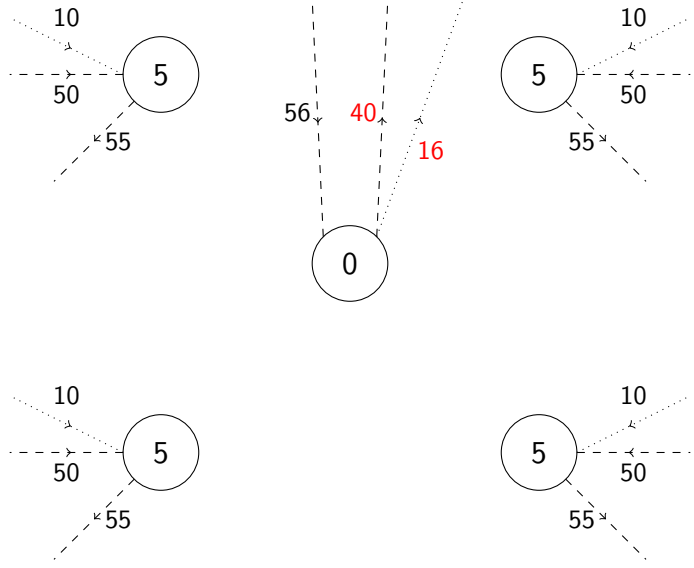
The Disconnected Network



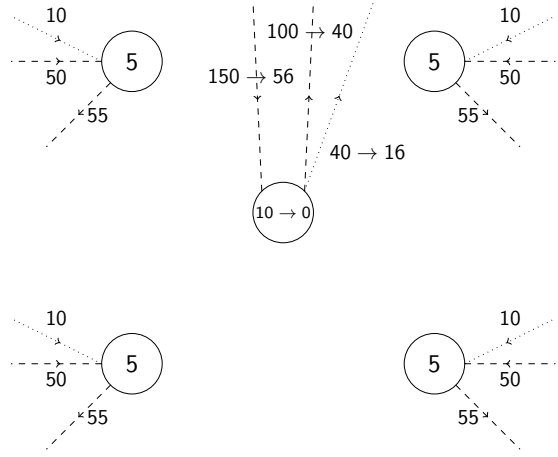
The Disconnected Network: Losses



The Disconnected Network: No Amplification



The Disconnected Network: Tallying Losses

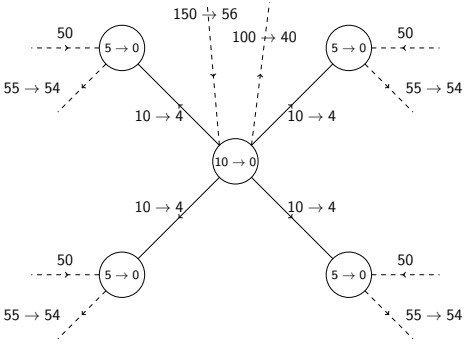


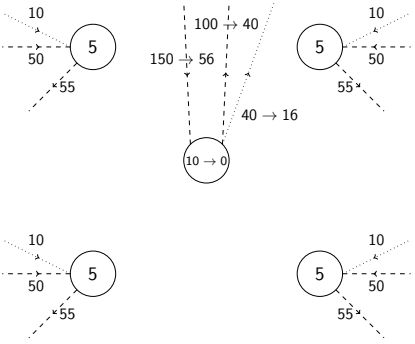
Asset losses =(150-56) for central node + (100-40) for top outside node +

