On the Interconnectedness of FIs: Emerging Market Experience

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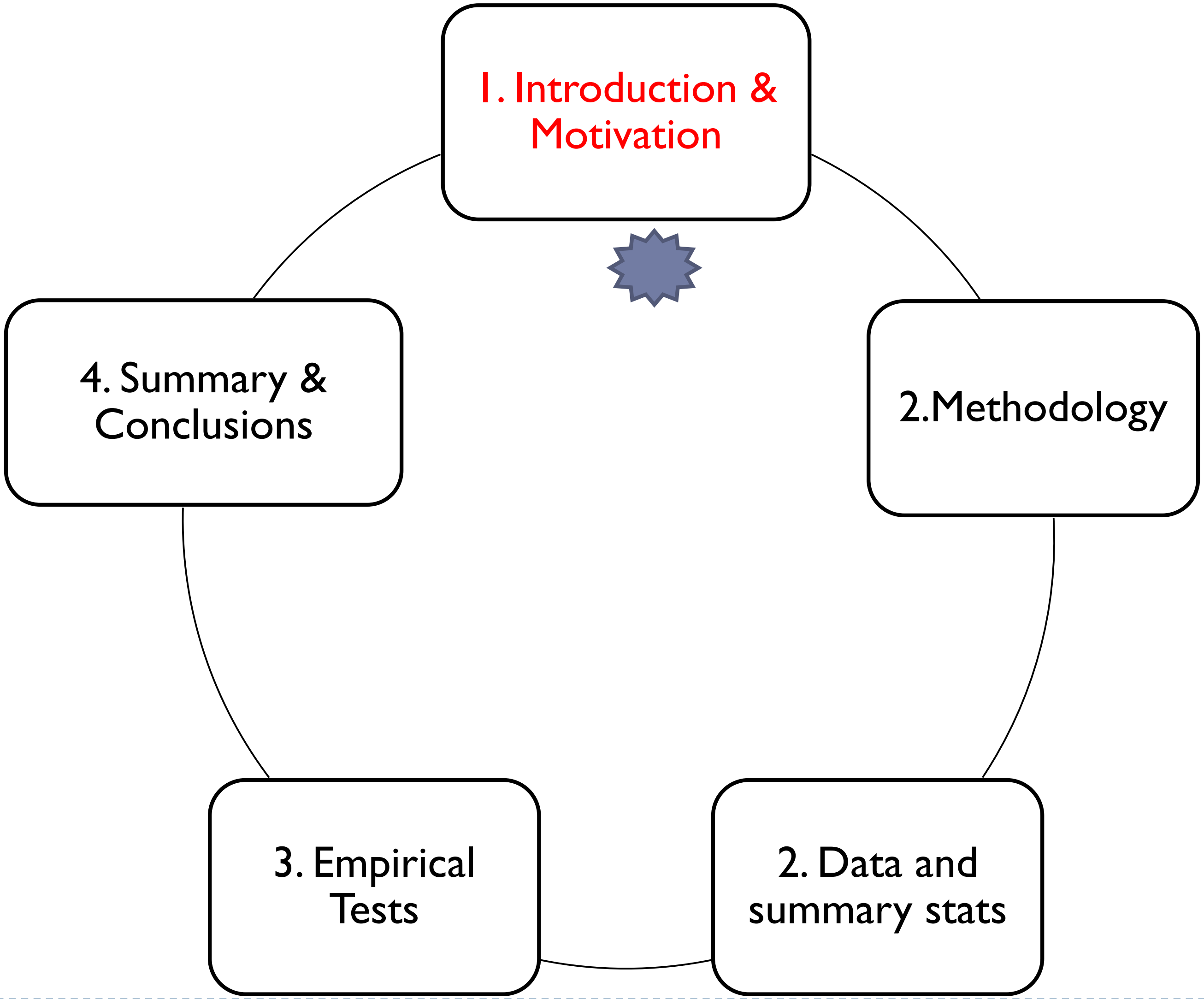
Agenda


1. Introduction & Motivation
2.Methodology
2. Data and summary stats
3. Empirical Tests
4. Summary & Conclusions

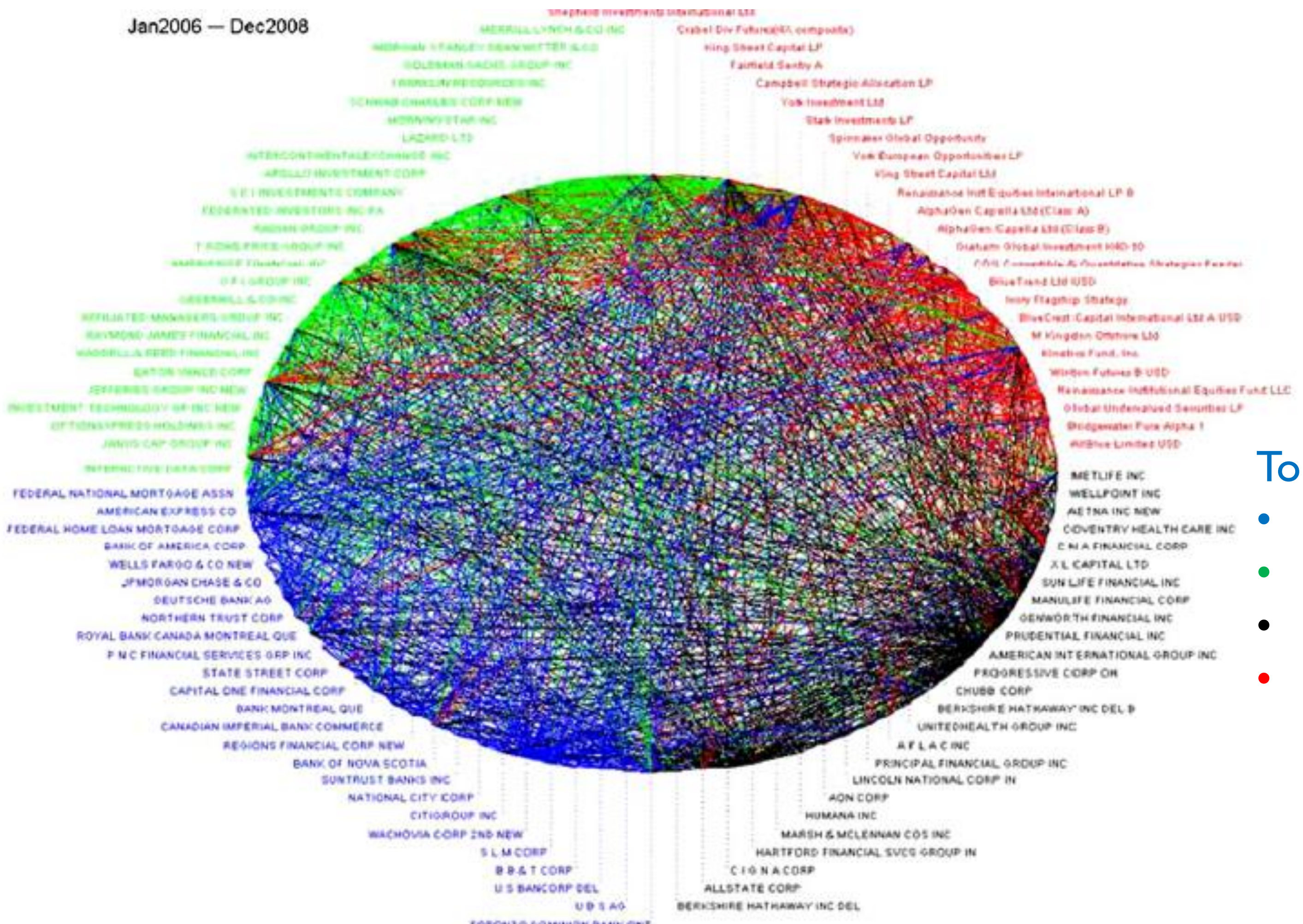
What is Systemic Risk?

- Systemic risk implies quick propagation of
  - illiquidity and insolvency risks, and financial losses
- through the financial system as a whole,
- impacting the connections and interactions among financial stakeholders,
  - especially so during periods of financial distress
  - (Billio, Getmanksy, Lo and Pelizzon, 2012)

Three aspects to systemic risk

- Magnitude (Large Impact)
- Widespread: affects a large number of entities or institutions,
- Ripple Effect that endangers the existence of the financial system.

Network diagram or Adjacency matrix (Billio et al., 2012)



Top 25 FIS:

- Banks
- Broker dealers
- Insurance
- Hedge funds

Fig. 3. Network diagram of linear Granger-causality relationships that are statistically significant at the 5% level among the monthly returns of the 25 largest (in terms of average market cap and AUM) banks, broker/dealers, insurers, and hedge funds over January 2006 to December 2008. The type of institution causing the relationship is indicated by color: green for broker/dealers, red for hedge funds, black for insurers, and blue for banks. Granger-causality relationships are estimated including autoregressive terms and filtering out heteroskedasticity with a GARCH(1,1) model.

Four sources of systemic risks (Allen and Carletti, 2013)

Banking related panics	Banking crises arising from falls in asset prices
Contagion	Foreign exchange mismatches in the banking system.

- They all lead to Asset price declines

Systemic risk & financial crisis

The 1987 crisis was a good example of *systematic risk*, i.e., a common factor driving asset correlations, and was large in effect,

unlike the systemic risks during 2008 crisis which adversely affected the wider financial system.

- During the pre-2008 crisis multiple potential vulnerabilities existed, including

weak financial firms

substantial interlinkages across these firms

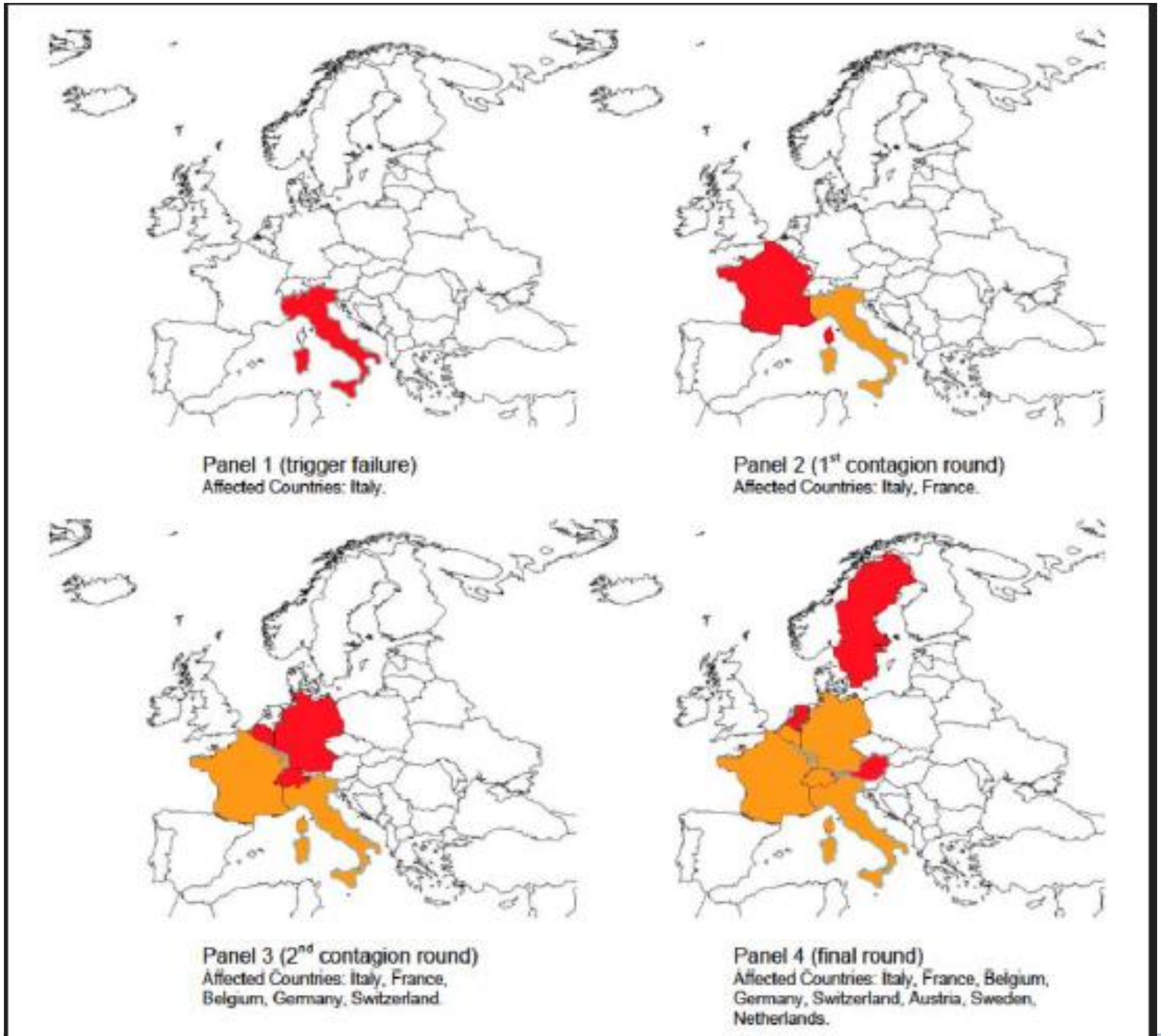
complex financial products

excessive leverage and maturity

funding mismatches fueled by the shadow banking system

(e.g., Brunnermeier, 2009; Adrian and Shin, 2010; Acharya, Schnabl and Suarez, 2013; Covitz, Liang and Suarez, 2013; Gorton and Metrick, 2012).

Contagion Networks (Espinosa-Vega & Sole, IMF 2010)



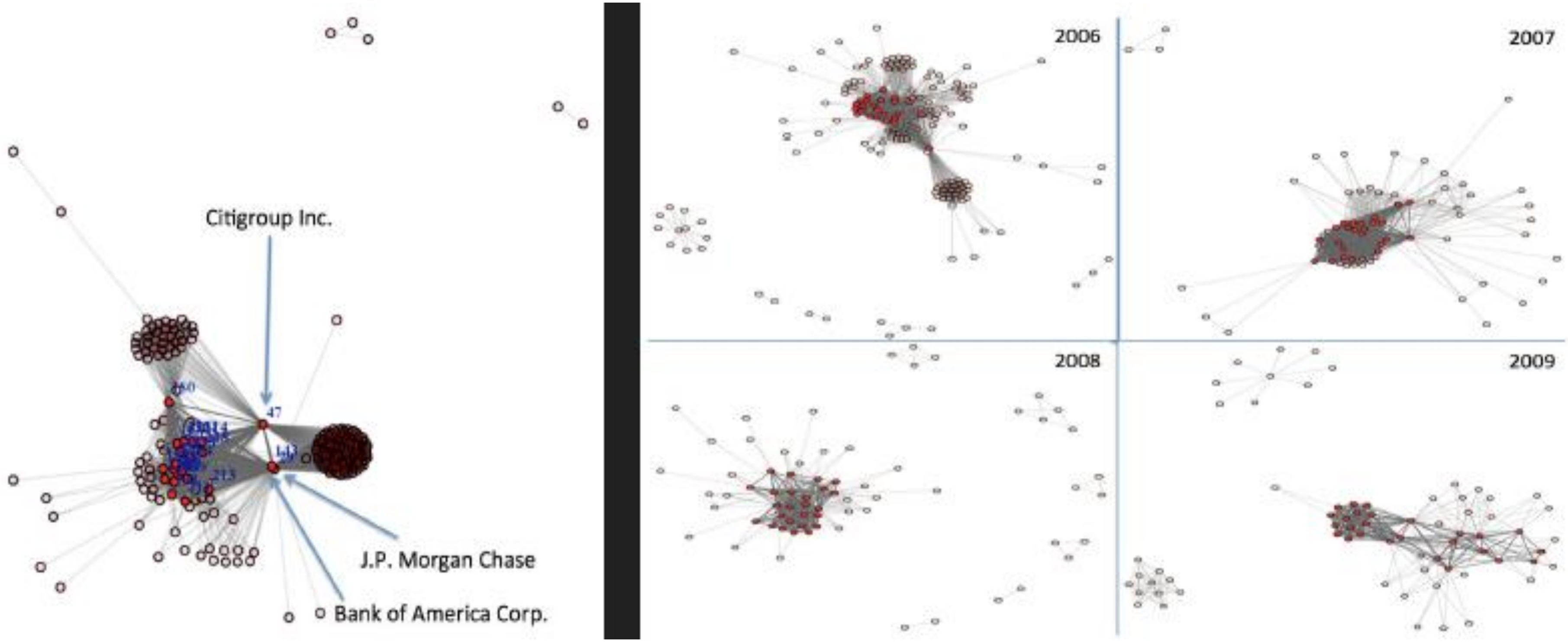
Panel 1 (trigger failure)
Affected Countries: Italy.

Panel 2 (1st contagion round)
Affected Countries: Italy, France.

Panel 3 (2nd contagion round)
Affected Countries: Italy, France, Belgium, Germany, Switzerland

Panel 4 (final round)
Affected Countries: Italy, France, Belgium, Germany, Switzerland, Austria, Sweden, Netherlands.

Interbank Loan Networks (US)



“Extracting, Linking and Integrating Data from Public Sources: A Financial Case Study,” Burdick et al., (2011)

In this paper..

- We undertake a large-scale empirical examination of systemic risk among major financial institutions in the emerging markets.
- We provide comparative analysis and new insights into policies for
  - measuring, managing and regulating systemic risk in the emerging market context.
- We consider four emerging market regions:
  - Asia,
  - EMEA (decomposed into Eastern Europe,& Southern Europe/Africa) and
  - Latin America, and
- evaluate relative systemic risks

Four broad Objectives

A. **Measurement:**
- Measuring systemic risk using data on financial entity linkages and their respective credit qualities.

B. **Decomposition:**
- Decomposing systemic risk by financial entity so as to understand how each entity impacts the system via risk decomposition.

C. **Management:**
- Managing systemic risk by understanding ways <u>in which financial linkages may be adjusted through regulation to dampen risk</u>.
  - When does the financial system become fragile, i.e., a local crisis in some financial entities spreads to many others?
  - When, if at all, should we break up too big to fail banks?

D. **Prediction:**
- Assessing whether or not we can predict systemic risk by econometrically relating it to macroeconomic and financial variables, uncovering useful lead-lag effects.

