Cerise
CENTRE FOR RUSSIAN INTERNATIONAL SOCIO-POLITICAL AND ECONOMIC STUDIES
BOFIT
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Bank networks, interbank liquidity runs and the identification of banks that are Too Interconnected to Fail

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What do we do?

- Basic idea of the paper
  1. Identify the scenarios that are sufficient to simulate real interbank market crises
  2. Use this methodology to calculate the potential contribution of $bank_{i,t}$ to contagion in period t.
  3. Identify the systemically important banks (SIFI or superspreaders) using only data on the position of the bank in the network, as opposed to size.

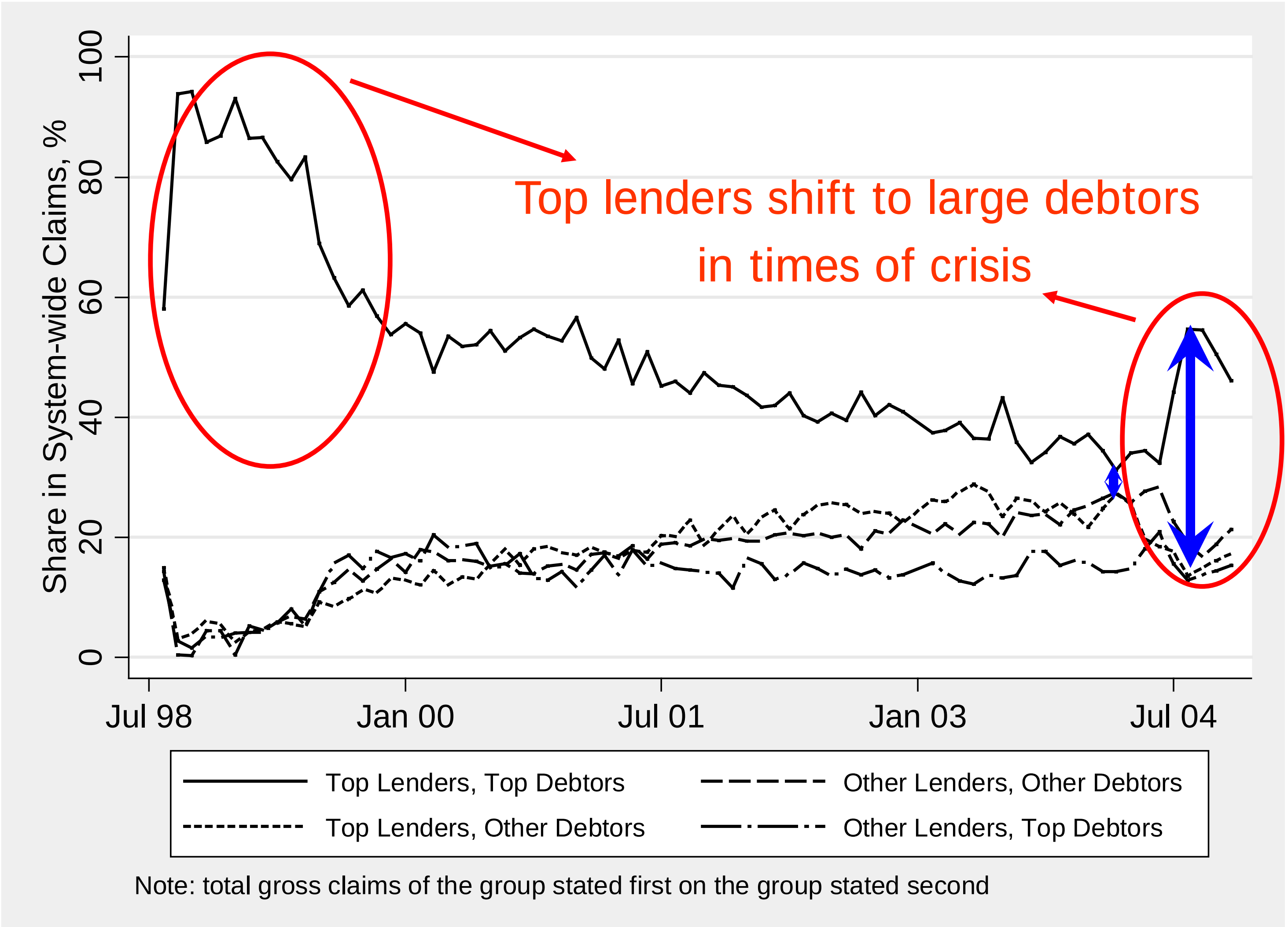
Basic findings

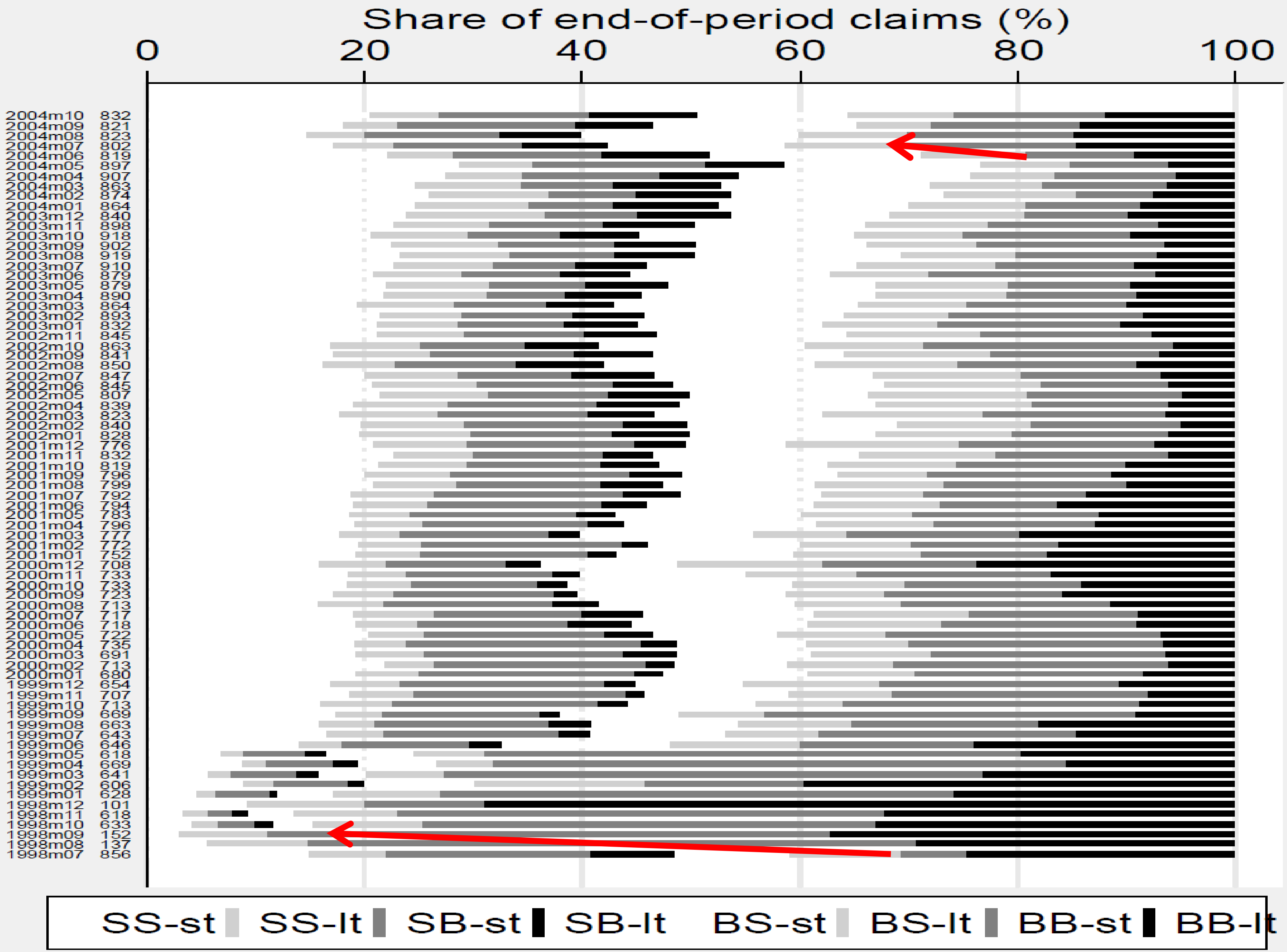
- Capital contagion, funding liquidity losses from infected banks and haircuts are not sufficient
- We need liquidity hoarding to reliably simulated real banking crises (preferential detachment)
- The superspreaders (SIFI) are best identified by their position in the network (K-shell index)
- This is NOT the same as size
- Incomplete network data already does a good job

We use Russian data as a training dataset

- 75 months of complete bilateral contract data (98-04)
  - Identity of both parties
  - Contract types
  - Volumes
  - Maturities