+ (40-16) for top virtual outside node

=178

Defaults Create Amplification



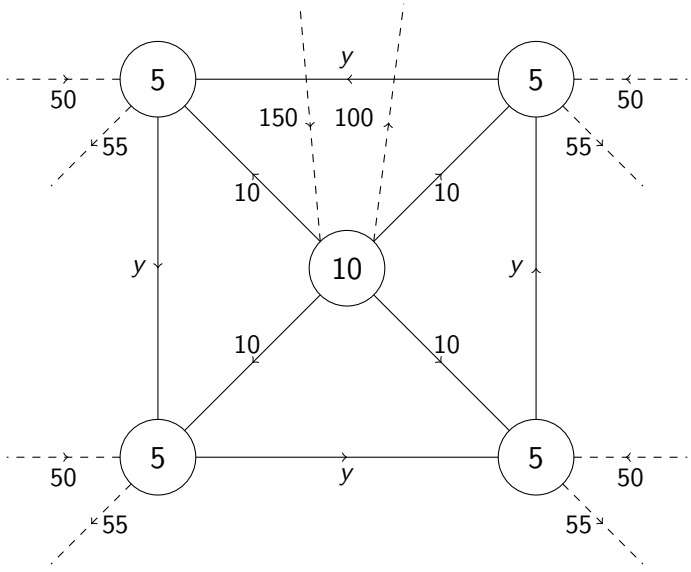


Actual Network = 182

Disconnected Network = 178

Amplification = 182/178 - 1 = 2.25%

A Fixed Point Example (Not As Easy To Solve)



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^{+} : $\beta^{+} = \max_{i \in S} \beta_i$

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

$$\text{contagion index} = w_i \beta_i \lambda_i$$

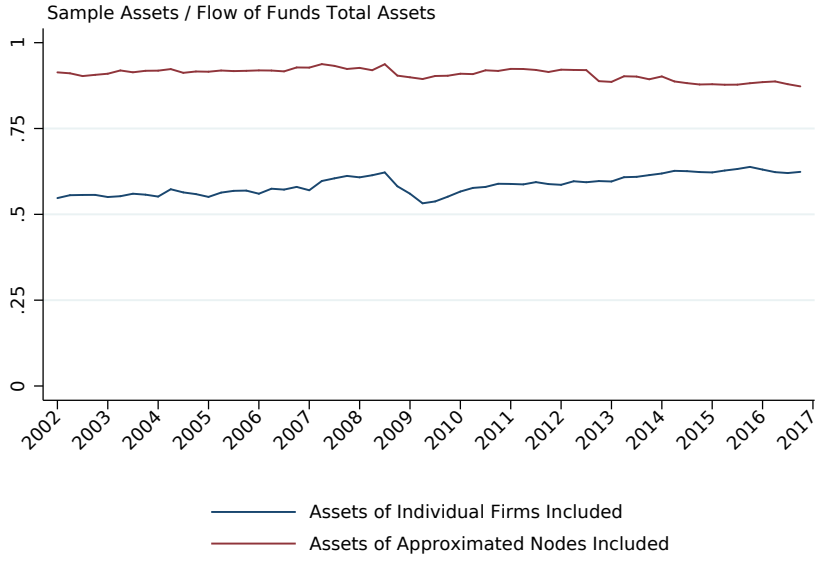
where $\lambda_i = \frac{c_i}{w_i}$ is the leverage of i's outside assets.