Previous literature: Measuring Systemic risk

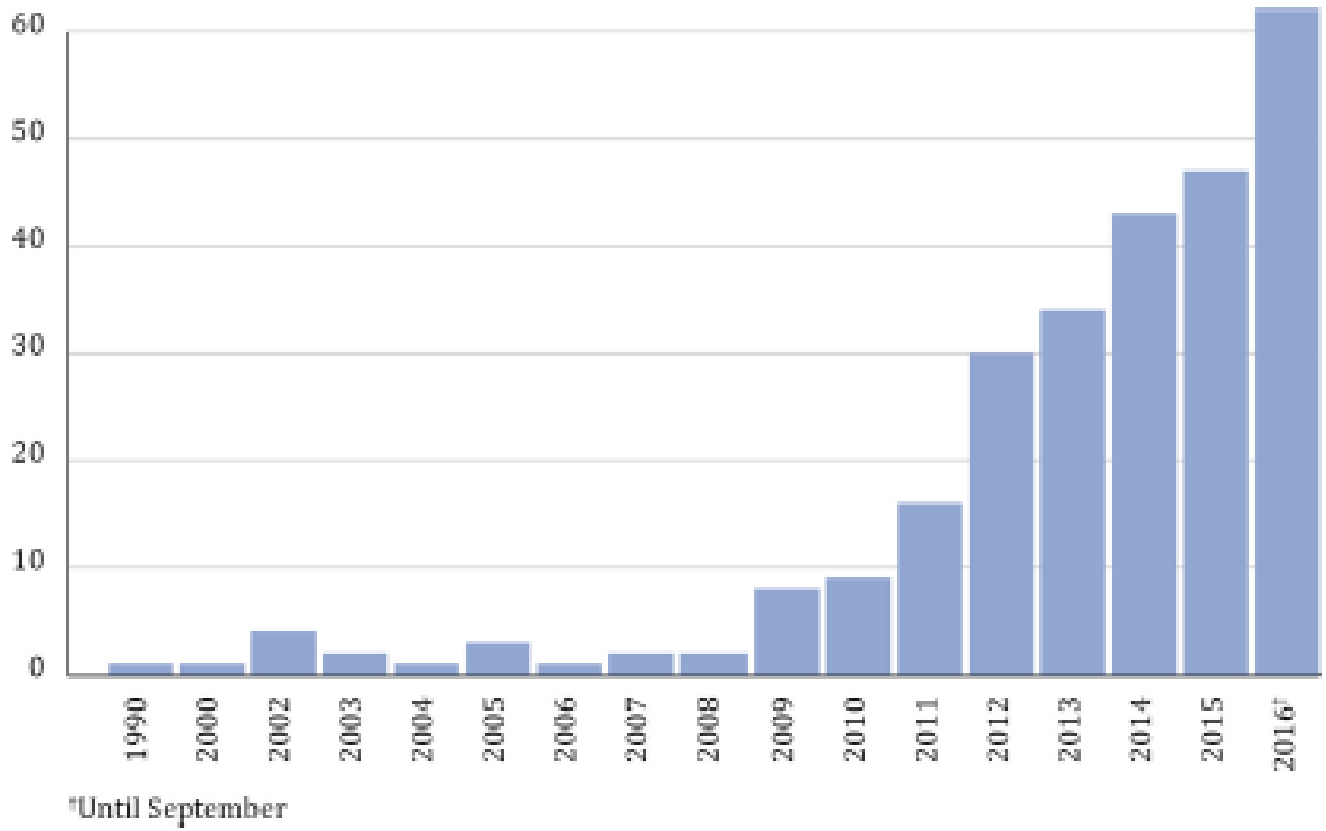
- *Cross-sectional Correlation Measures*
  - Distressed insurance premium (DIP) measure:
    - Huang, Zhou, and Zhu (2012)
  - Systemic expected shortfall (SES):
    - Acharya, Pedersen, Philippon and Richardson (2010)
  - Systemic Risk Measurement (or SRISK):
    - Brownlees and Engle (2015)
  - Conditional value at risk (CoVaR) model:
    - Adrian and Brunnermeier (2011)

- *Network-Based Measures*
  - Network analysis is built from data on direct interconnections between firms and
  - allows regulators to estimate how the distress of a given firm would directly affect the other firms in the network.
    - Billio, et al., (2012, 2013), Diebold and Yimaz (2014)-LASSO

Previous literature: Applications

- Ahern (2013): networks and cross-sectional asset pricing
  - shows that industries that are more central in the network of intersectoral trade earn higher stock returns than industries that are less central.
- Li and Zinna (2014) find that the US and UK differ not only in the evolution of systemic risk but, in particular, in their banks' systemic exposures.
  - Their results suggest that sovereign and bank systemic risk are particularly interlinked in the UK
- Giglio, Kelly and Pruitt (2016) study how systemic risk and financial market distress affect the distribution of shocks to real economic activity.
- Karolyi, Sedunov and Taboada (2016) document that cross-border bank flows reduce systemic risk by improving banks' asset quality, efficiency, and reliance on nontraditional revenue sources.

Number of articles on Systemic risk per year (JFS,2017)



But limited work on emerging markets

- Sensoya (2017, JFS) finds evidence from Turkey supporting the hypothesis that institutional ownership leads to an enhanced systematic liquidity risk by increasing the commonality in liquidity.

- Borrri (2017) adopt the CoVaR risk-measure to estimate the vulnerability of individual countries to systemic risk in the market for local currency government debt.

- Le and Dickinson (2016): Investigate the systemic risk of cross-border banking in East Asia.
  - They test the probability of the sudden stop in international lending and its simultaneous effect on the host countries' interbank markets.

Our Contribution

- A comprehensive analysis of systemic risks in emerging markets

- Overall, we extend the literature on network models by incorporating credit quality information in order to
  - compute a single summary systemic risk score that summarizes the level of systemic risk across all emerging market financial entities.
  - Understand the cross-sectional and time series dynamics of the systemic risk

- Our objectives serve the needs of academics, regulators, and financial practitioners.

Contributions -I

- We extend Billio et al., (2012) in terms of constructing the GC based network matrix and our systemic risk score S as well.
  - Our measure is closer to Billio et al. (2012) and CoVaR, versus the SES measure in terms of direction of risk.

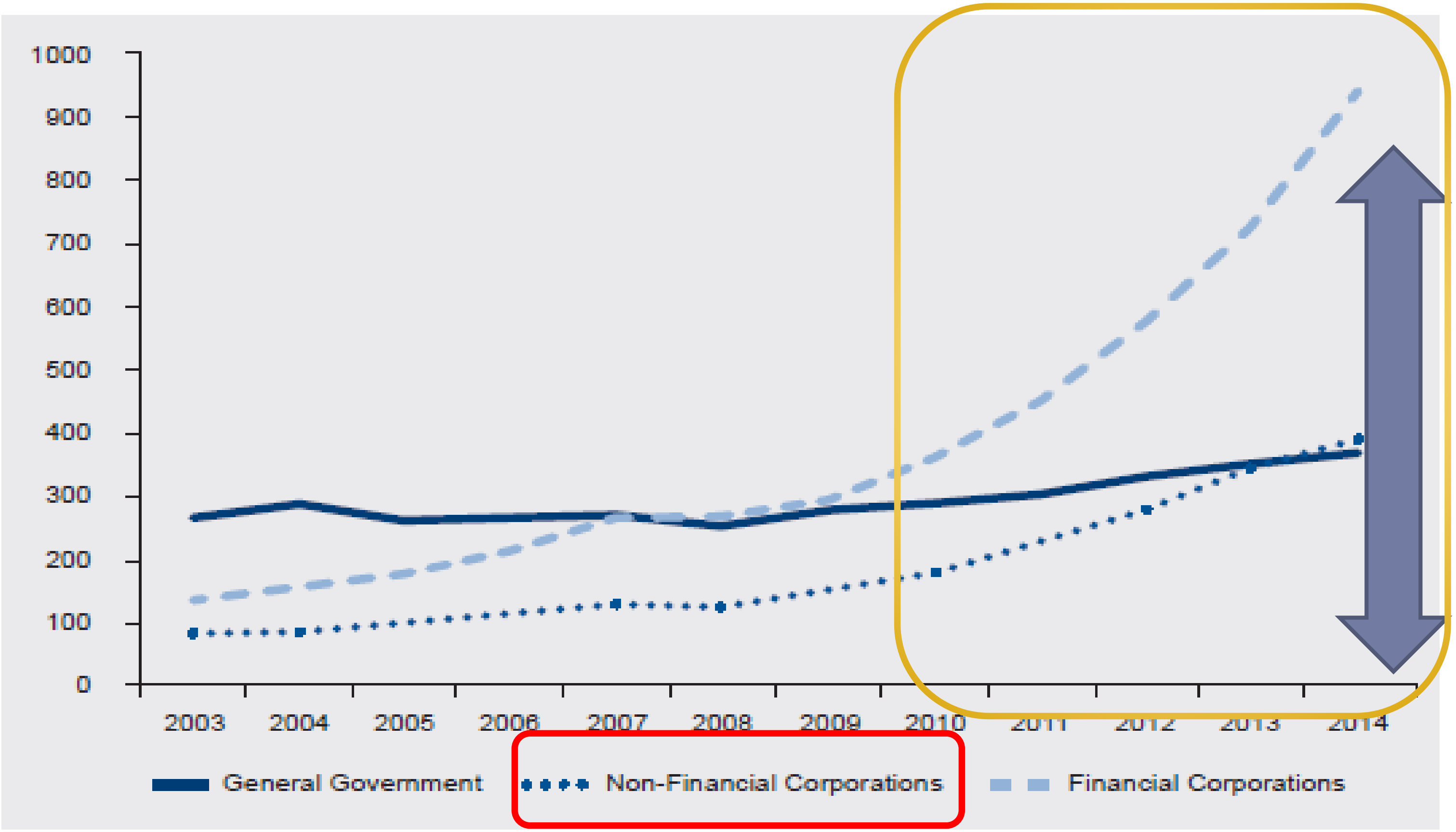
- Network versus correlation measures
  - Forward vs backward looking
  - Network-based measures directly model the underlying mechanics of the system by decomposing the systemic risk into network effect (connectivity) and individual bank risk (compromise)

Contributions – emerging market context. Why emerging markets ?

I. Emerging market corporate loans and debt rose from 73% of GDP at the end of 2007 to 107% (or 127% if we include shadow banking debt) of GDP by the end of 2014.

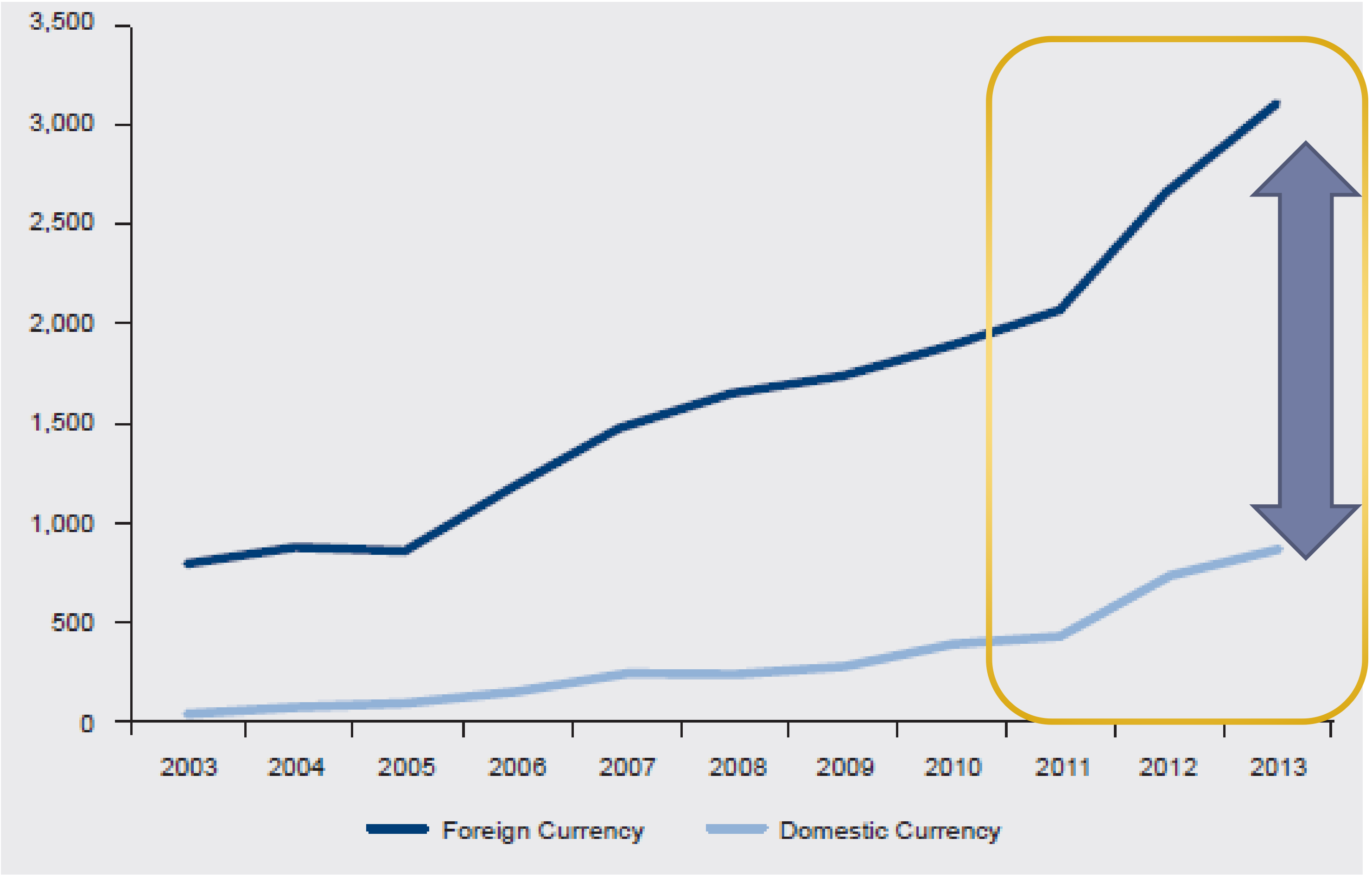
II. Offshore issuance of corporate bonds in foreign currency mainly by non-financial corporations has resulted in
   - currency mismatch on the consolidated balance sheets of emerging market firms (Shin, 2013)
   - increased borrower's interest rate, rollover and currency risks (Chui, Fender and Sushko , 2014)

International bond issuance by Emerging Market Economies ($ Bi)



Note: Emerging market includes Argentina, Brazil, Chile, China, Colombia, India, Indonesia, Israel, Korea, Malaysia, Mexico, Philippines, South Africa, Thailand, and Turkey. Financial corporations include banks and other financial corporations.
Source: BIS.

Currency Composition of Outstanding Emerging Market Bonds



Note: Billions of U.S. dollars on vertical axis.
Source: World Bank database

Bond Issuance by Emerging Market Nonfinancial Corporates (Cumulative Amounts, 2000-2013)

	Bonds			Firms
	Number of Issues	Volume in US$ Bn	Mean in US$ Mn	Number of Issuers
Bonds at International Markets				
Total	2,391	971	406	890
Latin America	1,037	518	500	301
Africa & Middle East	121	77	640	55
Emerging Europe	328	161	491	157
Emerging Asia	905	214	237	377
Bonds at Local Markets				
Total	10,808	1,260	117	1883
Latin America	1,559	266	170	551
Africa & Middle East	317	64	203	81
Emerging Europe	950	147	155	427
Emerging Asia	7,982	783	98	824

Source: Adapted from Fuertes and Serena (2014).

Why emerging markets?

III. Having obtained funds abroad, the foreign affiliate of a non-financial corporation normally transfer funds to its home country via three channels (Avdjiev, Chui and Shin, 2014):
   - it could lend directly to its headquarters (within company flows),
   - extend credit to unrelated companies (between-company flows) or
   - make across-border deposit in a bank (corporate deposit flows).

- Excessive corporate leverage can lead to increased risk exposure for banks.

- If the high leverage though foreign debt is not adequately hedged by emerging market firms in the face of
  - commodity and
  - currency market shocks and global monetary policy developments (e.g. U.S. QE taper-tantrum),
- it can further exacerbate the risks to domestic banks.

Why emerging markets?
Impact of Quasi-Exogenous events

IV. Furthermore, it will be interesting to examine how episodes such as "taper-tantrums" and "recent demonetization" can impact systematic risks of banks.

- Demonetization and regulatory efforts towards cashless economy in India will likely increase liabilities of its banks, and
- expand their balance sheets, thereby promoting greater financial linkages.

Key findings

- Regressions explaining cross-sectional and time-series evolution of systemic risk:
  - Systemic risks decomposed into credit and network risks with a considerable variation across country groups .

- Correlations of systemic risk:
  - Contemporaneous correlations matter far more than lagged correlation.
    - India is relatively isolated from other country groups.

- Granger causality of systemic risk:
  - Dependence on AR(1) variable is usually strong (the diagonal terms) but dependence on cross-lagged variables are usually weak. India is again found to be isolated from other groups

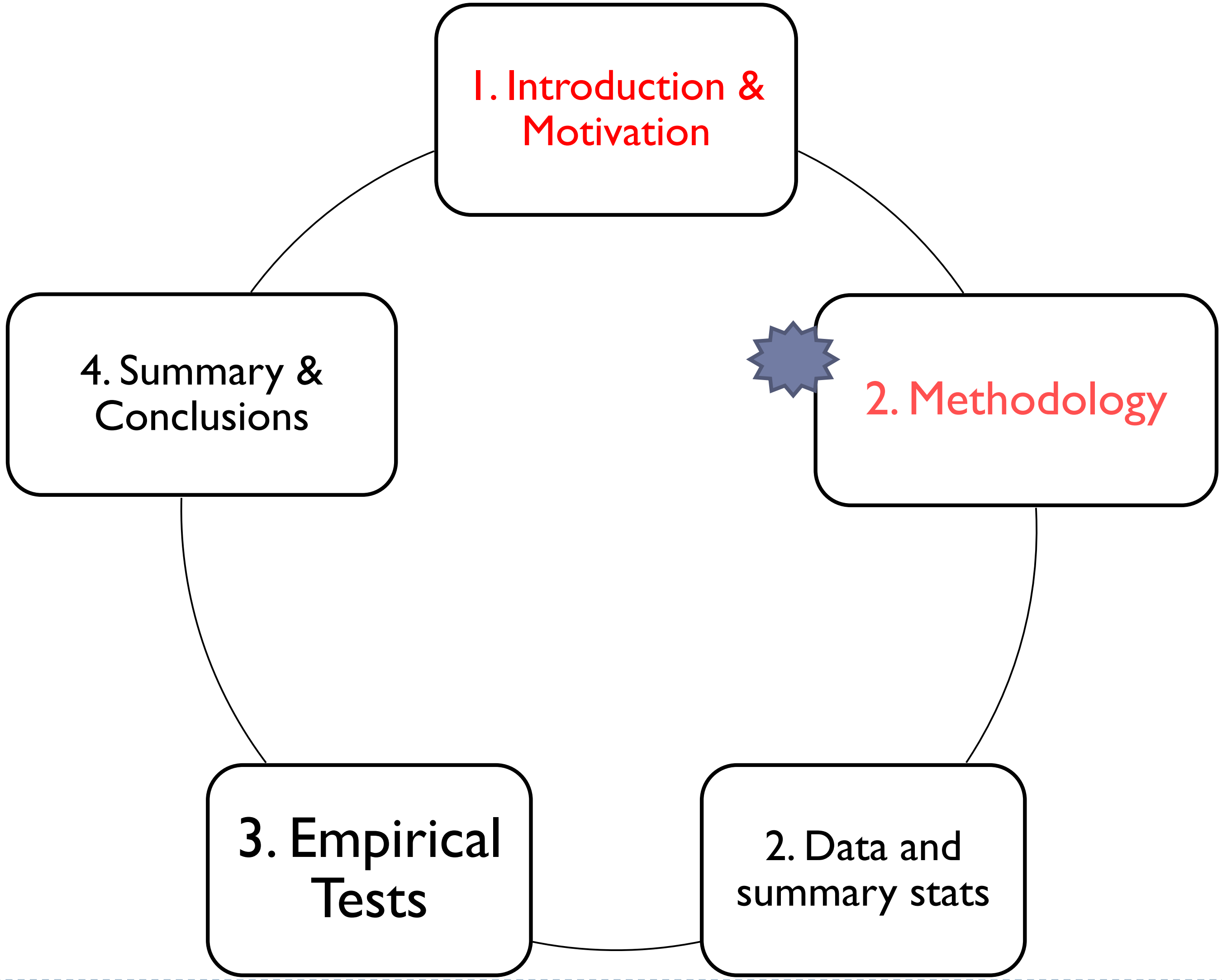
Key findings

- VAR analysis of systemic risks:
  - Contemporaneous dependence of systemic risk matters far more that lagged inter-dependence in country groups.