  - Prices
- Monthly bank balances and P&L (Interfax, Mobile)
  - Capital, liquidity, reserves, securities
- Two real but very different interbank market crises
  - The infamous 1998 default
  - The 2004 panic that was only stopped by deposit insurance
- An almost experimental setting

Flight to quality in crisis time




Share of end-of-period claims (%)
0
20
40
60
80
100
2004m10 832
2004m09 821
2004m08 823
2004m07 802
2004m06 819
2004m05 897
2004m04 907
2004m03 863
2004m02 874
2004m01 864
2003m12 840
2003m11 898
2003m10 918
2003m09 902
2003m08 919
2003m07 910
2003m06 879
2003m05 879
2003m04 890
2003m03 864
2003m02 893
2003m01 832
2002m11 845
2002m10 863
2002m09 841
2002m08 850
2002m07 847
2002m06 845
2002m05 807
2002m04 839
2002m03 823
2002m02 840
2002m01 828
2001m12 776
2001m11 832
2001m10 819
2001m09 796
2001m08 799
2001m07 792
2001m06 794
2001m05 783
2001m04 796
2001m03 777
2001m02 772
2001m01 752
2000m12 708
2000m11 733
2000m10 733
2000m09 723
2000m08 713
2000m07 717
2000m06 718
2000m05 722
2000m04 735
2000m03 691
2000m02 713
2000m01 680
1999m12 654
1999m11 707
1999m10 713
1999m09 669
1999m08 663
1999m07 643
1999m06 646
1999m05 618
1999m04 669
1999m03 641
1999m02 606
1999m01 628
1998m12 101
1998m11 618
1998m10 633
1998m09 152
1998m08 137
1998m07 856
SS-st
SS-lt
SB-st
SB-lt
BS-st
BS-lt
BB-st
BB-lt