Data and estimate of upper bound

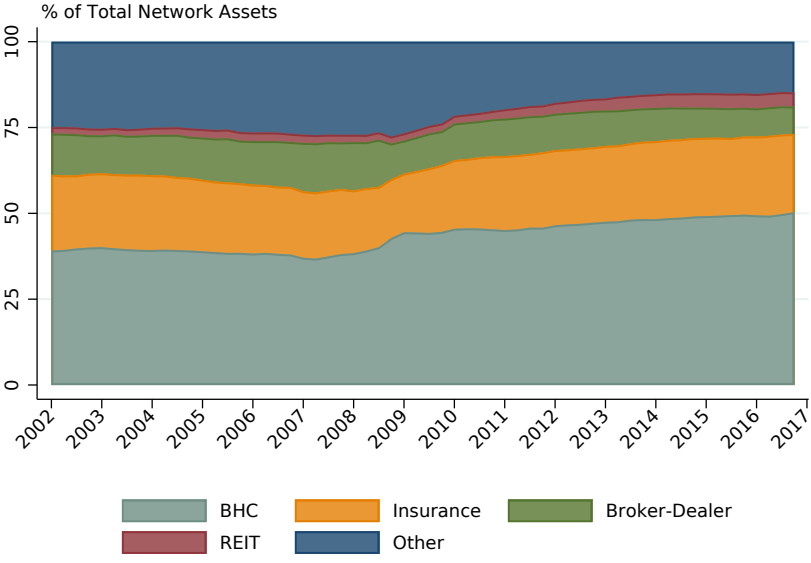
Data Sources

- 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



Distribution of Assets: BHC dominate



Classification of BHC Assets

BHC Assets Inside Financial System (%)	
Repos and Fed Funds	31.93
Interest Bearing Deposits	28.53
Private Label ABS	6.60
Goodwill	5.70
Other Trading Assets	4.83
Derivatives	3.67
Private Label MBS	1.92
Other MBS	1.05
Other	15.77
% of BHC Assets	19.06

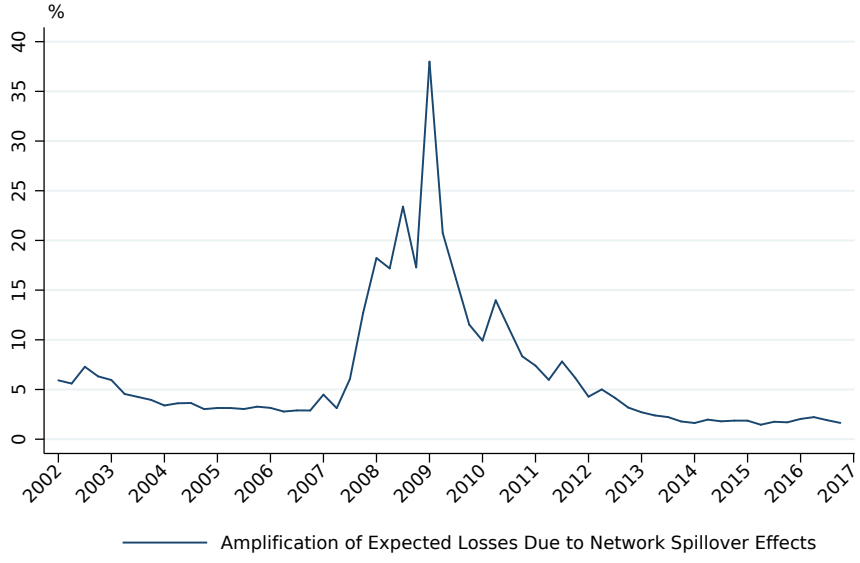
BHC Assets Outside Financial System(%)	
Loans	60.25
Agency MBS	13.82
State, Treasury, and Agency Debt	7.37
Other Securities	4.61
Interest Bearing Deposits	3.62
Noninterest Bearing Deposits	1.48
Goodwill	1.34
Other Trading Assets	1.14
Other	6.37
% of BHC Assets	80.94

Classification of BHC Liabilities

BHC Liabilities Inside Financial System (%)	
Uninsured Domestic Deposits	61.42
Repos and Fed Funds	10.73
Longer Term Debt	9.67
Trading Liabilities	4.38
Short Term Debt	3.92
Derivatives	2.96
Other	6.92
% of BHC Liabilities	45.51