- PCA analysis of all emerging market systemic risks :
  - shows that over three factors explain 90% of the systemic risk variation in emerging markets;
    - the 1st factor is related to the crisis (US default spreads)
    - 3rd factor is related to the taper tantrum (US VIX) and
    - 2nd and 3rd factors are related to the recent exchange crisis .

- Out of sample tests – in progress

Agenda



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Systemic Analysis and SIFI

- The Dodd-Frank Act (2010) and Basel III regulations characterize a systemically risky FI as one that is
  - 1. Large;
  - 2. Complex;
  - 3. Interconnected;
  - 4. Critical, i.e., provides hard to substitute services to the economy.
- The DFA does not provide quantification guidance.

- Definition:
  - the measurement and analysis of relationships across entities with a view to understanding the impact of these relationships on the system as a whole.
- Challenge:
  - requires most or all of the data in the system; therefore, high-quality information extraction and integration is critical.

Attributes of Systemic Risk Measures

- Systemic risk is an attribute of the economic system and not that of a single entity.
- Its measurement should have two important features:
  - 1. Quantifiability (Aggregation): must be measurable on an ongoing basis.
  - 2. Decomposability (Attribution): Aggregate system-wide risk must be broken down into additive risk contributions from all entities in the system.
- Financial institutions that make large risk contributions to system-wide risk are deemed "systemically important."

Methodology

A. Measurement
B. Decomposition
C. Management
D. Prediction

Methodology: A.Measurement

- The measure of systemic risk will generate a score denoted *S*, based on the extension of theory paper by Das (2016).
- We undertake a large-scale empirical implementation of this model using data on many major financial entities from emerging markets.
- The systemic risk score is computed as follows:

One Score for Systemic Risk

$$S = \frac{1}{n}\sqrt{C^{\top} \cdot A \cdot C} \geq 0$$

Systemic score total

banks (normalization across time)

Adjacency matrix

$A(i,j)$ in $(0,1)$
$A(i,i) = 1$

Vector of credit risk scores {PD, rating, etc}. Higher = more risk

Incl value weights

$C(i) > 0$

Because we normalized the score by n, we may compare this score across countries, and across epochs for the same country. The S score represents a per-bank, dollar-weighted, and network-weighted credit risk measure for the entire financial system.

B.Decomposition

- We are also interested in understanding which emerging market financial entities pose the greatest threats to the financial system through their contribution to systemic risk.

- Using Euler's Theorem, systemic risk may be decomposed into the risk contribution of each financial entity.

$S(C,A)$ is linear homogenous in C

Apply Euler's Formula

$$S = \frac{\partial S}{\partial C_1} C_1 + \frac{\partial S}{\partial C_2} C_2 + \ldots + \frac{\partial S}{\partial C_n} C_n = \sum_{i=1}^{n} \frac{\partial S}{\partial C_i} C_i$$

Risk Contribution

Risk Increment & Risk Decomposition in closed form

$$\frac{\partial S}{\partial C} = \frac{1}{2n^2 S}[A \cdot C + A^\top \cdot C] \in \mathcal{R}^n$$

Closed vector form makes computation facile.

Systemic score by a FI

$$\frac{\partial S}{\partial C_i} \cdot C_i = \frac{1}{2n^2 S} \cdot [A \cdot C + A^\top \cdot C] \odot C$$

$$S = \left[\frac{\partial S}{\partial C_i} \cdot C_i \right] \cdot 1$$

Total Systemic Risk Score

Both, risk contribution and risk increment…

- are useful in identifying the source of system vulnerabilities, and in remediation.
- In assessing whether a node should be allowed to fail, we may disconnect it from the network and assess how these metrics are impacted.
- This systemic risk decomposition may be used to identify SIFIs (Dodd-Frank Act, 2010).

Network construction

Billio, Getmansky, Lo, Pelizzon (2012)

$$r_{j,t} = a + b \cdot r_{j,t-1} + c \cdot r_{i,t-1} + e_{j,t}$$

return

Significant,
p-value <0.01

$$r_{j,t} = a + b \cdot r_{j,t-1} + c \cdot r_{i,t-1} + d \cdot r_{EW,t-1} + e_{j,t}$$

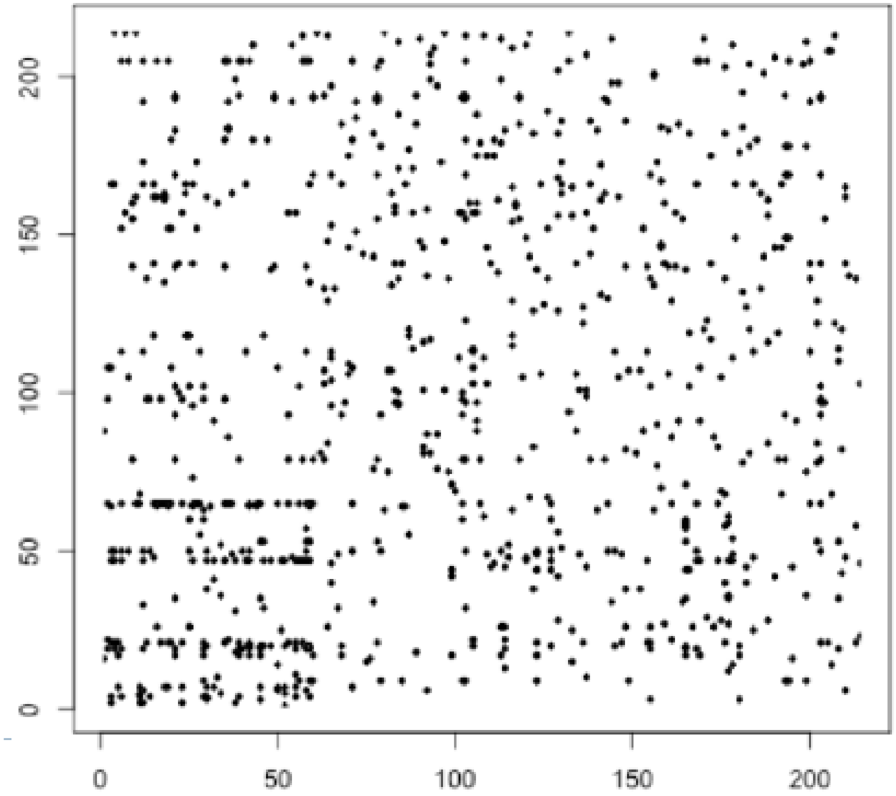
Lookback period = 130 days

Equally weighted return

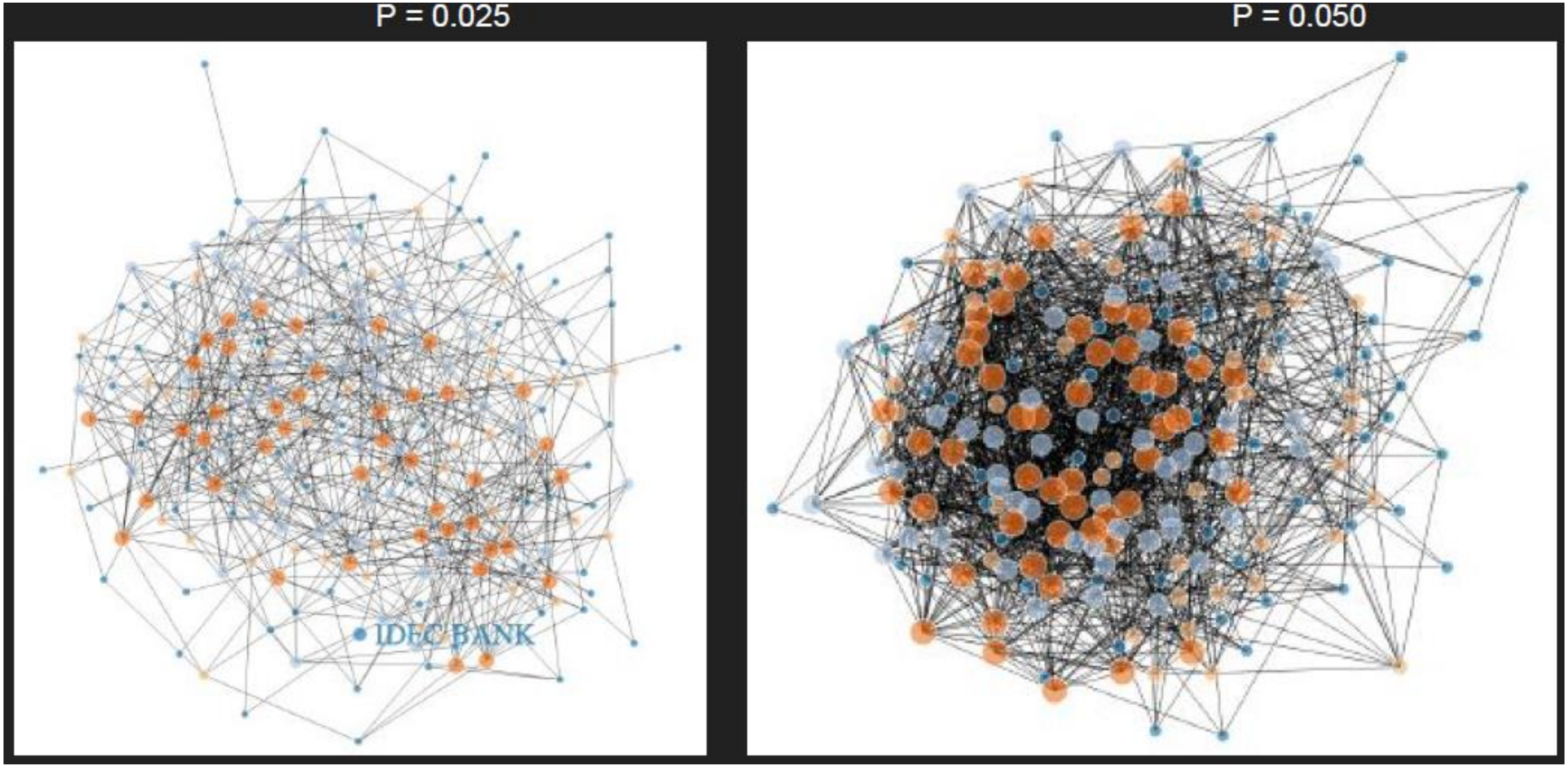
Exclude banks that have more than ⅓ days with zero returns

Adjacency matrix for Q4 2016

A dot in row i and column j means that $A(i,j) = 1$. For this period, there are 214 banks that made it through the filters above. To construct this matrix we ran $n(n-1) = 45,582$ regressions. The number of cells in the adjacency matrix that are of value 1 is 1.83%. The diameter of the network (longest shortest path between any two nodes) is 9, and the average degree (incoming and outgoing links) per node is 7.79.



Network (we use p=0.025 in the paper)



We estimate several Systemic risk attributes

- Centrality
  - Betweenness centrality
- Diameter
- Fragility
- Degree
  - Degree HHI
- Clusters
  - Degree HHI

- We next describe each of them.

Systemic risk attributes

- 1.Centrality: How much each bank is exposed to the risk?
  - the importance of any node in the network in terms of its loading in the principal eigenvector calculated from an eigenvalue decomposition of the network adjacency matrix

- 2. Betweenness centrality for each bank in the network,
  - which is a measure of "how central is the bank's position".

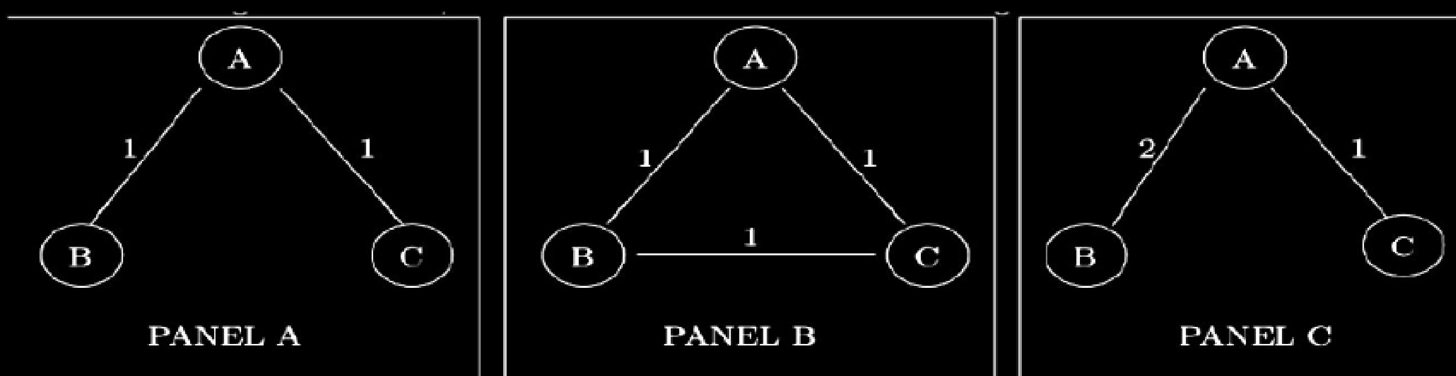
  - See next slide

Centrality (Bonacich 1987)

$$c_i = \sum_{j=1}^{n} A_{ij} c_j, \forall i$$

Eigenvalue Centrality

- Similar to PageRank by Google.
- Adjacency matrix: $A_{ij} \in \mathcal{R}^{N \times N}$
- Influence: $x_i = \sum_{j=1}^{N} A_{ij} x_j$
- $\lambda \mathbf{x} = \mathbf{A} \cdot \mathbf{x}$
- Centrality is the eigenvector $\mathbf{x}$ corresponding to the largest eigenvalue.



$\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$ $\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$ $\begin{bmatrix} 0 & 2 & 1 \\ 2 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$

Centrality scores = {0.71, 0.50, 0.50}

Centrality scores = {0.58, 0.58, 0.58}

Centrality scores = {0.71, 0.63, 0.32}

Centrality contd.

$$c_i = \sum_{j=1}^{n} A_{ij} c_j, \forall i$$

Eigenvalue Centrality

$$b_v = \sum_{\substack{i,j \\ i \neq j \\ i \neq v \\ j \neq v}} \left[\frac{g_{ivj}}{g_{ij}} \right]$$

Betweenness Centrality

- The g_ivj is the number of shortest paths between nodes i and j that pass through node v,
-
- g_ij is the number of shortest paths between i and j.

Systemic risk attributes contd.

- 3. Diameter: contagion travels further when diameter is low.

- 4. Fragility: How susceptible the network is to a local problem becoming a global one?

- Definition: how quickly will the failure of any one node trigger failures across the network? Is network malaise likely to spread or be locally contained?
- Metric:

$$R = \frac{E(d^2)}{E(d)},$$

where d is node degree. i.e. the number of connections it has to other nodes

- Similar to a normalized Herfindahl Index.

Concentration of degree induces fragility.

Systemic risk attributes contd.

- 5. Degree : the number of connections of each node, which characterizes how interconnected the network is.

- 6. Degree HHI: where the Herfindahl index of node degree describes the extent of concentration in the network
  - (more concentrated networks support contagion because of their hub and spoke shape).

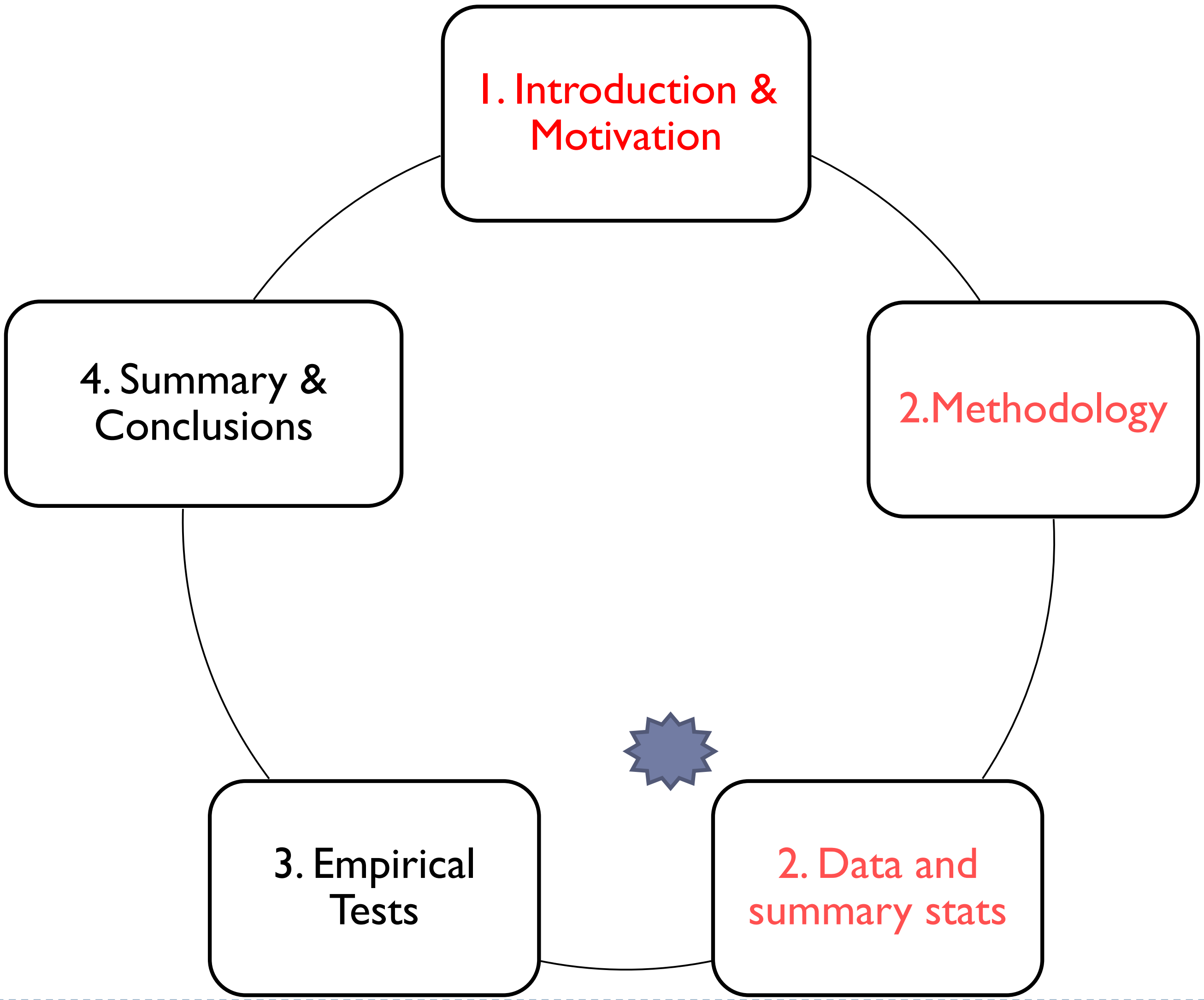
- 7. Clusters, and the cluster HHI, where a cluster is an independent group of nodes that is not connected to any other group of nodes.
  - The greater the number of disconnected clusters, the less likely we might have economic contagion,
  - but the more concentrated nodes are in a single cluster we have a greater chance of contagion and systemic risk

Methodology contd.