Interbank market contagion

- Scenario 1
  - Credit losses deplete a bank's capital
  - Default on interbank obligations
  - Potential domino effects via credit losses of other banks
  - Contagion propagates until it stops
- Scenario 2
  - We add funding liquidity losses
  - The borrowers of the initial failing bank lose funding that can only partially be replaced
  - If the loss >liquid assets, we get haircuts on fire sales
  - More banks fail in the further rounds

Interbank market contagion

- Scenario 3
  - If a bank severely hit by scenario 1/2, it may face a run on total interbank obligations by uninfected banks as in Rochet and Vives (2004).
  - Preferential detachment from banks that are hit but still solvent and liquid
  - The network structure itself changes endogenously
  - This does the trick
- Scenario 4
  - Panic and complete liquidity hoarding
  - All banks run on each other regardless fundamentals

The early literature

- Early theoretical literature was based on capital channel
  - Allen and Gale (2000)
- Early empirical literature was based on the capital channel
  - Sheldon and Maurer (1998) for Switzerland,
  - Furfine (2003) for the U.S.,
  - Upper and Worms (2004) for Germany,
  - Lelyveld and Liedorp (2006) for the Netherlands,
  - Degryse and Nguyen (2007) for Belgium

New channels

- Fire sales, haircuts and asset prices
  - Eisenberg and Noe, 2001
  - Cifuentes et al. (2005), Shin (2008)
- Liquidity hoarding and rund
  - Rochet and Vives (2004): large well-informed investors don’t renew interbank credit if a large adverse shock to one bank creates uncertainty about other banks
  - Also Müller, 2006
- Overview of possible channels in Upper (2001)
- Recent theoretical contributions of Gai, Haldane and Kapadia (2010, 2011)

Bilateral simulations

- Krause and Giansante (2011)
  - Generate theoretical networks and attack them
  - Draw conclusions about contagion
- Our approach
  - Start from real endogenously formed network
  - Attack it allowing increasingly more damaging channels
  - Random attack (we also did correlated attacks)
  - Till you reproduce the real crises
  - Then use the scenario to calculate the SIFI banks (those with largest contributions to contagion)
  - And identify them with more limited information

Formal bank balance sheet

Panel A. Simplified bank balance sheet identity

$$r_i + \sum_{j=1}^{n} y_{ij}^{st} + \sum_{j=1}^{n} y_{ij}^{lt} + s_i + a_i = c_i + \sum_{j=1}^{n} y_{ji}^{st} + \sum_{j=1}^{n} y_{ji}^{lt} + l_i$$

r_i	— excess reserves	c_i	— capital
$\sum_{j=1}^{n} y_{ij}^{st}$	— short-term interbank lending	$\sum_{j=1}^{n} y_{ji}^{st}$	— short-term interbank borrowing
$\sum_{j=1}^{n} y_{ij}^{lt}$	— long-term interbank lending	$\sum_{j=1}^{n} y_{ji}^{lt}$	— long-term interbank borrowing
s_i	— securities		
a_i	— other assets	l_i	— other liabilities

with n— total number of banks,

$$\sum_{j=1}^{n} y_{ij} = \sum_{j=1}^{n} y_{ij}^{st} + \sum_{j=1}^{n} y_{ij}^{lt},$$

$$\sum_{j=1}^{n} y_{ji} = \sum_{j=1}^{n} y_{ji}^{st} + \sum_{j=1}^{n} y_{ji}^{lt}$$

Formal condition set (solvency, liquidity, Infection)

Panel B. Conditions for being insolvent (S), illiquid (L) and infected (I)

Irreplacable funding liquidity loss — Remaining liquid assets

$S1 \quad c_i < \lambda \sum_{j=1}^{n} \theta_j y_{ij}$

$S2 \quad c_i < \lambda \sum_{j=1}^{n} \theta_j y_{ij} + \max\left\{0, \delta\left[\rho \sum_{j=1}^{n} \theta_j (y_{ji}^{st} + y_{ji}^{lt}) - r_i - \sum_{j=1}^{n} (1-\theta_j)(y_{ij}^{st} + y_{ij}^{lt})\right]\right\}$

$S3 \quad c_i < \lambda \sum_{j=1}^{n} \theta_j y_{ij} + \max\left\{0, \delta\left[\sum_{j=1}^{n} (y_{ji}^{st} + y_{ji}^{lt}) - r_i - \sum_{j=1}^{n} (1-\theta_j)(y_{ij}^{st} + y_{ij}^{lt})\right]\right\}$