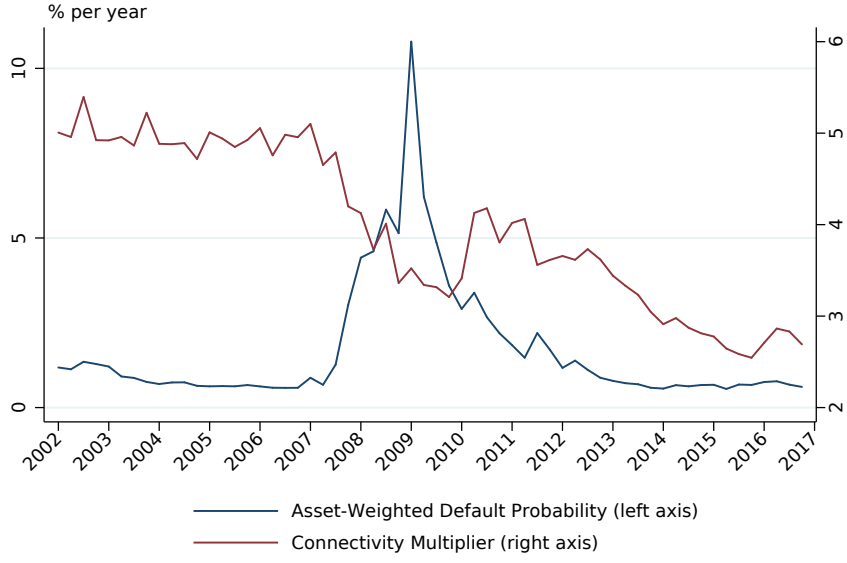
BHC Liabilities Outside Financial System (%)	
Insured Domestic Deposits	62.78
Foreign Deposits	17.38
Longer Term Debt	8.08
Short Term Debt	3.27
Subordinated Debt	2.62
Other	5.87
% of BHC Liabilities	54.49