- c) Management:
  - First, we create a list of key events in the time line and assess how S responded to these events.
    - This will inform us as to what types of events cause systemic risk to exacerbate, and thus we can be better prepared to control system wide shocks once their related events are known.
  - Second, we break down the changes in S, i.e., $S(t)-S(t-1)$ over time into attributing it to changes in $\boldsymbol{C}$ and changes in $\boldsymbol{E}$.

- d) Prediction:
  - Having determined the time series of systemic risk $S(t)$, $t=1 \ldots T$, we examine what economic and financial variables it is correlated to.
  - We consider contemporaneous and lead-lag relationships.
  - We run both GC regressions and vector auto-regressions (VAR). And PCA decomposition.

Agenda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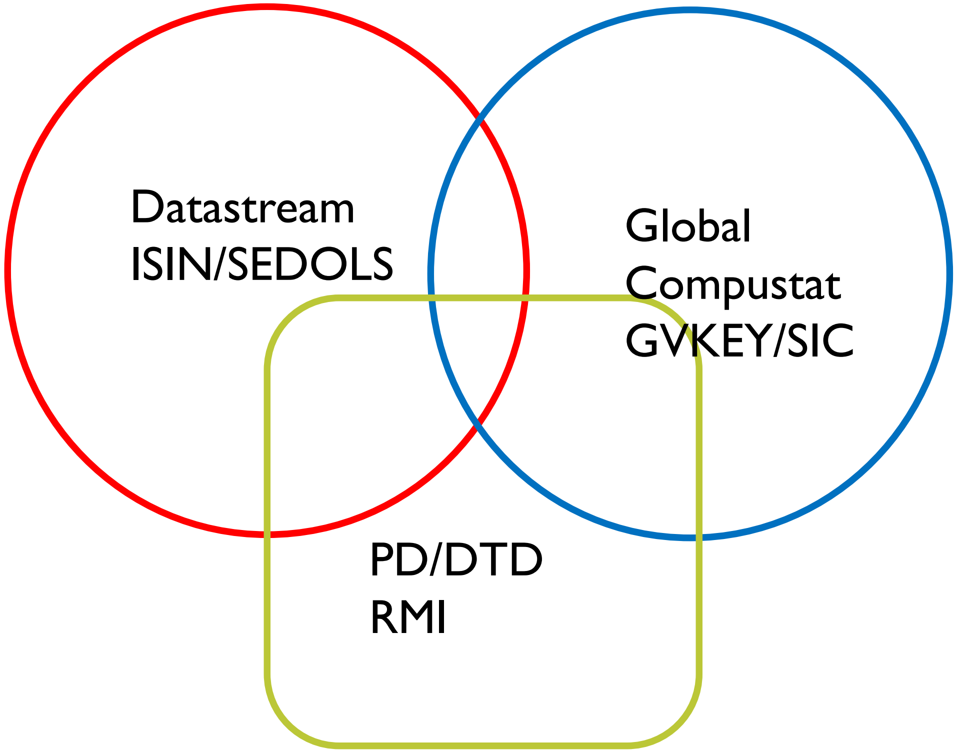
Data sources: Emerging markets



We identify the list of emerging countries by combining the IMF's & MSCI's lists of emerging countries. Out of the 28 emerging countries from the IMF's and MSCI's lists, 23 emerging countries have CDS data available in Markit database.

1.Argentina.xlsx
2.Brazil.xlsx
3.Bulgaria.xlsx
4.Chile.xlsx
5.China.xlsx
6.Columbia.xlsx
7.Czech.xlsx
8.Egypt.xlsx
9.Greece.xlsx
10.Hungary.xlsx
11.India.xlsx
12.Indonesia.xlsx
13.South Korea.xlsx
14.Malaysia.xlsx
15.Malaysia.xlsx
15.Mexico.xlsx
16.Phillipines.xlsx
17.Poland.xlsx
18.Russia.xlsx
19.South Africa.xlsx
20.Taiwan.xlsx
21.Thailand.xlsx
22.Turkey.xlsx
23.Ukraine.xlsx

Sample selection

- Identify financial firms that are active firms, and have common equity that are major securities trading in a primary exchange in the local market.

- Filter out
  a. non-financial firms,
  b. inactive (delisted) firms,
  c. firms with only preferred stock,
  d. foreign firms trading in local exchanges, and
  e. firms trading exclusively in either a minor local exchange or a foreign exchange,
  f. reject firms with less than 125 active trading days (six months).

Based on SIC codes, we categorize firms into four groups

a) Banks (SIC: 6000-6199)

b) Broker-Dealers (SIC: 6200-6299)

c) Insurers (SIC: 6300-6499)

d) Others (all other SICs)

- Eliminate firms with no SIC code and firms classified as others
  - (which include financial subsidiaries of non-financial corporations and specialized investment vehicles such as funds, REITs and securitized assets).

Extract Balance sheet variables (Datastream)

1. Log(Assets) and Log(Market Cap) as measures of firm size in terms of book value of assets and market value of equity, respectively;
2. Loans/Assets and Loans/Deposits ratios to capture banks' focus on traditional lending activities and core financing activities (these ratios are set to zero for non-bank financial institutions);
3. Debt/Assets and Debt/Equity ratios to capture leverage;
4. Debt/Capital as a measure of the liquidity position of the financial firm;
5. ROA (return on assets) and ROE (return on equity) as measures of operating performance of the financial firm; and
6. Market/Book value of equity ratio of the financial institution as a measure of the stock price based performance.

Consider our data sample for India

- Extract 838 Indian firms from the Datastream database.

INDUSTRY	TOTAL NUMBER	NUMBER WITH VALID RETURNS	RATINGS	DTD	PD
Bank	193	193	20	176	177
Broker-Dealer	191	191	0	177	177
Insurer	3	3	0	2	2
Total	387	387	20	355	356

Sample of Indian banks

Table 1: Bank Identification Data. This table contains a sampling of the bank name, and various other identification information.

MNEMONIC	ISIN	SEDOL	NAME	INDUSTRY	GVKEY	SIC
IN:ALN	INE428A01015	6708289	ALLAHABAD BANK	Bank	272772	6020
IN:CKB	INE476A01014	6580012	CANARA BANK	Bank	255701	6020
IN:ICG	INE090A01021	BSZ2BY7	ICICI BANK	Bank	223148	6020
IN:SBK	INE062A01020	BSQCB24	STATE BANK OF INDIA	Bank	203666	6020
IN:UBI	INE692A01016	6579634	UNION BANK OF INDIA	Bank	257156	6020
IN:TYA	INE865C01022	B0HXGC5	ADITYA BIRLA MONEY	Broker-Dealer	289796	6211
IN:ERE	INE143K01019	B56JDC8	ESSAR SECURITIES	Broker-Dealer	293675	6200
IN:KGC	INE929C01018	B03K039	K L G CAPITAL SERVICES	Broker-Dealer	289851	6211
IN:NKK	INE526C01012	B03J1D3	NIKKI GLOBAL FINANCE	Broker-Dealer	296350	6211
IN:UEI	INE519C01017	B5NH8B9	SUMMIT SECURITIES	Broker-Dealer	296724	6211
IN:BFS	INE918I01018	B2QKWK1	BAJAJ FINSERV	Insurer	288902	6300

Overall Emerging market data sample

	Group 1	Group 2	Group 3	Group 4	Group 5
	South America	Eastern Europe	South Europe & Africa	East Asia	India
Countries	Argentina, Brazil, Chile, Columbia, Mexico	Bulgaria, Czech, Hungary, Poland, Russia, Ukraine	Egypt, Greece, South Africa, Turkey	China, Indonesia, Malaysia, Philippines, South Korea, Taiwan, Thailand	India
# of Banks	33	55	53	181	180
# of Brokers-Dealers	14	35	30	106	179
# of Insurers	10	10	19	70	3
Total firms	57	100	102	357	362

Distribution of Centrality-Indian sample

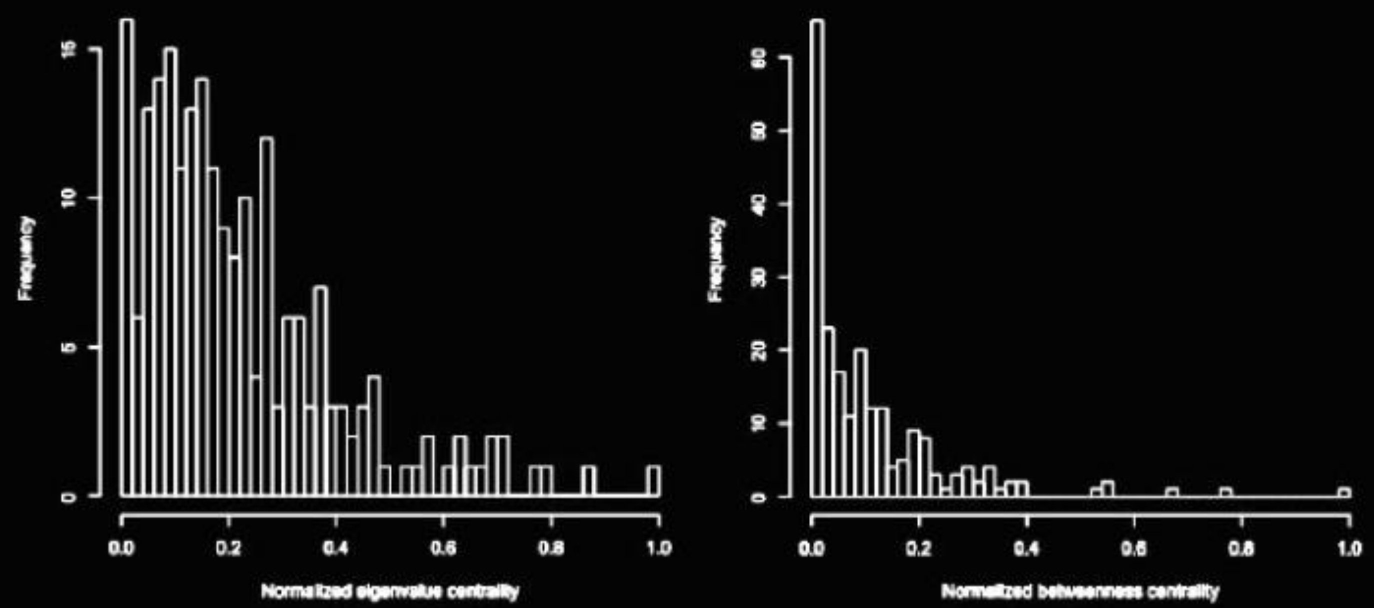


Figure 3: Distribution of Eigenvalue Centrality and Betweenness Centrality for all the nodes in the network, for Q4 2016. The centrality is normalized, so that it ranges from 0 to 1.

Top 20 Indian Banks, Q4 2016

Bank	EVCENT	BCENT
PRITI MERCANTILE COMPANY	1.000000	0.217527
DHANLAXMI BANK	0.879521	0.289056
BANK OF MAHARASHTRA	0.797941	0.033656
INDIAN BANK	0.771766	0.033376
UCO BANK	0.710815	0.082385
UNITED BANK OF INDIA	0.708690	0.033280
RR FINL.CONSULTANTS	0.694695	0.135618
UNION BANK OF INDIA	0.687011	0.047011
CENTRAL BANK OF INDIA	0.675282	0.667370
IFCI	0.656577	0.053150
P N B GILTS	0.633888	0.248902
GLOBAL CAPITAL MARKETS	0.629967	0.375415
J M FINANCIAL	0.601884	0.132343
CORPORATION BANK	0.564888	0.000000
INTER GLOBE FINANCE	0.562848	0.533449
STATE BANK OF INDIA	0.548690	0.175723
BANK OF BARODA	0.539016	0.009665
S P CAPITAL FINANCING	0.497271	0.022460
SOUTH INDIAN BANK	0.476020	0.091634
TRANSWARRANTY FINANCE	0.472221	0.072575

Number of Banks in the network

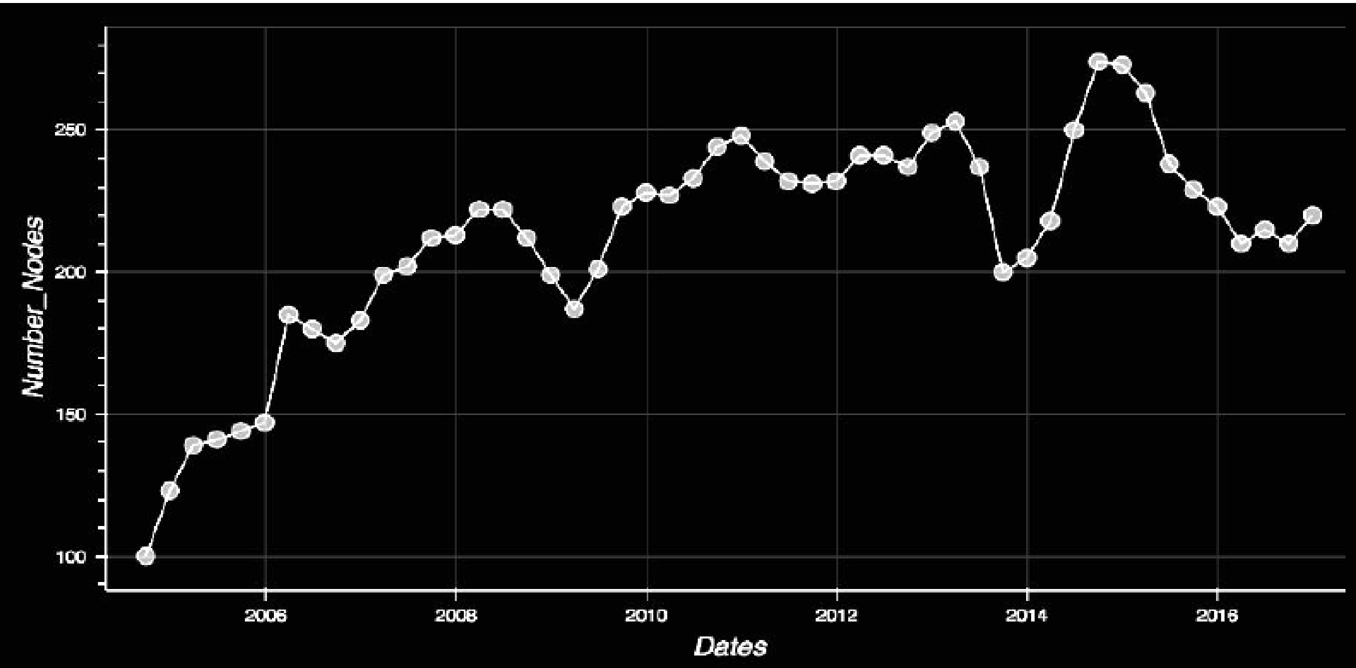
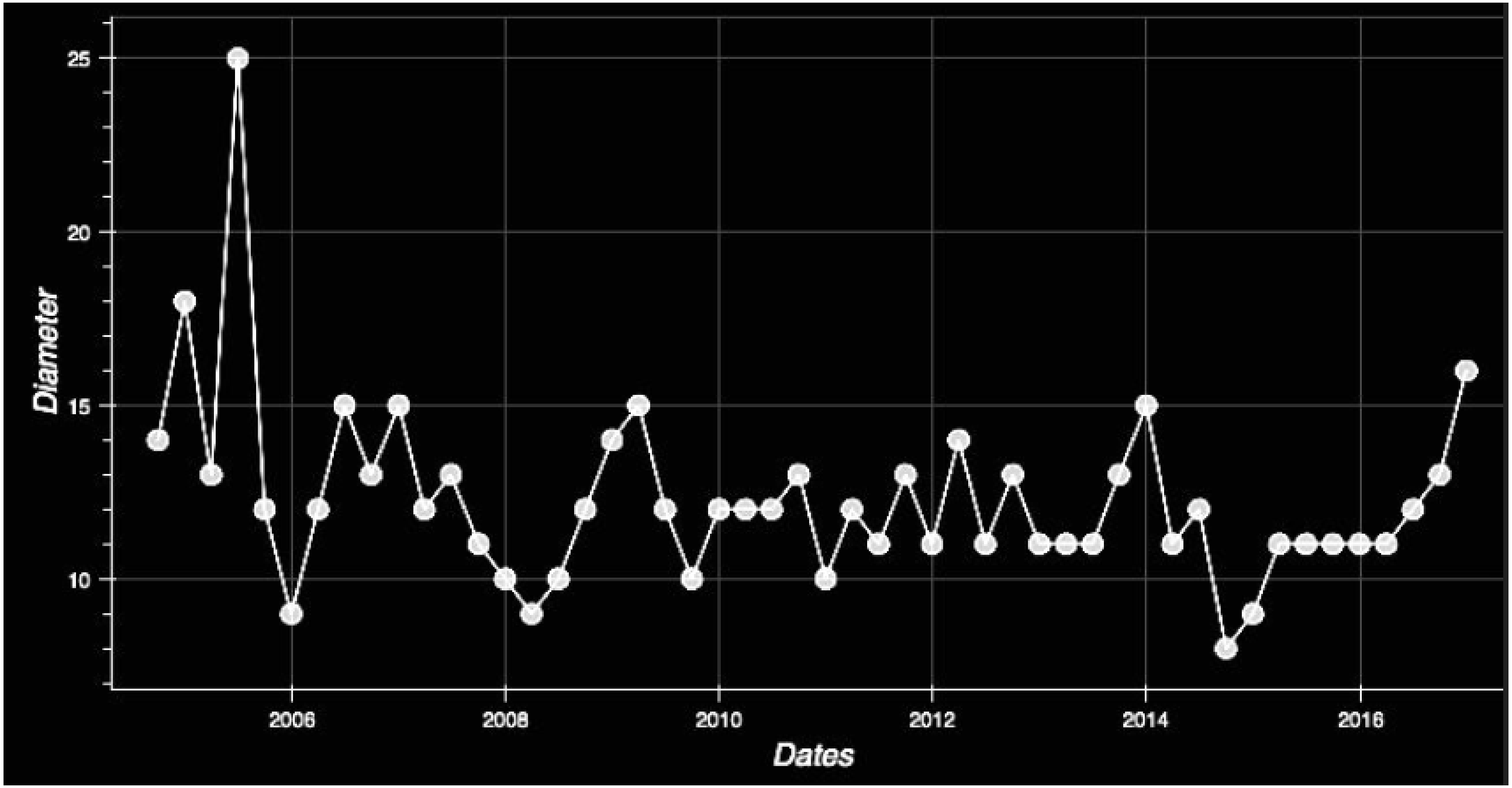
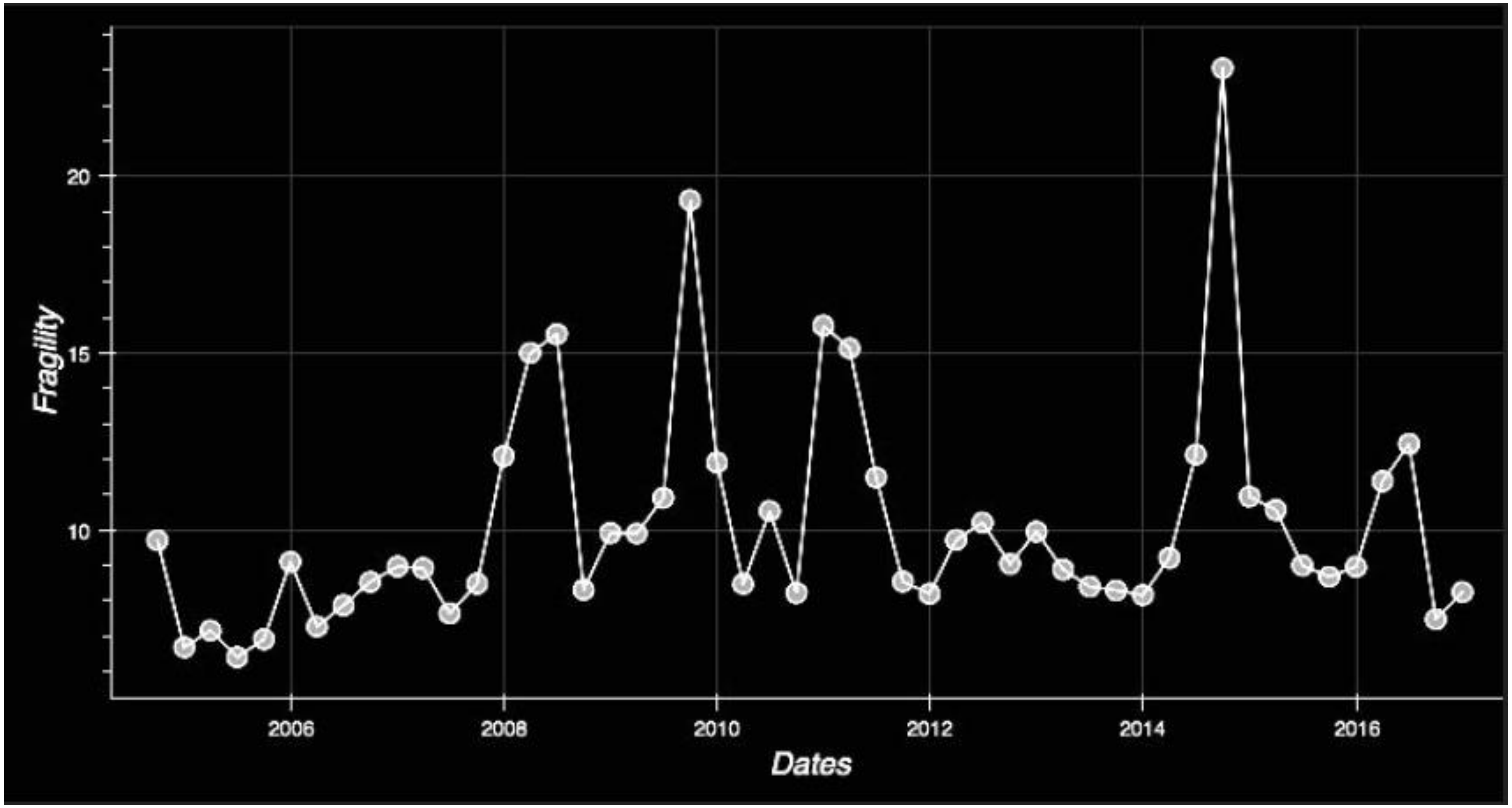