$L1 \quad r_i + \sum_{j=1}^{n} (1-\theta_j)(y_{ij}^{st} + y_{ij}^{lt}) + (1 - \frac{\delta}{1+\delta}) s_i < \rho \sum_{j=1}^{n} \theta_j (y_{ji}^{st} + y_{ji}^{lt})$

$L2 \quad r_i + \sum_{j=1}^{n} (1-\theta_j)(y_{ij}^{st} + y_{ij}^{lt}) + (1 - \frac{\delta}{1+\delta}) s_i < \sum_{j=1}^{n} (y_{ji}^{st} + y_{ji}^{lt})$

Market value securities after haircut

$I1 \quad 0 < \lambda \sum_{j=1}^{n} \theta_j y_{ij}$

$I2 \quad 0 < \rho \sum_{j=1}^{n} \theta_j (y_{ji}^{st} + y_{ji}^{lt})$

$I3 \quad \max[0, (1-\mu) c_i] < \lambda \sum_{j=1}^{n} \theta_j y_{ij} + \max\left\{0, \delta\left[\rho \sum_{j=1}^{n} \theta_j (y_{ji}^{st} + y_{ji}^{lt}) - r_i - \sum_{j=1}^{n} (1-\theta_j)(y_{ij}^{st} + y_{ij}^{lt}\right.\right.$

$I4 \quad (1-\mu) r_i < \rho \sum_{j=1}^{n} \theta_j (y_{ji}^{st} + y_{ji}^{lt})$

where:

$\theta_j = 1$ if bank j has defaulted, and 0 otherwise

λ - loss given default (LGD) on interbank assets

ρ - fraction of lost funding from failed banks that cannot be replaced

δ - fire sale asset haircut: selling assets worth $(1+\delta)$ a bank takes a loss of δ

$(1-\mu)$ - fraction of capital c_i / reserves r_i needed to be destroyed to trigger a run

Scenario's

Panel C. Default rules for different contagion scenarios

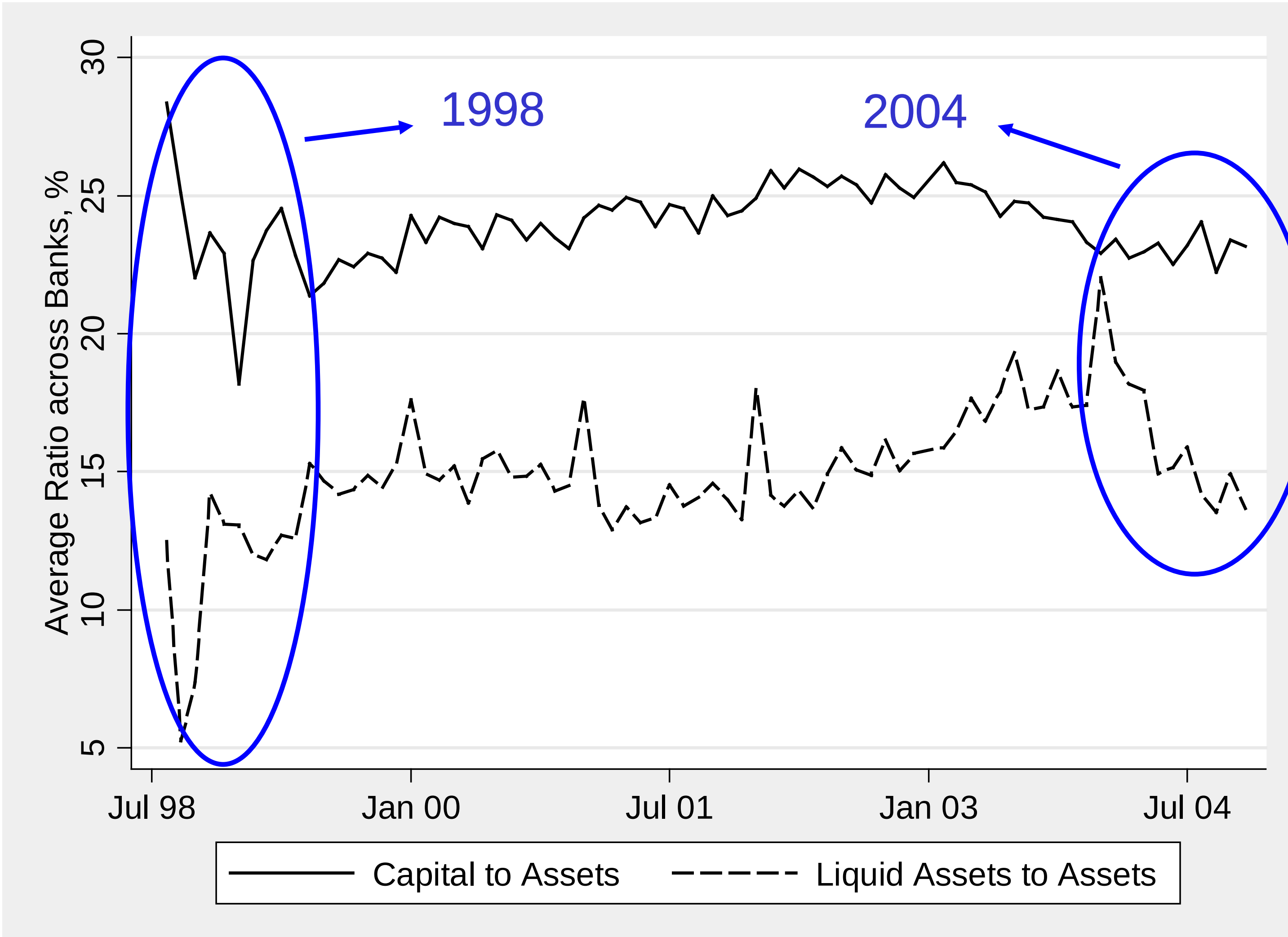
Contagion scenario	Default rule
1a: credit loss	$S1$ & $I1$
2a: credit + funding loss	$(S2$ *or* $L1)$ & $(I1$ *or* $I2)$
3a: credit + funding loss + run on infected	$\{(S2$ *or* $L1)$ & $(I1$ *or* $I2)\}$ *or* $\{(S3$ *or* $L2)$ & $(I3$ *or* $I4)\}$
4a: credit + funding loss + run on all	$S3$ *or* $L2$
2s, 3s, 4s:	same as 2a, 3a, 4a but all $y^{lt} = 0$