Main Result: NVI can be Large

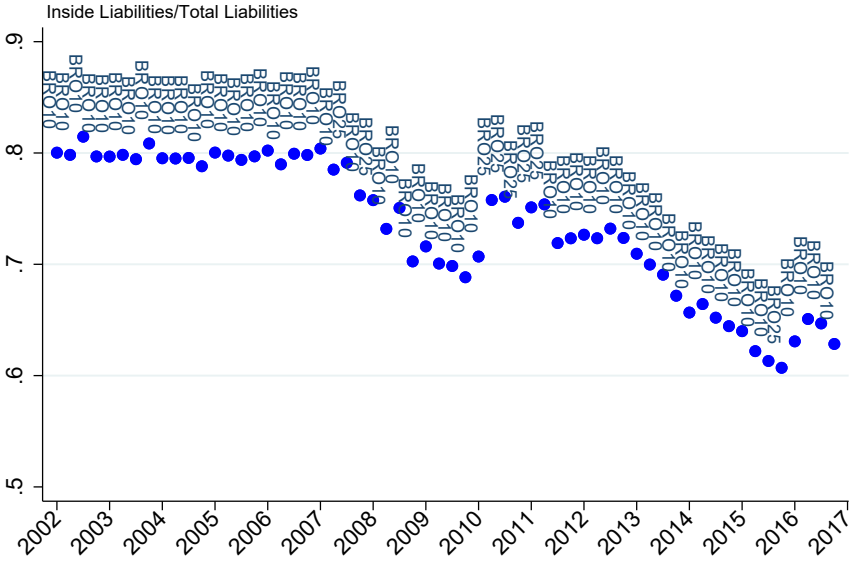


Decompositions, robustness

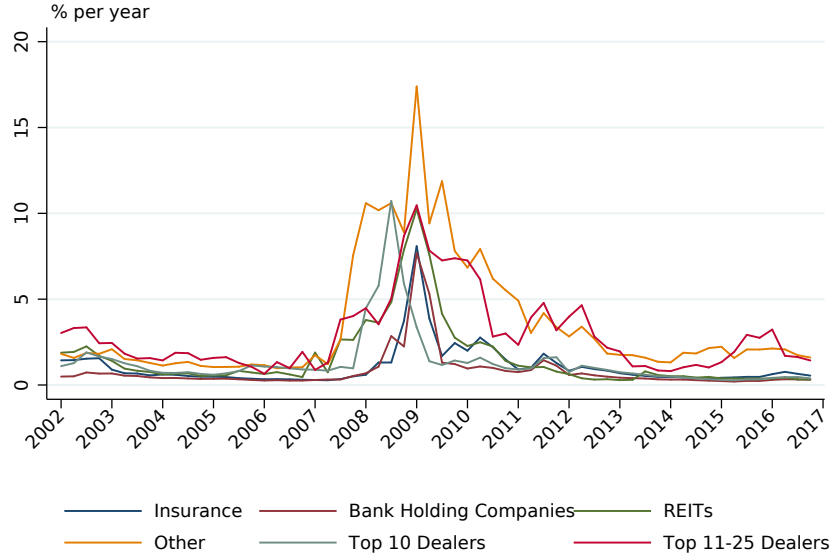
Both Components are Important



Broker-Dealers Drive Connectivity



Ignoring Sectors Underestimates NVI



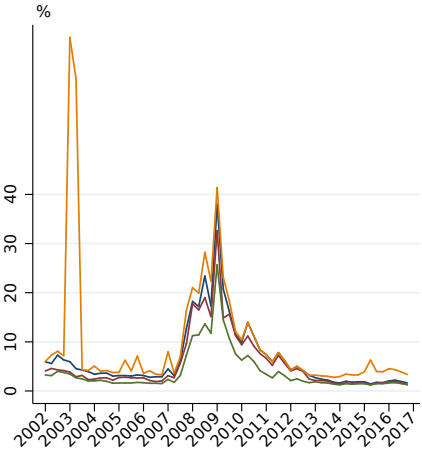
'Other' Firm Category, Top Firms by Assets

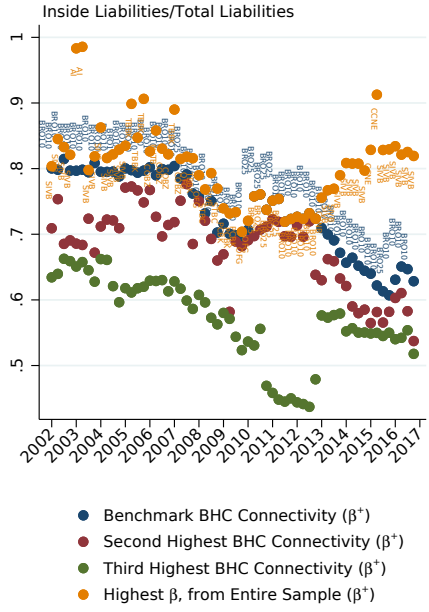
Other Financial Firm	Asset Weighting
Principal Financial Group Inc	0.22
Navient Corp	0.12
Blackrock Inc	0.07
Visa Inc	0.06
Oaktree Capital Group Llc	0.05
Santander Consumer Usa Hldgs	0.04
Kkr Co Lp	0.04
Nelnet Inc	0.03
Invesco Ltd	0.02
Blackstone Group Lp	0.02
Number of Firms in Sample	128
Weighting from Rest of Sample	0.18