Figure 4: The number of banks in the network for all quarters between Q3 2004 and Q4 2016.

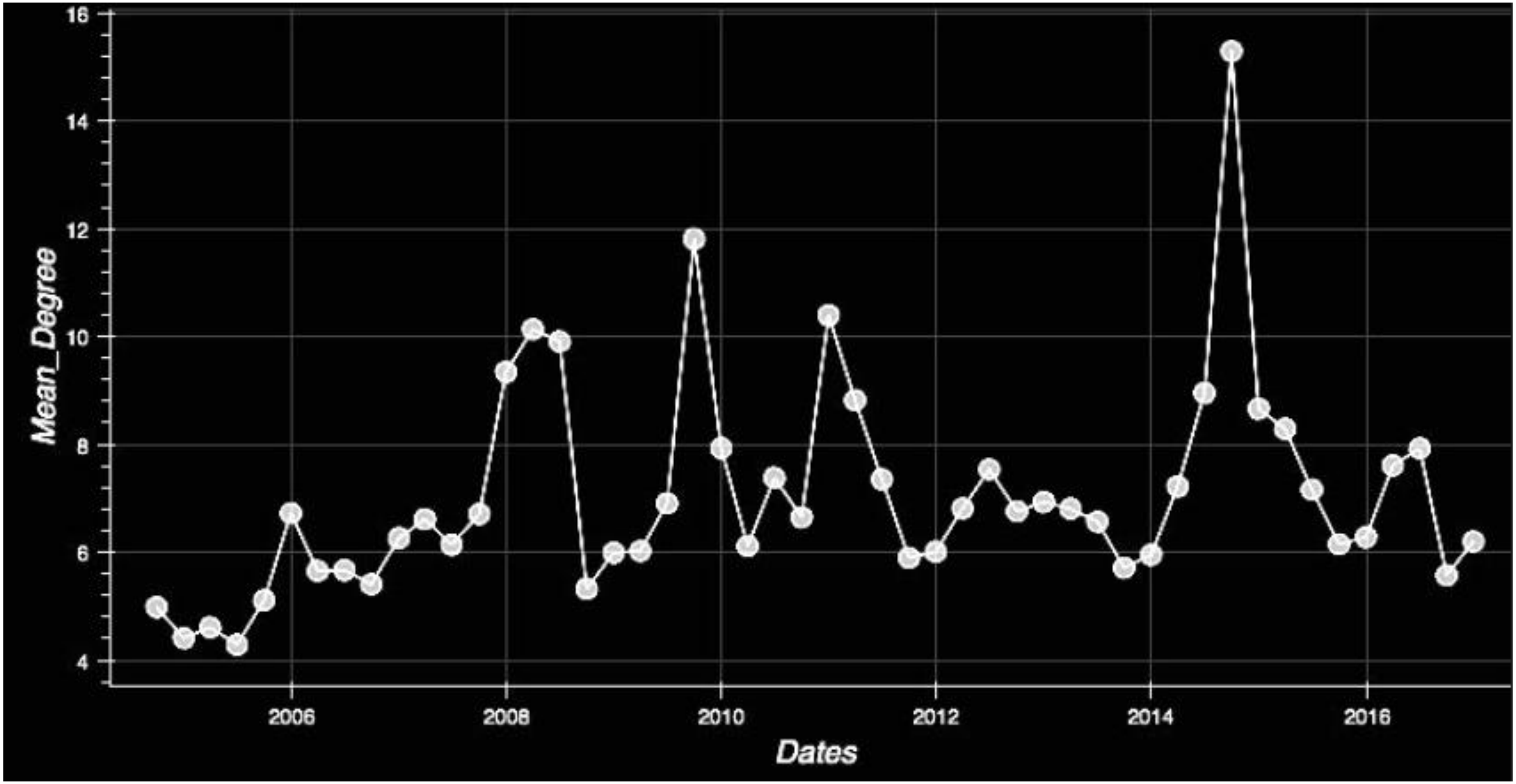
Diameter



Fragility

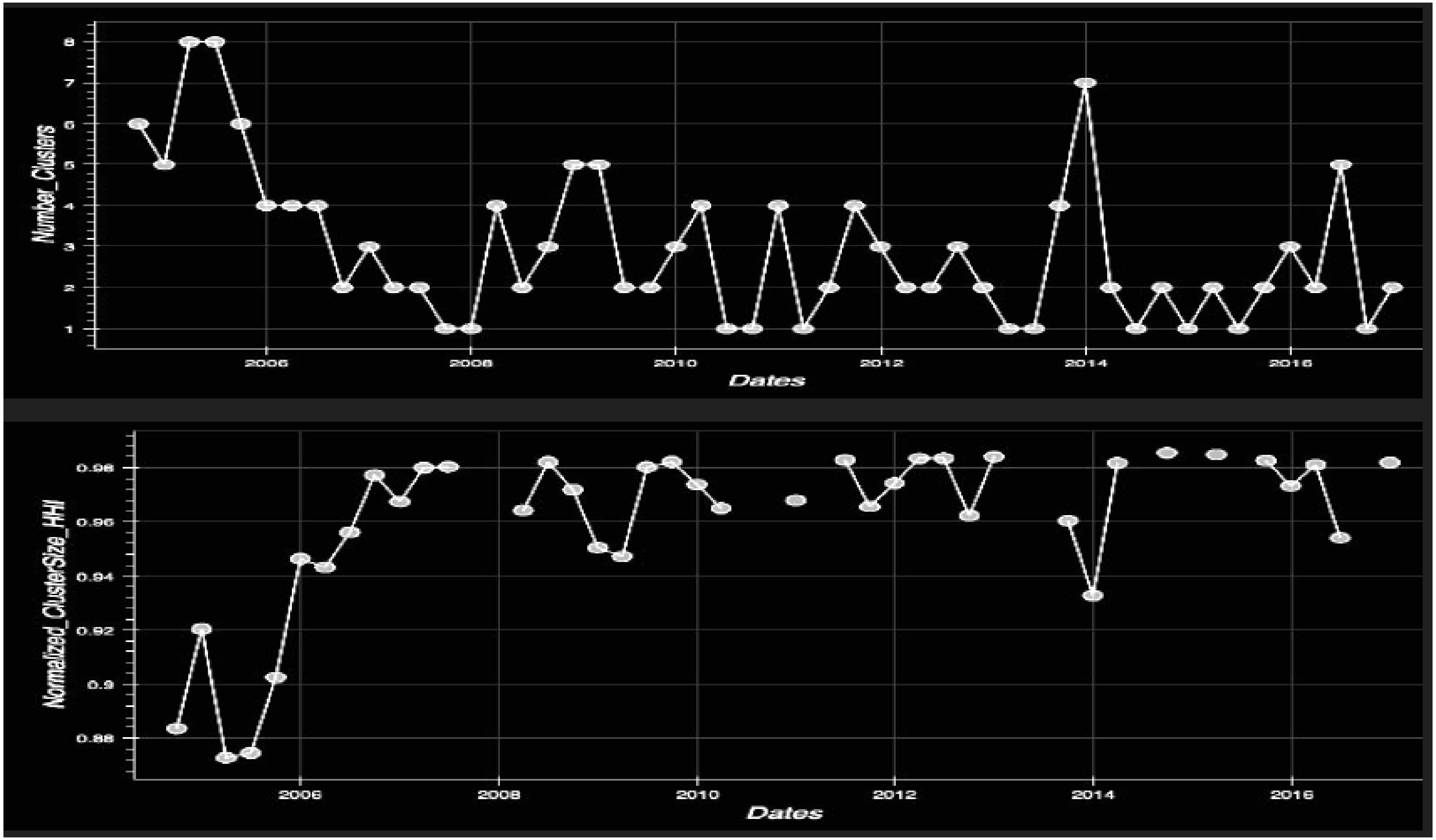


Degree

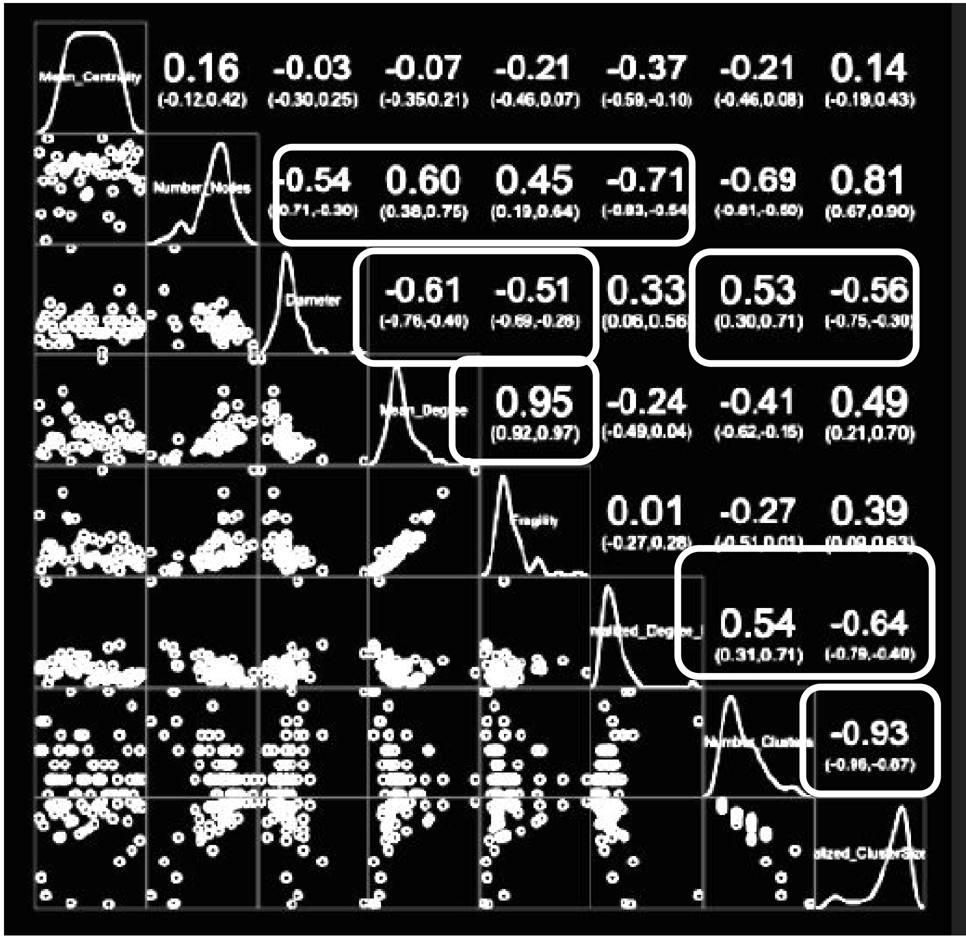


16
14
12
10
8
6
4
Mean_Degree
2006
2008
2010
2012
2014
2016
Dates

Clusters


Number_Clusters
Dates
2006
2008
2010
2012
2014
2016
Normalized_ClusterSize_HHI
0.98
0.96
0.94
0.92
0.9
0.88