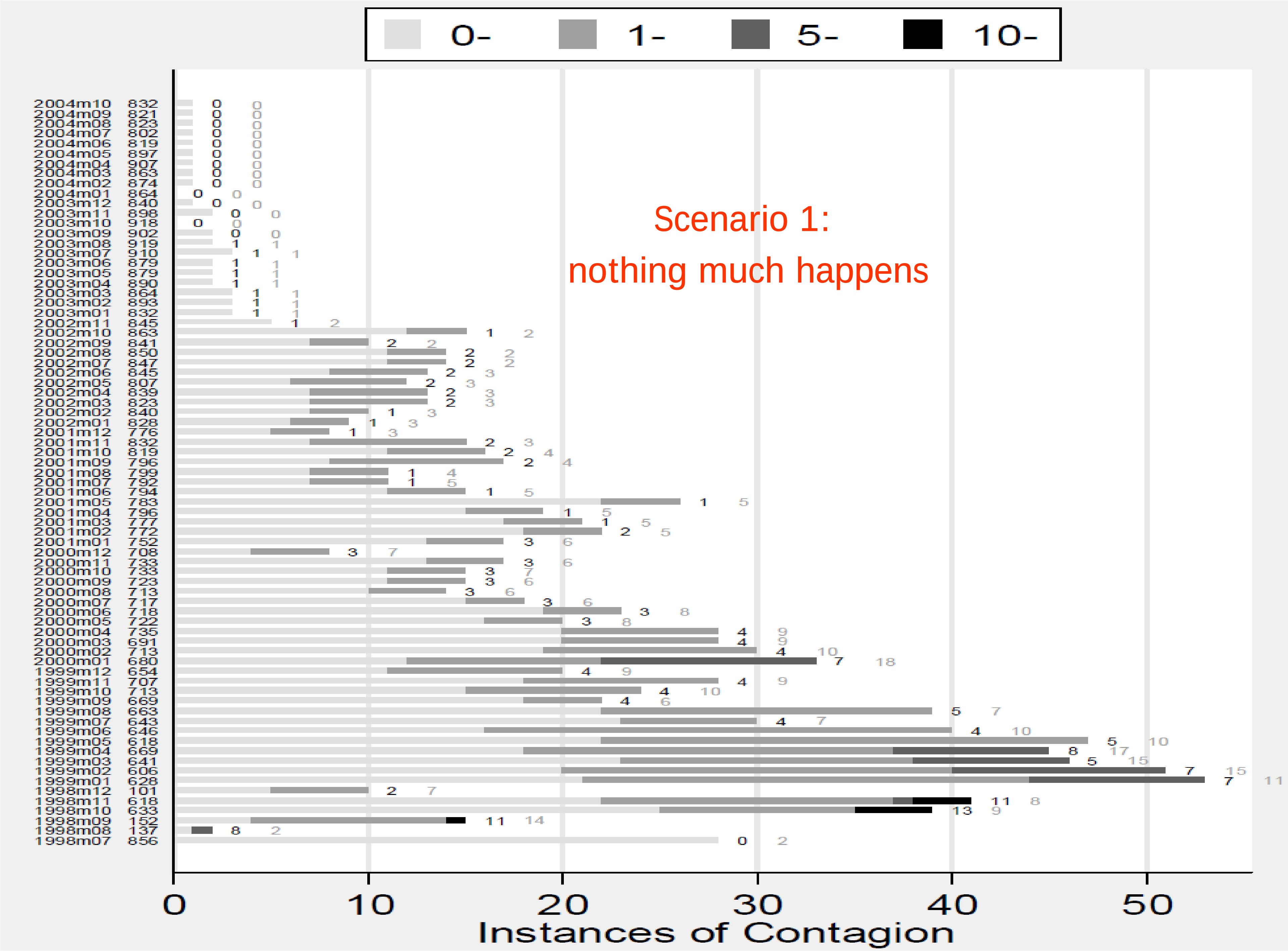
6

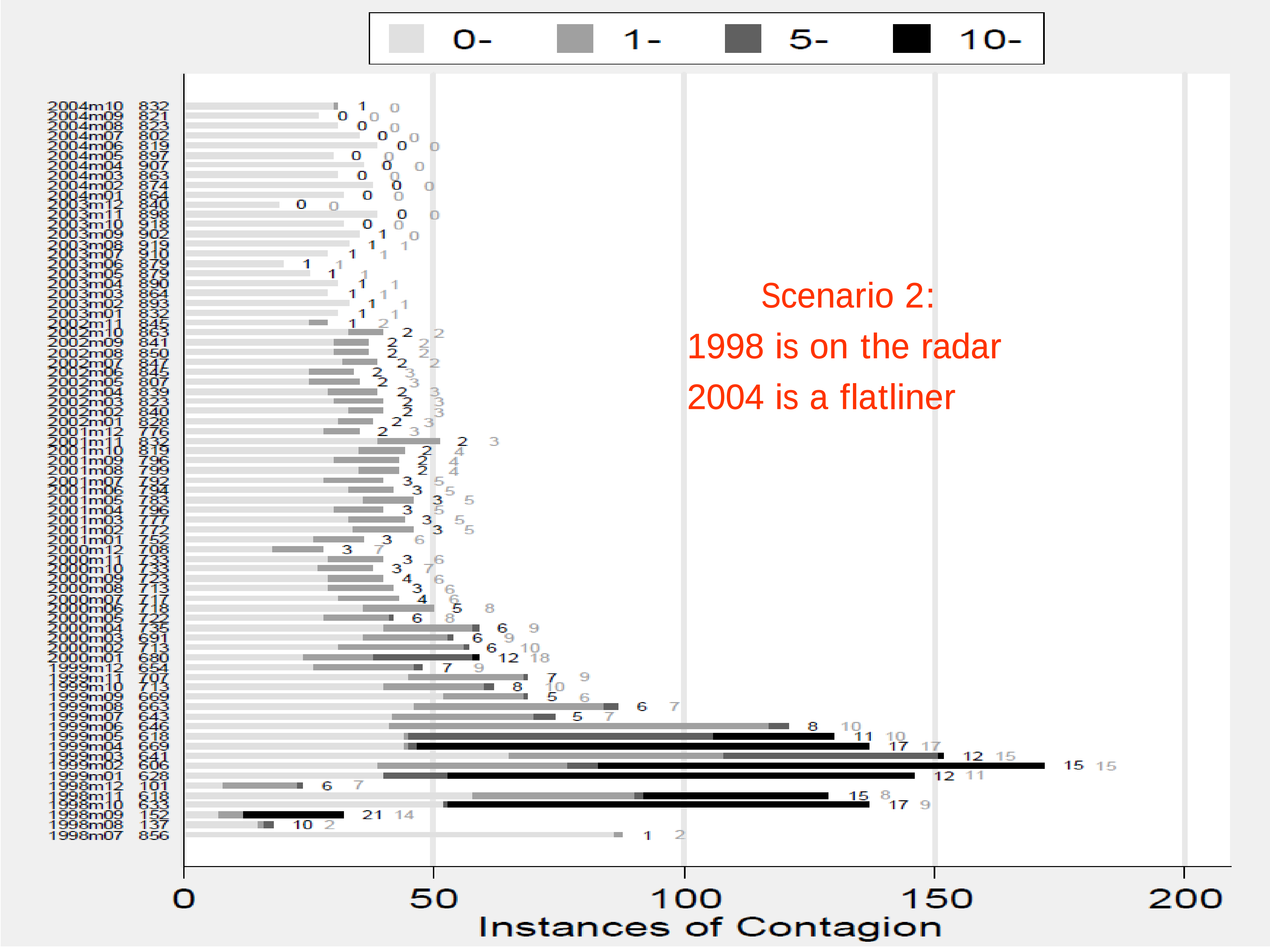
On haircuts

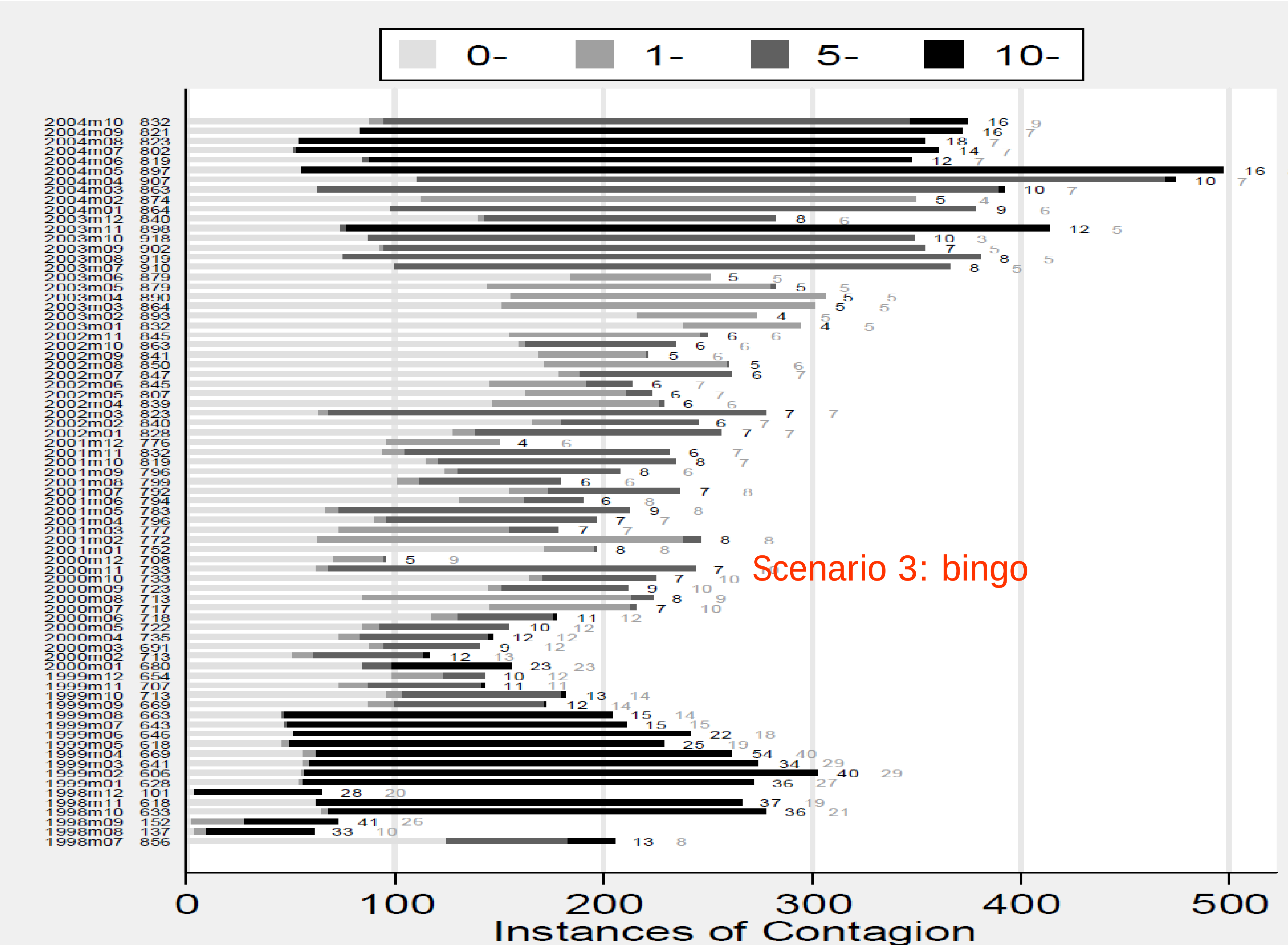
- Why not endogenous?
  - We could increase the haircut in function of results of previous rounds (spirit of Eisenberg and Noe; Müller)
  - But this would only reinforce results
- Why not after liquidity hoarding?
  - We could also change the order,
  - but the scenario with hoarding, but no haircut yet, would suffice to get contagion
  - Haircut would then drop from the simulation scenario
- More important in more developed markets?

Financial crises and bank health
Capital versus liquidity




0-
1-
5-
10-
Scenario 1:
nothing much happens