Individual Node Contagion Index

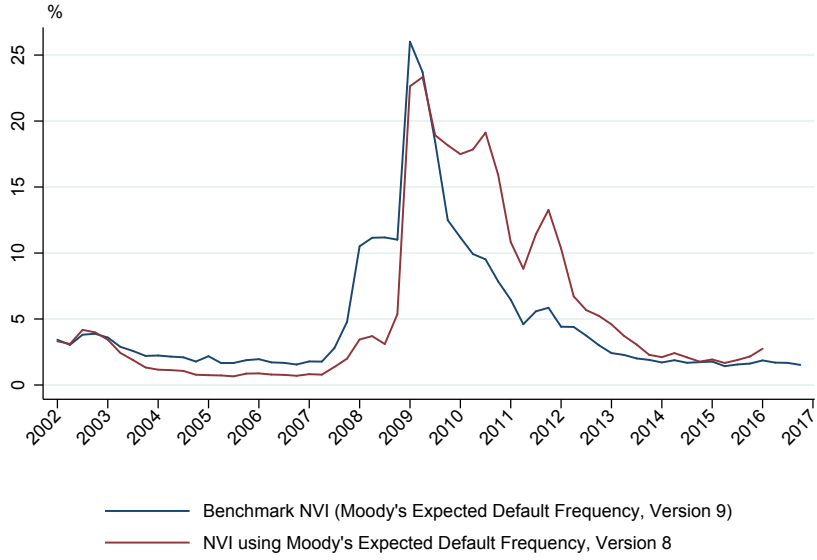
	Connectivity	Contagion Index	Outside Assets	Net Worth
JP Morgan Chase	767.62	0.54	1683.01	254.40
Bank of America	732.66	0.50	1727.24	266.84
Wells Fargo	624.17	0.45	1601.25	200.50
Citigroup	519.09	0.48	1297.92	226.14
Top 10 Dealers	418.97	0.63	774.12	107.39
U S Bank	164.01	0.45	415.33	47.93
Top 11-25 Dealers	121.74	0.52	292.91	56.78
Pnc	104.62	0.39	316.84	46.85
Bank of NY Mellon	91.46	0.52	216.21	39.58
Capital One	80.22	0.28	332.25	47.51
BBT	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	54.03	0.49	131.97	21.22
Keycorp	53.33	0.46	130.03	15.24
American Express	51.94	0.43	140.27	20.50

Robustness: Choices for Connectvity



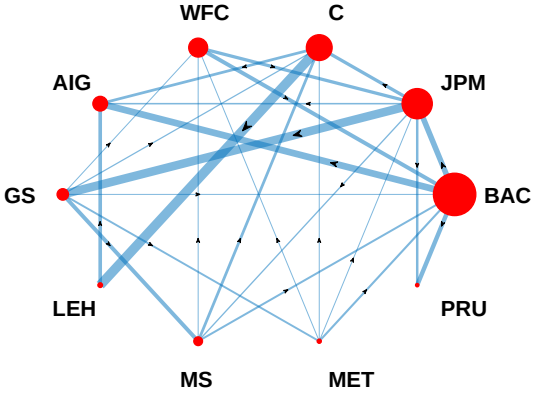


Robustness: NVI using Pre- and Post-Crisis EDF

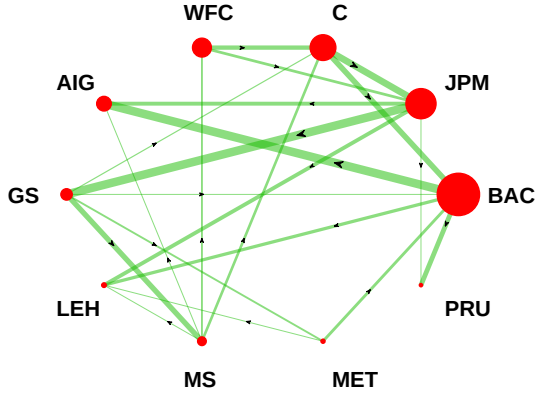


Worst and best networks given empirical data

Optimizing Network Spillovers: 2008-Q4 example



Maximum Amplification = 2.5%



Minimum Amplification = 0.2%

Conclusion

- First empirical estimate of network default spillovers for entire US financial system
- Large increase in spillover potential 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