Correlations



Mean Centrality

Number of Nodes

Diameter

Mean Degree

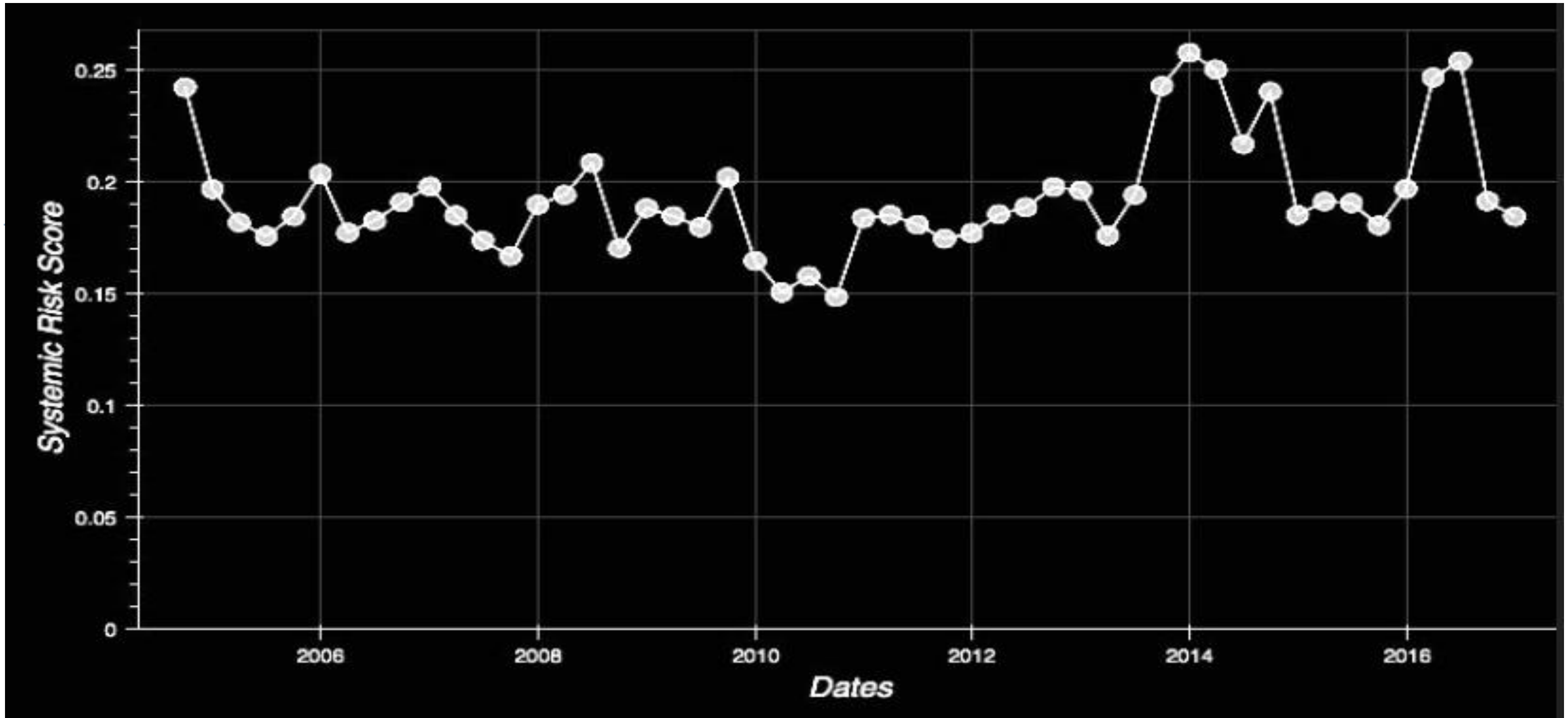
Fragility

Normalized degree Herfindahl Index

Number of Clusters

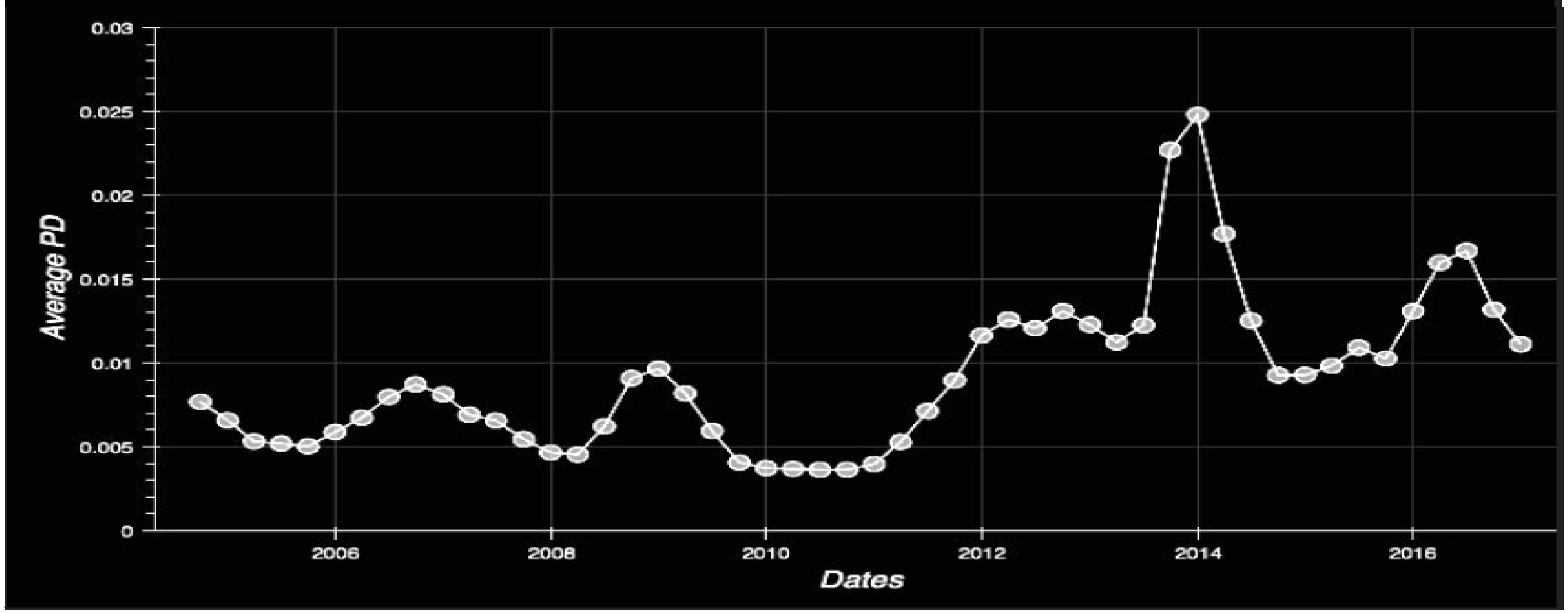
Normalized cluster size Herfindahl

Systemic risk



Corr 70%

Mean PD

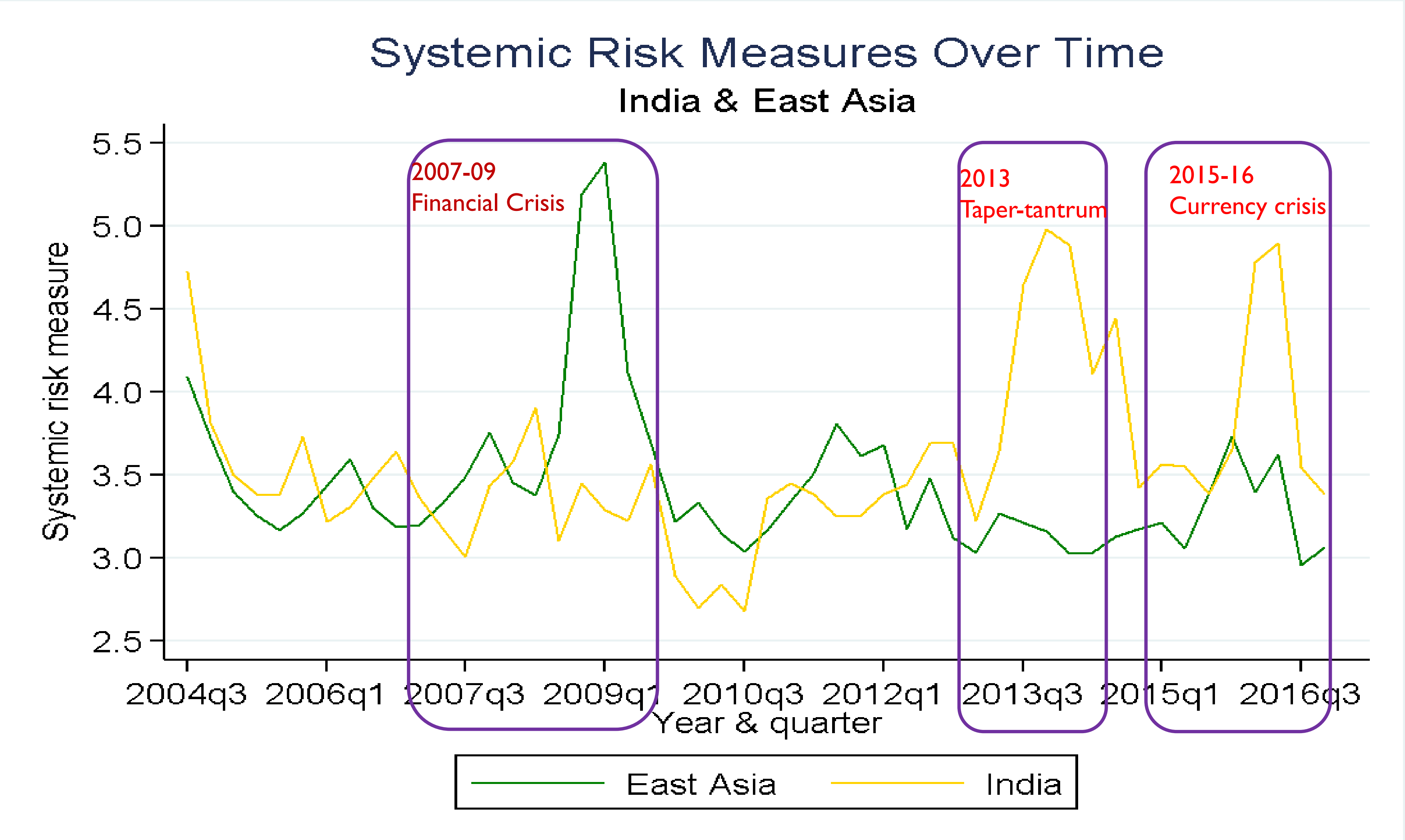


Risk Contributions of top 20 banks

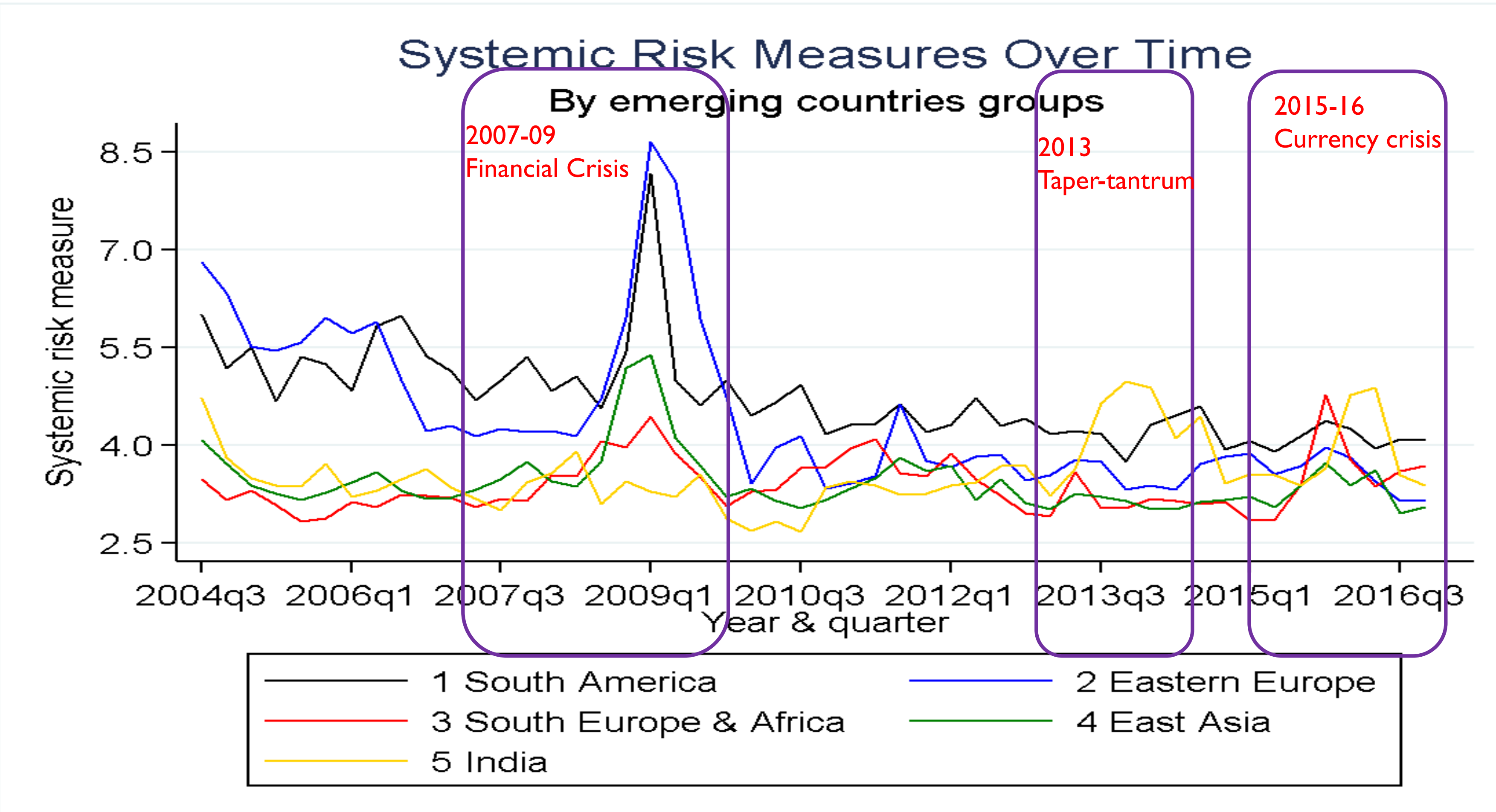
Table 4: Percentage of systemic risk contributed by the top 20 contributors in 2005-Q1 and 2016-Q1.

	2005-Q1		2016-Q1	
	Bank Name	Risk Decomp	Bank Name	Risk Decomp
1	STATE BANK OF INDIA	3.012025	BANK OF MAHARASHTRA	2.834978
2	PRIME SECURITIES	2.788330	UCO BANK	2.162268
3	UCO BANK	2.534994	STATE BANK OF INDIA	2.015743
4	CORPORATION BANK	1.962745	POWER FINANCE	1.924221
5	GIC HOUSING FINANCE	1.883520	STATE BK.OF BIN.& JAIPUR SUSP - SUSP.15/03/17	1.695611
6	UNION BANK OF INDIA	1.711946	INDIAN OVERSEAS BANK	1.695445
7	I N G VYSYA BANK SUSP - SUSP.15/04/15	1.644337	DENA BANK	1.632034
8	IFCI	1.545299	UNITED BANK OF INDIA	1.593664
9	P N B GILTS	1.508761	BANK OF BARODA	1.588961
10	SUNDARAM FINANCE	1.460714	BANK OF TRAVANCORE SUSP - SUSP.15/03/17	1.570695
11	JAMMU & KASHMIR BANK	1.380232	CIL SECURITIES	1.494462
12	ALMOND GLOBAL SECURITIES	1.248903	ANDHRA BANK	1.448089
13	MARGO FINANCE	1.218949	ORIENTAL BK.OF COMMERCE	1.254426
14	PUNJAB NATIONAL BANK	1.217674	CANARA BANK	1.095249
15	ANDHRA BANK	1.215547	JAGSONPAL FIN.& LSG.	1.047905
16	DEWAN HOUSING FINANCE	1.207646	DEWAN HOUSING FINANCE	1.042408
17	BANK OF BARODA	1.206728	ALLAHABAD BANK	1.019390
18	DENA BANK	1.187408	CUBICAL FINANCIAL SVS.	1.017735
19	DHANLAXMI BANK	1.174342	SYNDICATE BANK	1.015910
20	BANK OF INDIA	1.163571	SOUTH INDIAN BANK	0.986080
	TOTAL	32.27367		30.13527

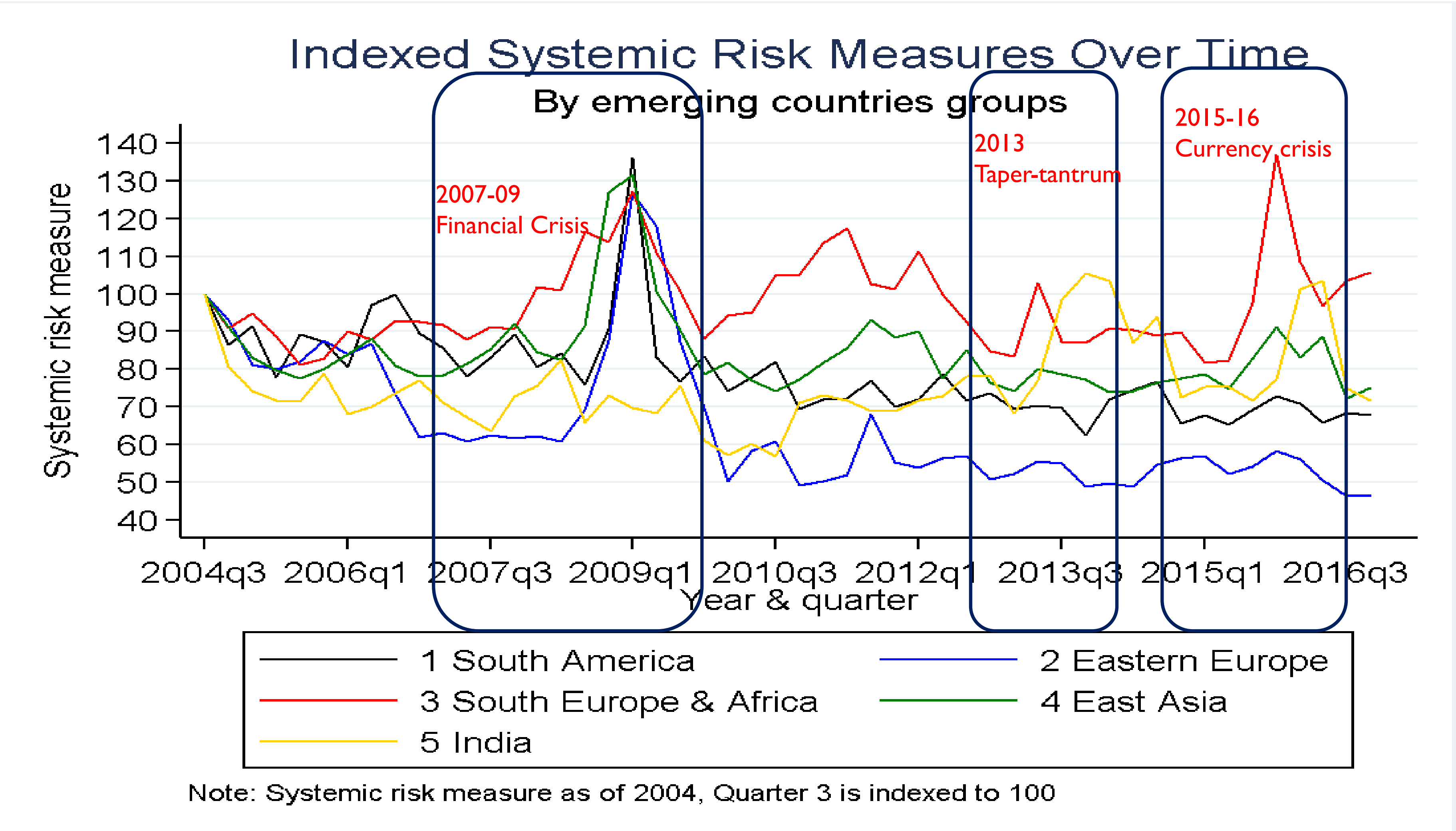
Systemic risks: India vs Asia



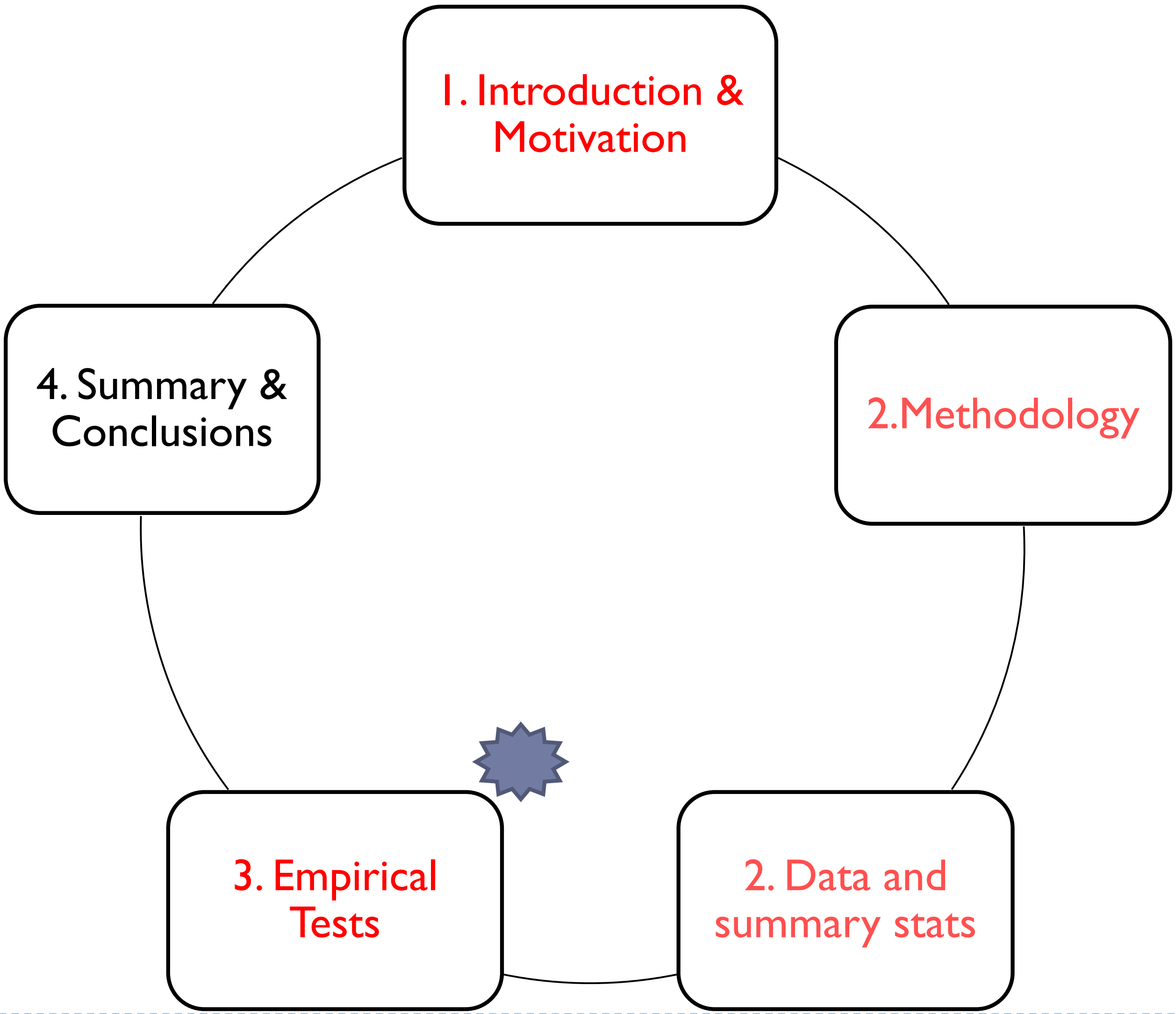
Systemic risks: India vs emerging markets



