Network Analysis

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 - Joint Solvency-Liquidity Contagion



Introduction

- Post crisis, interconnectedness between financial institutions as an attribute of systemic risk has gained significant importance
- Network analysis is an analytical tool of assessing interconnectedness in the financial system
 - Data on inter-institution exposures can be collected and the existing network structure can be assessed
 - A study of the network structures over a period of time may reveal changes in the structure, which in turn may indicate changing systemic importance of entity/entities
 - Possible contagion channels can be monitored
 - Network models are also used as additional stress testing tools
 - Assists in macroprudential policy decisions

Network analysis in the Reserve Bank of India - 1

- ► Network analysis, *as part of its macroprudential surveillance* mechanism was adopted by RBI in 2010
- The model that is used for network analysis was developed through a collaborative effort of RBI and external experts
- ► For the exercise, data on bilateral exposures are collected on a quarterly basis from:
 - All the Scheduled Commercial Banks (SCBs) (86 in nos);
 - 21 Insurance Companies;
 - 22 Asset Management Companies managing Mutual Funds (AMC-MFs);
 34 Non Banking Financial Companies (NBFCs);
 20 Scheduled Urban Cooperative Banks (SUCBs); and

 - The four all India financial institutions
- ► All the entities in the sample together make up for more than 95% of the Indian financial system

RBI was appreciated for its pioneering efforts in this field by IMF in its FSAP of 2011

Network analysis in the Reserve Bank of India - 2

► At the core of the analysis is *matrix algebra*

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- Actual information of each institution's lending (outstanding position) to all others in the sample is collated
 - The <u>information</u> include granular data in the form of various fund based and non fund based exposures like Call, CDs, long term debt, interest rate swaps, options etc.
- The data is arranged to form a square matrix which is called the gross matrix 'X', such that x i represents the flow of gross financial obligations from the borrower i to the lender j.
- From the gross matrix, a **bilateral net flow matrix 'M'** is derived which has entries in the form of $(x_{ij} x_{ji})$. The **net matrix** is nothing but skew symmetric of matrix 'X'
- The links or the relationships in the form of lending and borrowing, which exists between *N* institutions are viewed in this matrix
- *Directed graphs*' are derived that are useful to study relative asymmetries and imbalances in link formation and their weights

Network analysis in the Reserve Bank of India - 3

- A network structure has certain *nodes* and *links*. The nodes are the entities whereas the links are the relationships between these entities
- Various statistical analysis are carried out to determine the level of interconnectedness and activity that exist in the system
- ► Some of the most important measures are
 - Connectivity This is a measure of actual number of links relative to all total possible links in a network
 - Cluster Coefficient This statistic measures how connected each node's neighbours are
 - Eigenvector Measure of Centrality Measure of centrality (importance) based not only on your own connections but on your neighbour's connections as well



Note: A complete network is one, where all the nodes are linked to every other node.

Mapping the network of the Indian banking system - 1

Size of the interbank market (total turnover) 14 9000 12 7000 Per cent 8 billion 5000 8 3000 6 4 1000 Mar 13 Mar 15 Sep 15 Mar 12 Mar 14 Size of the interbank market (RHS) ---- Interbank exposures as % of total assets --- Interbank exposure as % of total outside liabilities



Share of different bank groups in the interbank market

As of September 2015, the turnover in the interbank market is over `7 billion which is dominated by the public sector banks (PSBs). With an HH index of around 6, the interbank market displays a low concentration

Source: FSR, December 2015



Mapping the network of the Indian banking system - 2

- The network structure of the Indian banking system is tiered in nature, which implies that some banks are more connected than others
- In our graphical representation, the most connected banks are in the inner most circle of the network plot
- Network plots of different time periods helps in understanding the changing contours of the system
- The connectivity ratio a basic indicator of interconnectedness – has always hovered around 25%