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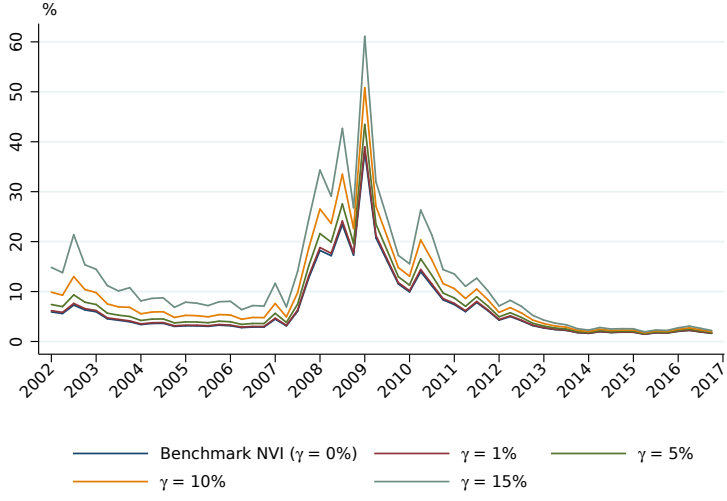
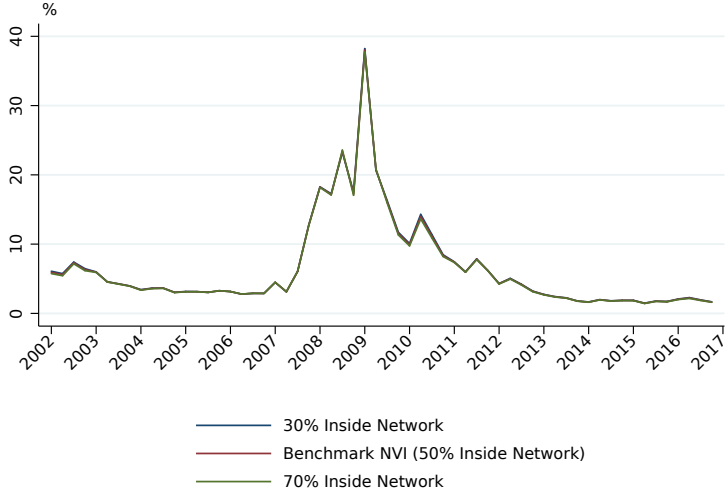
Appendix: Additional Robustness

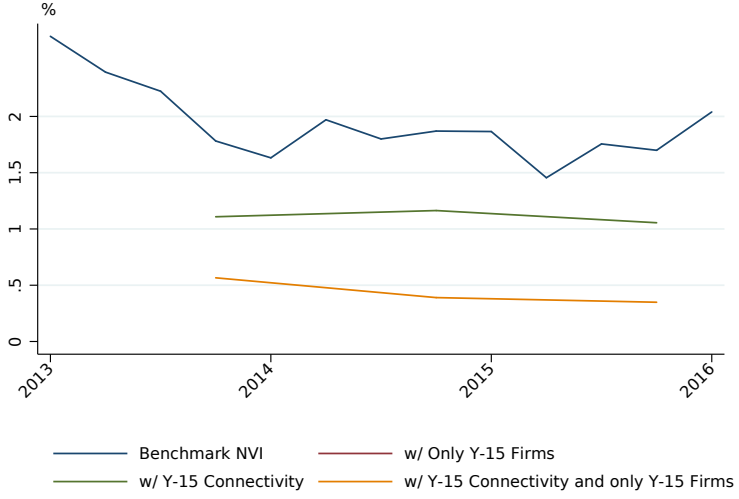
Additional Costs to Bankruptcy, γ



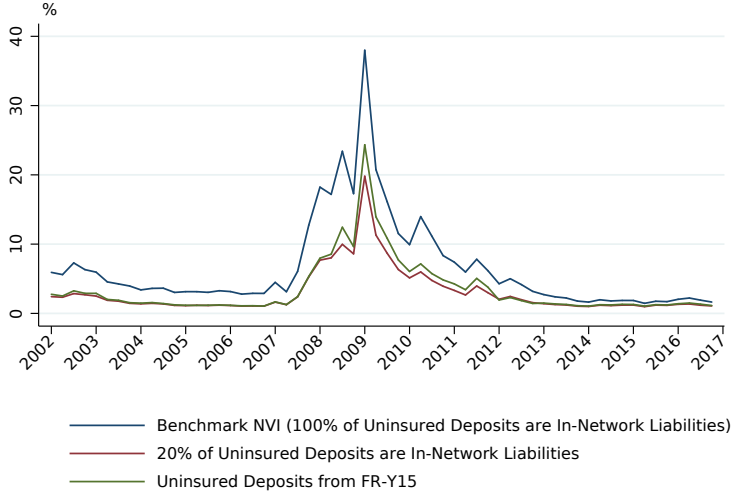
Different Classifications of Hard-To-Classify Assets and Liabilities