Systemic risks: India vs emerging markets indexed



Agenda


1. Introduction & Motivation
2.Methodology
2. Data and summary stats
3. Empirical Tests
4. Summary & Conclusions

Summary of empirical tests

- Time series and Panel regressions of Systemic risk
  - (controlled for fixed effects and robust std. errors)
- Correlations
  - Contemporaneous and lagged
- Granger Causality tests
- VAR
- PCA
- Out-of-sample forecasting

Table 5: Time series regressions of quarterly systemic risk against credit risk, network and firm-specific variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	2.8167***	2.7818***	7.9469	-0.0022	-0.0022	7.3917	7.3917
	(22.68)	(8.15)	(1.71)	(-0.00)	(-0.00)	(1.59)	(1.59)
Mean PD	83.7515***		111.9661***	104.5427***	104.5427***	109.1854***	109.1854***
	(6.96)		(16.49)	(8.00)	(8.00)	(8.77)	(8.77)
Mean Degree		0.0694	0.2908**	0.1245	0.1245	0.2727*	0.2727*
		(1.77)	(3.18)	(1.25)	(1.25)	(2.35)	(2.35)
Degree HHI		142.6410*	140.9054*	102.4228	102.4228	149.4726**	149.4726**
		(2.44)	(2.57)	(1.94)	(1.94)	(2.90)	(2.90)
Mean Bet. Centrality			-0.0013**	-0.0012*	-0.0012*	-0.0009	-0.0009
			(-3.14)	(-2.32)	(-2.32)	(-1.87)	(-1.87)
Diameter			0.0068	0.0082	0.0082	0.0010	0.0010
			(0.46)	(0.57)	(0.57)	(0.07)	(0.07)
Fragility			-0.0933	0.0070	0.0070	-0.0791	-0.0791
			(-1.68)	(0.12)	(0.12)	(-1.19)	(-1.19)
Num. Clusters			-0.0898	-0.0462	-0.0462	-0.0894	-0.0894
			(-1.42)	(-0.69)	(-0.69)	(-1.48)	(-1.48)
Cluster HHI			-6.0311	-1.8428	-1.8428	-6.7961	-6.7961
			(-1.31)	(-0.36)	(-0.36)	(-1.48)	(-1.48)
Median Log(Assets)				0.1285	0.1285		
				(1.19)	(1.19)		
Median Log(Market Cap)						0.0890*	0.0890*
						(2.38)	(2.38)
Median Loans/Assets				-0.0837	-0.0837	0.1695	0.1695
				(-0.26)	(-0.26)	(0.54)	(0.54)
Median Loans/Deposits				1.5464	1.5464	-0.3376	-0.3376
				(0.66)	(0.66)	(-0.21)	(-0.21)
Median Debt/Assets				1.8750	1.8750		
				(0.93)	(0.93)		
Median Debt/Equity						2.1829	2.1829
						(1.56)	(1.56)
Median Debt/Capital				0.0022	0.0022	0.0084	0.0084
				(0.29)	(0.29)	(1.43)	(1.43)
Median ROA				0.0191	0.0191		
				(0.86)	(0.86)		
Median ROE						-0.0133	-0.0133
						(-0.64)	(-0.64)
Median Market/Book				0.3245	0.3245	0.0681	0.0681
				(1.70)	(1.70)	(0.71)	(0.71)
Observations	50	50	50	50	50	50	50
R^2	0.502	0.136	0.900	0.933	0.933	0.941	0.941
Adjusted R^2	0.492	0.099	0.881	0.904	0.904	0.914	0.914

Table 6: Panel regressions of quarterly systemic risk contributions of firms against credit risk, network and firm-specific variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.2933***	-0.0562***	6.0451***	7.2741***	7.2741***	8.0971***	8.0971***
	(75.00)	(-3.62)	(16.91)	(9.21)	(9.21)	(9.23)	(9.23)
PD	19.0255***		17.4201***	14.7766***	14.7766***	15.4945***	15.4945***
	(45.05)		(52.90)	(28.63)	(28.63)	(30.92)	(30.92)
Degree		0.0480***	0.0571***	0.0617***	0.0617***	0.0676***	0.0676***
		(33.74)	(36.20)	(28.67)	(28.67)	(29.80)	(29.80)
Degree HHI		86.8167***	71.7714***	107.5495***	107.5495***	122.4065***	122.4065***
		(16.14)	(12.32)	(9.70)	(9.70)	(8.98)	(8.98)
Bet. Centrality			-0.0000***	-0.0000***	-0.0000***	-0.0001***	-0.0001***
			(-7.53)	(-4.27)	(-4.27)	(-4.54)	(-4.54)
Diameter			0.0022	-0.0045	-0.0045	-0.0032	-0.0032
			(1.44)	(-1.39)	(-1.39)	(-0.92)	(-0.92)
Fragility			-0.0351***	-0.0484***	-0.0484***	-0.0571***	-0.0571***
			(-26.63)	(-18.42)	(-18.42)	(-18.06)	(-18.06)
Num. Clusters			-0.0766***	-0.0975***	-0.0975***	-0.1093***	-0.1093***
			(-15.41)	(-9.72)	(-9.72)	(-9.68)	(-9.68)
Cluster HHI			-5.8770***	-7.3126***	-7.3126***	-7.9533***	-7.9533***
			(-16.66)	(-9.35)	(-9.35)	(-9.19)	(-9.19)
Log(Assets)				0.0201***	0.0201***		
				(7.76)	(7.76)		
Log(Market Cap)						0.0186***	0.0186***
						(6.60)	(6.60)
Loans/Assets				0.1883***	0.1883***	0.2901***	0.2901***
				(6.27)	(6.27)	(10.00)	(10.00)
Loans/Deposits				-0.0145	-0.0145	-0.0325***	-0.0325***
				(-1.75)	(-1.75)	(-3.65)	(-3.65)
Debt/Assets				-0.0749***	-0.0749***		
				(-4.57)	(-4.57)		
Debt/Equity						-0.0001	-0.0001
						(-1.46)	(-1.46)
Debt/Capital				-0.0002	-0.0002	-0.0005*	-0.0005*
				(-0.86)	(-0.86)	(-2.21)	(-2.21)
ROA				0.0007	0.0007		
				(1.85)	(1.85)		
ROE						0.0001	0.0001
						(0.32)	(0.32)
Market/Book				0.0019**	0.0019**	-0.0021*	-0.0021*
				(2.60)	(2.60)	(-2.13)	(-2.13)
Observations	10609	10609	10609	4329	4329	3375	3375
R^2	0.420	0.315	0.770	0.831	0.831	0.833	0.833
Adjusted R^2	0.420	0.315	0.770	0.830	0.830	0.832	0.832

Summary of time-series & panel regressions

Table: Summary of adjusted R^2s from time-series and panel regressions of systemic risk

	Country Group				
Included explanatory variables	South America	Eastern Europe	South Europe & Africa	East Asia	India
Panel A: Adjusted R^2s from time-series regressions					
Credit risk (only)	38%	25%	57%	63%	49%
Network interconnectedness (only)	62%	21%	59%	68%	10%
Credit risk + network parameters	93%	93%	91%	94%	88%
Credit risk + network parameters + firm-specific attributes	96-97%	96%	94-96%	96%	91-92%
Panel B: Adjusted R^2s from panel regressions					
Credit risk (only)	14%	2%	43%	17%	42%
Network interconnectedness (only)	53%	44%	31%	43%	32%
Credit risk + network parameters	71%	69%	80%	74%	77%
Credit risk + network parameters + firm-specific attributes	90-91%	83-84%	85%	82%	83%

Regression Results overall..

- Majority of systemic risk is explained by credit risk and network risks.
  - Relative contribution of credit vs network risks varies across groups
- Firm-specific attributes add very little explanatory power.

Contemporaneous Correlations

Table, Panel A: Contemporaneous correlations (and p-values) of systemic risk between country groups

	Current measure				
Current measure	South America	Eastern Europe	South Europe & Africa	East Asia	India
South America	1.0000				
Eastern Europe	0.7864	1.0000			
	(0.0000)				
South Europe & Africa	0.1710	0.1637	1.0000		
	(0.2352)	(0.2559)			
East Asia	0.6260	0.6933	0.5559	1.0000	
	(0.0000)	(0.0000)	(0.0000)		
India	−0.1819	−0.1433	−0.1224	−0.0672	1.0000
	(0.2061)	(0.3207)	(0.3971)	(0.6430)	

Lagged Correlations

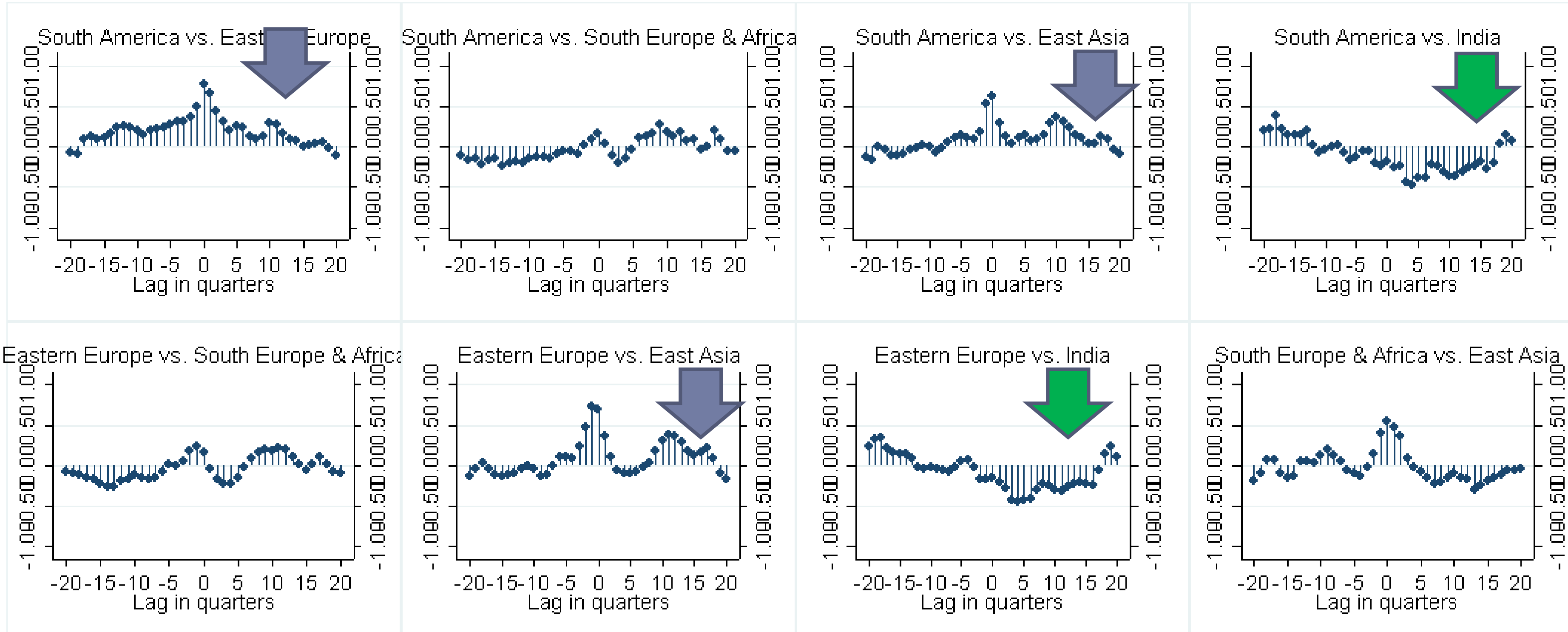
Table, Panel B: Lagged correlations (and p-values) of systemic risk between country groups

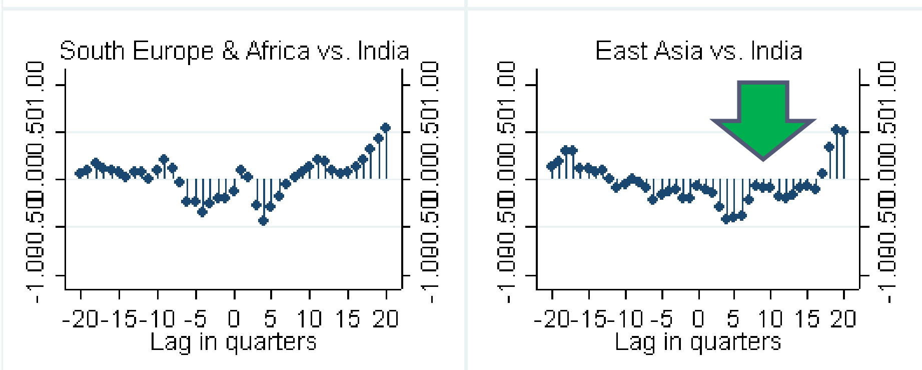
	Lagged measure				
Current measure	South America	Eastern Europe	South Europe & Africa	East Asia	India
South America	0.4998	0.5257	0.0942	0.5623	−0.2444
	([illegible])	(0.0001)	(0.5199)	(0.0000)	(0.0906)
Eastern Europe	0.7089	0.8354	0.2533	0.7620	−0.1720
	(0.0000)	(0.0000)	(0.0791)	(0.0000)	(0.2372)
South Europe & Africa	[illegible]	−0.0317	0.5907	0.3998	−0.1996
	(0.8109)	(0.8287)	([illegible])	(0.0044)	(0.1692)
East Asia	0.3147	0.3799	0.4923	0.6827	−0.2073
	(0.0276)	(0.0071)	(0.0003)	(0.0000)	(0.1529)
India	−0.2660	−0.2235	0.1037	−0.1159	0.6408
	(0.0647)	(0.1226)	(0.4783)	(0.4276)	(0.0000)

- Contemporaneous correlations matter far more than lagged correlation. India is relatively isolated from other country groups – correlations are very small and trivial vs. other four groups.

Cross-Correlograms

By pairs of emerging countries groups





- SA leads EE & vice versa
- SA leads EA
- EA leads EE
- SA, EE and EA negatively lead India

In each pair of countries-groups, quarterly lags & leads are applied to the second group relative to the first group

Interpretation:cross-correlagram

- The 1st named group in a pair imparts leads and lag relative to the 2nd named group
  - In plot 1: to the right of zero (x-axis > 0) South America leads Eastern Europe ; to the left of zero (x-axis < 0) South America lags Eastern Europe
  - In plot 10: to the right of zero (x-axis > 0) East Asia leads India ; to the left of zero (x-axis < 0) East Asia lags India
- Lead and lag effects are usually very short-term. Long-term effects fade out. Often the highest correlation is contemporaneous (x-axis = 0)

Granger causality

Table: Granger causality regressions

Details: contemporaneous values of systemic risk are regressed on 1-period lagged values of all 5 systemic risk measures (including itself). The reported values are F-statistics of significance (and corresponding p values in parentheses).

Explanatory variables: lagged systemic risk of	Dependent variable: systemic risk corresponding to South America	Eastern Europe	South Europe & Africa	East Asia	India
Panel A: Univariate F-statistics of lagged variables					
South America	0.22	0.17	0.03	0.86	0.35
	(0.6435)	(0.6838)	(0.8739)	(0.3600)	(0.5591)
Eastern Europe	0.02	14.29	4.94	0.14	0.07
	(0.8949)	(0.0005)	(0.0316)	(0.7125)	(0.7897)
South Europe & Africa	4.98	1.32	6.12	0.22	4.82
	(0.0309)	(0.2504)	(0.0174)	(0.6421)	(0.0336)
East Asia	10.47	11.46	6.21	16.56	1.24
	(0.0023)	(0.0015)	(0.0166)	(0.0002)	(0.2711)
India	3.35	0.78	2.85	2.84	33.33
	(0.0740)	(0.3817)	(0.0987)	(0.0990)	(0.0000)
Panel B: Joint F-statistic of all four lagged cross-variables					
All 4 lagged cross-variables	3.99	3.73	2.45	1.34	1.70
	(0.0077)	(0.0108)	(0.0607)	(0.2709)	(0.1672)

- Dependence on self-lagged variable is usually strong (the diagonal terms) but dependence on cross-lagged variables are usually weak.
- The first 3 country groups marginally depend *jointly* on cross-lagged variables but not the last 2 country groups.

VAR model

- Conducted Vector Autoregression (VAR) to capture the linear time-series interdependencies between the systemic risk across the five country groups.