0
10
20
30
40
50
Instances of Contagion


0-
1-
5-
10-
Scenario 2:
1998 is on the radar
2004 is a flatliner
0
50
100
150
200
Instances of Contagion



0-
1-
5-
10-
2004m10 832
2004m09 821
2004m08 823
2004m07 802
2004m06 819
2004m05 897
2004m04 907
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1999m05 618
1999m04 669
1999m03 641
1999m02 606
1999m01 628
1998m12 101
1998m11 618
1998m10 633
1998m09 152
1998m08 137
1998m07 856
Scenario 3: bingo
0
100
200
300
400
500
Instances of Contagion

Intermediate conclusion

- The capital channel does not suffice
  - The 1998 crisis is somewhat predicted by it
  - The 2004 crisis is off the screen
- Funding liquidity and asset sales don't do it either
  - 1998 is now really on the screen
  - 2004 is still flat
- Scenario 3 captures both crisis periods
  - Liquidity runs and preferential detachment are essential
  - We will use this scenario to calculate individual banks' contributions to contagion in a second step

Last step: Identifying the spreaders of contagion

- We have identified by simulation the banks that contribute most to contagion
- The question: can we identify the "SIFI" by
  - Looking at the structure of the network
  - And at the position of banks in the network
- Conventional wisdom
  - Degree, centrality indices, betweenness
- Our contribution
  - K-core centrality