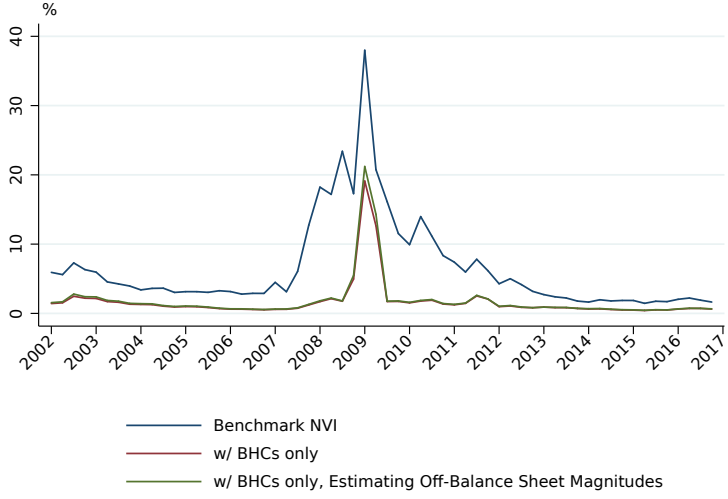
Using FR-Y15 Data



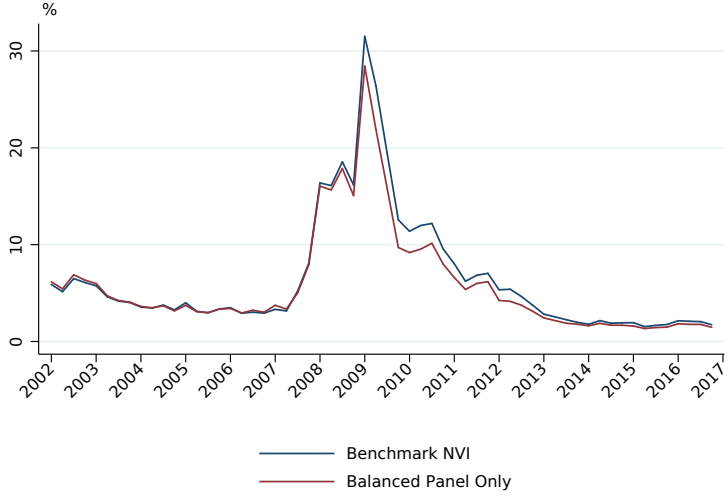
Classification of Uninsured Deposits



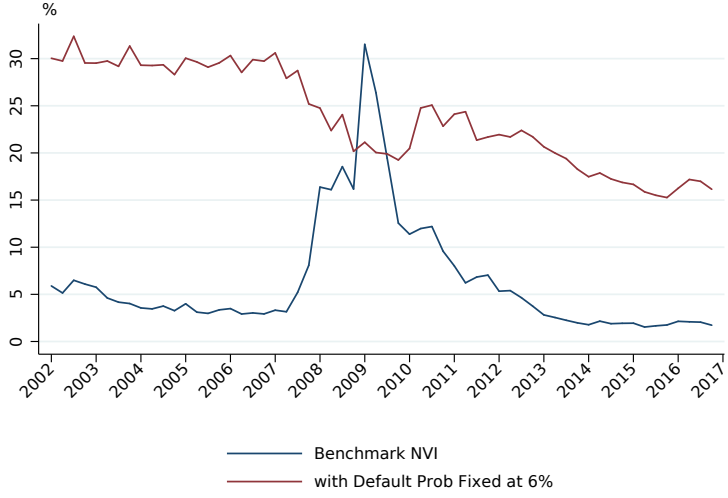
Extrapolating FR-Y15 Off-Balance Sheet Items



Balanced FR-Y9C Panel



Fixed, High Default Probability



Cross-Section of Financial Connectivity