- Model

$$\begin{pmatrix} Sys\,risk\;\; South\;America \\ Sys\,risk\;\; East\;Europe \\ Sys\,risk\;\; South\;Europe\;and\;Africa \\ Sys\,risk\;\; East\;Asia \\ Sys\,risk\;\; India \end{pmatrix}_t = intercept + \begin{pmatrix} Sys\,risk\;\; South\;America \\ Sys\,risk\;\; East\;Europe \\ Sys\,risk\;\; South\;Europe\;and\;Africa \\ Sys\,risk\;\; East\;Asia \\ Sys\,risk\;\; India \end{pmatrix}_{t-1} + \cdots + \begin{pmatrix} Sys\,risk\;\; South\;America \\ Sys\,risk\;\; East\;Europe \\ Sys\,risk\;\; South\;Europe\;and\;Africa \\ Sys\,risk\;\; East\;Asia \\ Sys\,risk\;\; India \end{pmatrix}_{t-4} + \mathrm{Error}_t$$

- Both Likelihood ratio (LR) and Akaikae's Information Criterion (AIC) suggest that lags are not highly significant; maximum of 4 lags are material.

VAR summary

- Out of 100 lagged explanatory variables (5 regressions * 5 explanatory variables * 4 lags):
  - only 7 are significant at 5% level
  - (5 positive, 2 negative; 6 are 1-quarter lags and 1 is 3-quarter lag; 3 are self-lag dependence and 4 are cross-lag dependence).

- Main message of VAR analysis:
  - consistent with all other results: across country groups, contemporaneous dependence of systemic risk matters far more that lagged inter-dependence.

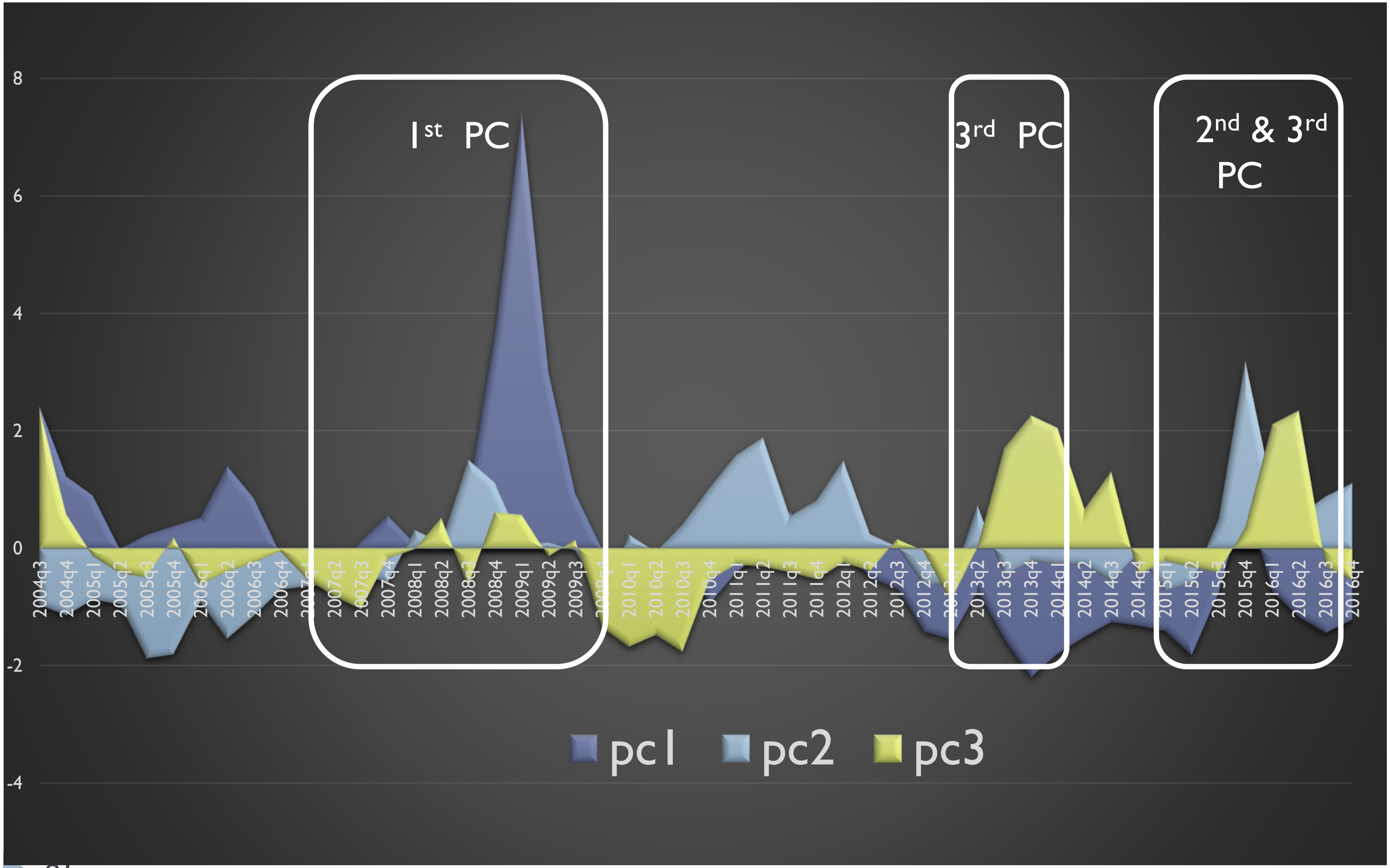
Principal components analysis

- We next conduct PCA of the systemic risks for five regions.

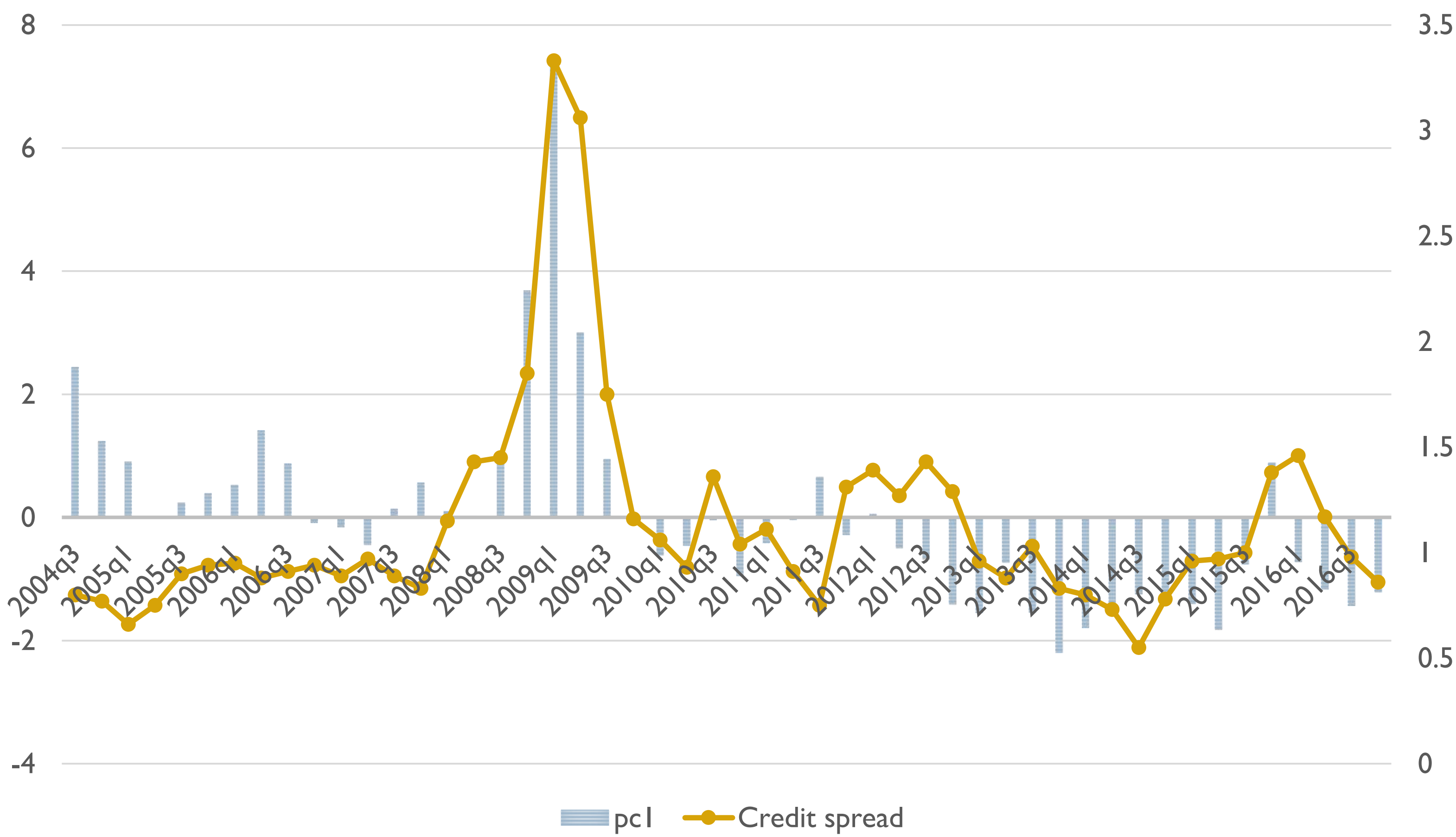
- We find evidence for five PCs.
  - The prime PC explains 52% of variance.
  - The first three explain 92% of variance.

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.61244	1.6143	0.5225	0.5225
Comp2	.998144	.0244684	0.1996	0.7221
Comp3	.973676	.729328	0.1947	0.9169
Comp4	.244348	.0729608	0.0489	0.9657
Comp5	.171387	.	0.0343	1.0000

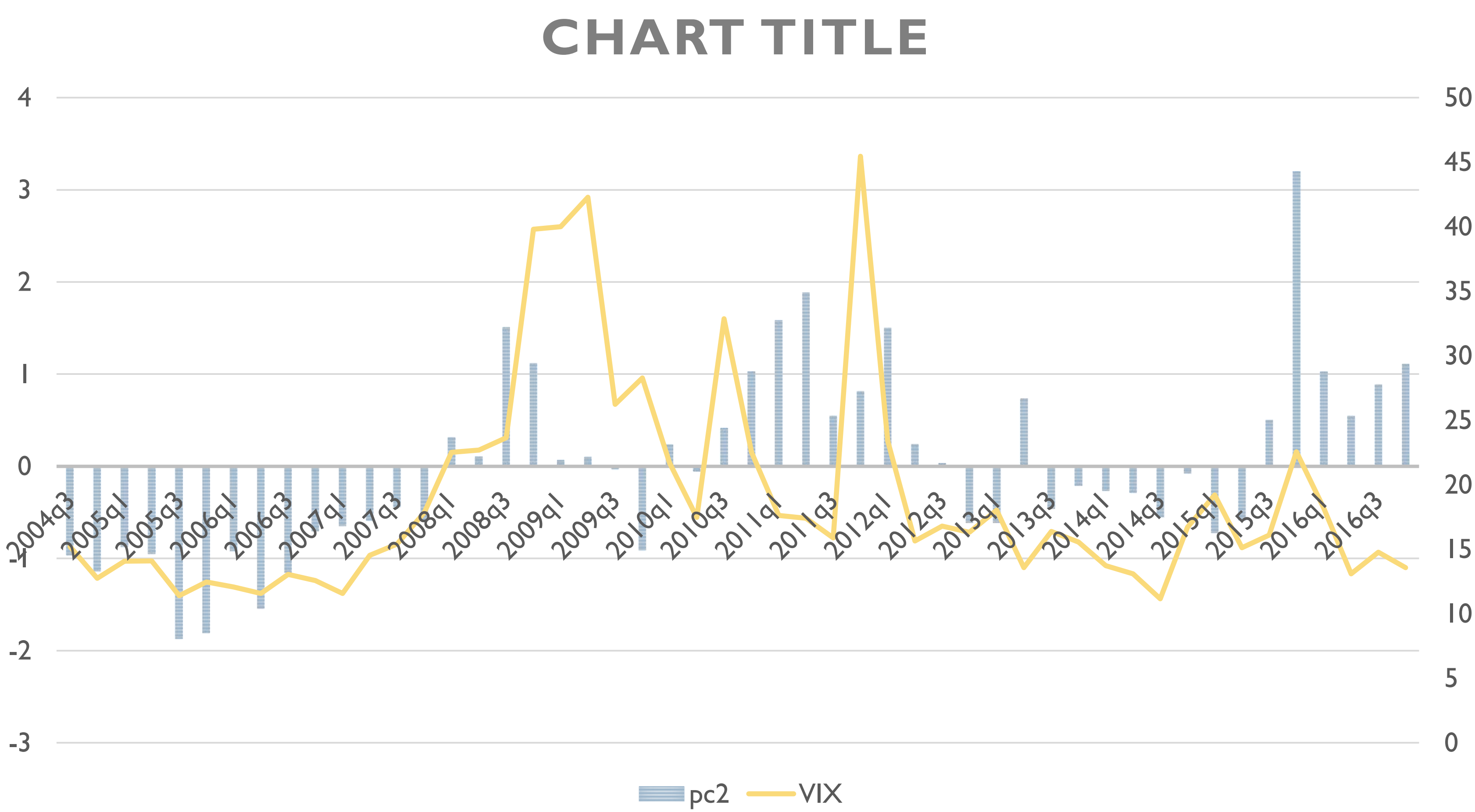
First three PCs



PC1 Vs US credit spread



PC2 Vs. US VIX (risk aversion)



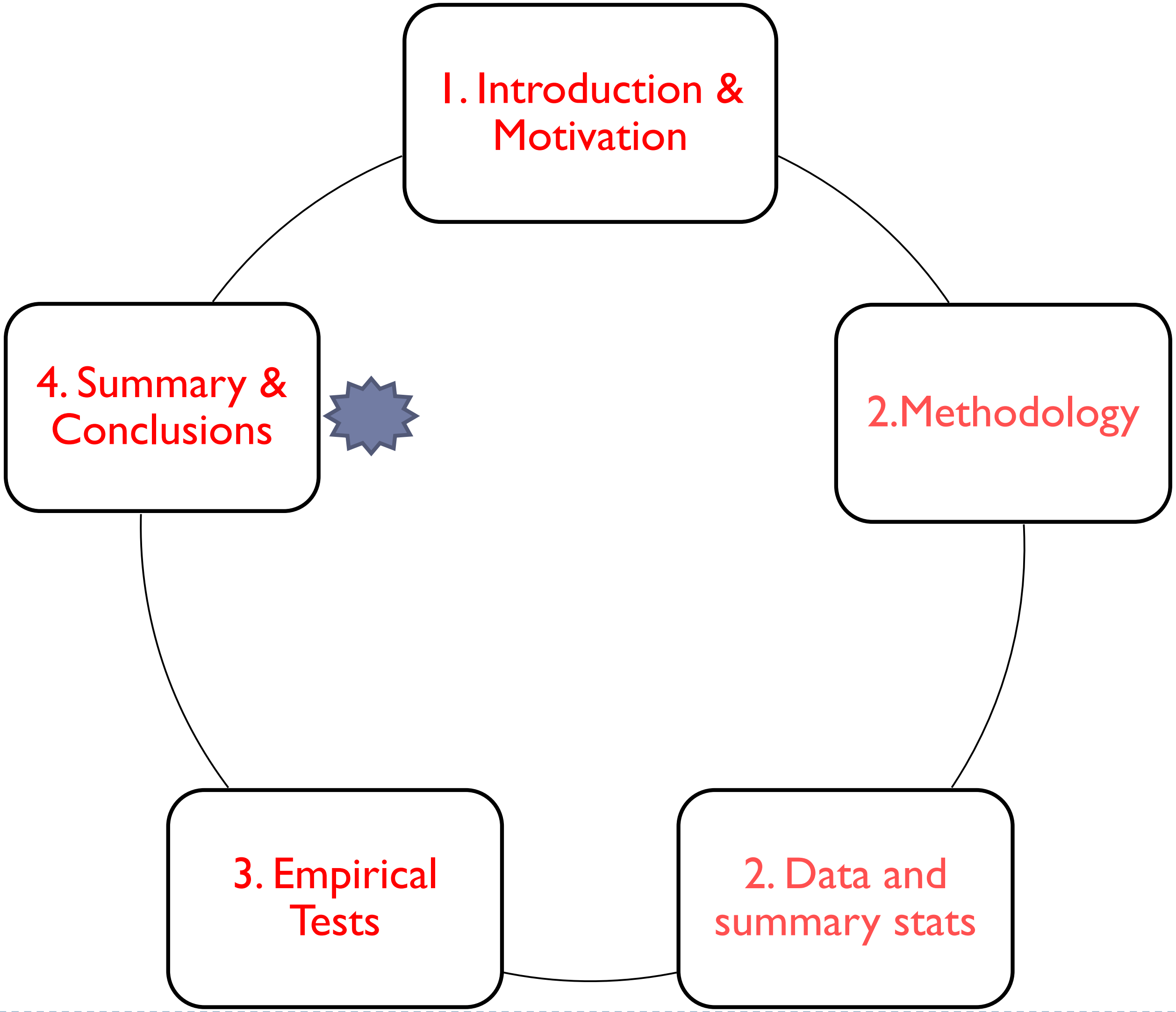
PC3

- Temper tantrum
- Recent exchange rate

In progress…

- Out of sample forecasting systemic risk..
  - We have downloaded IMF database on country specific systemic risk episodes
- Identifying PCS with macro variables…

Agenda


1. Introduction &
Motivation
2.Methodology
2. Data and
summary stats
3. Empirical
Tests
4. Summary &
Conclusions

Summary

- We undertake a large-scale empirical examination of systemic risk among major financial institutions in the emerging markets.

- We provide computation and dynamics of systemic risk evolution across emerging markets.

Four broad Objectives

A. **Measurement:**
- Measuring systemic risk using data on financial entity linkages and their respective credit qualities.

B. **Decomposition:**
- Decomposing systemic risk by financial entity so as to understand how each entity impacts the system via risk decomposition.

C. **Management:**
- Managing systemic risk by understanding ways <u>in which financial linkages may be adjusted through regulation to dampen risk</u>.
  - When does the financial system become fragile, i.e., a local crisis in some financial entities spreads to many others?
  - When, if at all, should we break up too big to fail banks?

D. **Prediction:**
- Assessing whether or not we can predict systemic risk by econometrically relating it to macroeconomic and financial variables, uncovering useful lead-lag effects.

Key findings

- Regressions:
  - Systemic risks decomposed into credit and network risks with a considerable variation across country groups .
- Correlations:
  - Contemporaneous correlations matter far more than lagged correlation.
  - India is relatively isolated from other country groups
  - Cross correlograms show that Lead and lag effects are usually very short-term. Long-term effects fade out.
    - Often the highest correlation is contemporaneous
- Granger causality:
  - Dependence on AR(1) variable is usually strong (the diagonal terms) but dependence on cross-lagged variables are usually weak.
  - India is again found to be isolated from other groups
- VAR analysis:
  - Contemporaneous dependence of systemic risk matters far more that lagged inter-dependence in country groups.
- PCA analysis:
  - shows that over three factors explain 90% of the systemic risk variation in emerging markets;
    - the 1^{st} factor is related to the crisis
    - 3^{rd} factor is related to the taper tantrum and
    - 2^{nd} and 3^{rd} factors are related to the recent exchange crisis