Network structure of the Indian banking system-Sep 15

Source: FSR, December 2015

Mapping the network of the entire financial sector

- Data collected from different institutions are used to map the financial sector
- In the larger financial system, insurance companies followed by the AMC-MFs emerge as the largest fund providers, while NBFCs followed by private banks are the largest receiver of funds



Network plot of the Indian financial system-Sep 15

Source: FSR, December 2015



Contagion analysis

- ► A stress test to ascertain gross loss to the system due to domino effects
- Contagion analysis using network tools are conducted to ascertain loss to the system under three different conditions leading to:
 - Solvency Contagion
 - Liquidity Contagion
 - Joint Solvency-Liquidity Contagion

Solvency contagion analysis

- Solvency contagion estimates potential loss to the system due to the failure of a net borrower bank
- Insolvency of a bank will *impact its net lenders* thereby triggering a contagion
- If a lender bank's Tier I capital remains above the threshold (distress criteria) even after taking the hit, then the bank is considered to have survived and would not thus propagate further contagion
- A round by round or sequential algorithm for simulating contagion that is now well known from Furfine (2003) is followed in this model



Flowchart depicting a typical solvency contagion

Liquidity contagion analysis

- Liquidity contagion estimates potential loss to the system due to the failure of a net lender
- The basic assumption for the analysis is that a bank will initially dip into its liquidity reserves or buffers to tide over a liquidity stress caused by the failure of a net lender
 - Liquidity buffers=excess CRR + excess SLR + available MSF
- If the liquidity buffers alone are not sufficient, then a bank will call in all loans that are 'callable short term assets'





Flowchart depicting a typical liquidity contagion

Joint solvency-liquidity contagion analysis

- A bank typically has both positive net lending positions against some banks while against some other banks it might have a negative net lending position
- Therefore, failure of a bank is likely to generate both solvency and liquidity shocks simultaneously
- Joint solvency-liquidity contagion analysis captures this phenomenon



Flowchart depicting a joint solvency-liquidity contagion



Contagion analysis - *results*

Contagion triggered by select net borrower banks					Contagion triggered by select net lender banks			
	Percentage	loss of	total	Tier I		Percentage	e loss of	total Tier I
capital of the banking system					capital of the banking system			
Trigger	Solvency	Liquidity	Joint		Trigger	Solvency	Liquidity	Joint
Bank	contagion	contagion	solver liquidi conta	ncy ity gion	Bank	contagion	contagion	solvency liquidity contagion
Bank A	1.8	0.	4	2	Bank F	0.7	4.2	2 5.1
Bank B	4.2	0.	4	4.4	Bank G	0.1	1.2	2 1.8
Bank C	1.2	0.	4	1.6	Bank H	0.1	0.7	7 0.8
Bank D	2.4	0.	2	2.6	Bank I	2.1	7.(9.2
Bank E	2.1	0.	1	2.3	Bank J	0.4	4.3	3 5.0





Annex

- Criteria of selection of different financial institutions for network analysis sample
- Scheduled Commercial Banks (SCBs) all SCBs present in the system
- Insurance companies top 21 companies in terms of assets under management (AUM). Includes both life and non-life insurance companies
- Asset Management Companies managing Mutual Funds (AMC-MFs) top 22 AMC-MFs in terms of AUM
- Non Banking Financial Companies (NBFCs) 34 companies in the sample, which includes both deposit taking and non-deposit taking NBFCs. They have been selected on the basis of their asset size.
- Urban Co-operative Banks (UCBs) 20 UCBs in the sample. All of them are scheduled banks. They have also been selected on the basis of their asset size
- All India Financial Institutions All 4 institutions under this category are present in the network analysis sample (NABARD, NHB, SIDBI and Exim Bank)
- Average Path Length A measure of the distance between two nodes i.e., the number of directed links that separate them and this is referred to as their path length
- Shortest Path Length The average number of directed links between a node and each of the other nodes in the network
- In-betweenness Centrality This shows how shortest path lengths pass through a node