Table 2: Centrality Indices

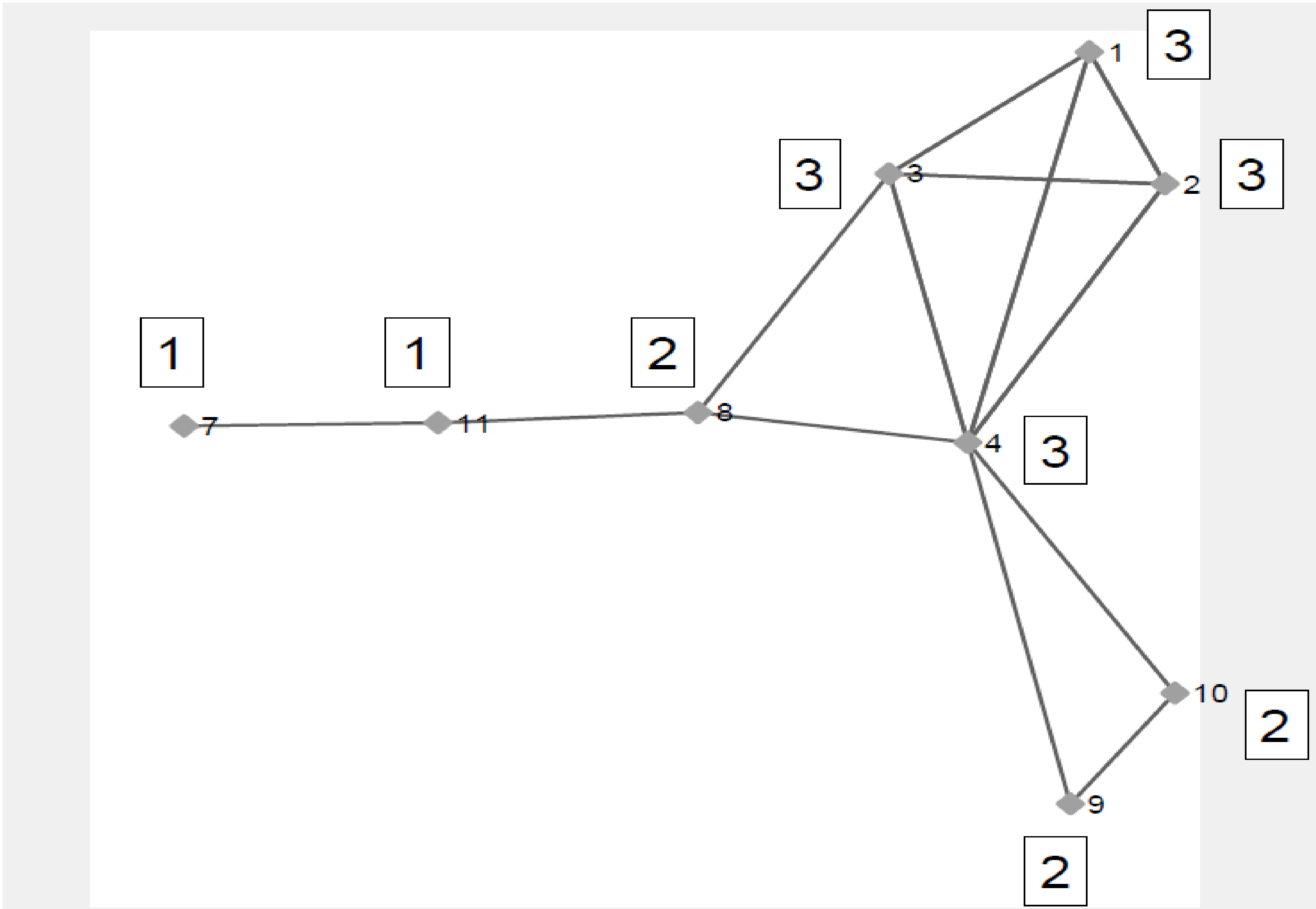
Index	Formula	Description
Valued Outdegree	$0 \leq VO_i = \frac{\sum_{j=1}^{n} y_{ij}}{\text{System-wide Assets}} \leq 1$	bank share in system-wide interbank assets
Valued Indegree	$0 \leq VI_i = \frac{\sum_{j=1}^{n} y_{ji}}{\text{System-wide Liabilities}} \leq 1$	bank share in system-wide interbank liabilities
Non-valued Outdegree	$0 \leq NO_i = \frac{\sum_{j=1}^{n} (y_{ij} > 0)}{n-1} \leq 1$	% of market participants a bank has as counterparties on its asset side
Non-valued Indegree	$0 \leq NI_i = \frac{\sum_{j=1}^{n} (y_{ji} > 0)}{n-1} \leq 1$	% of market participants a bank has as counterparties on its liability side
Betweenness Centrality	see Miura (2011) whose Stata Graph Library we use	% of shortest paths linking institutions other than bank i passing through bank i

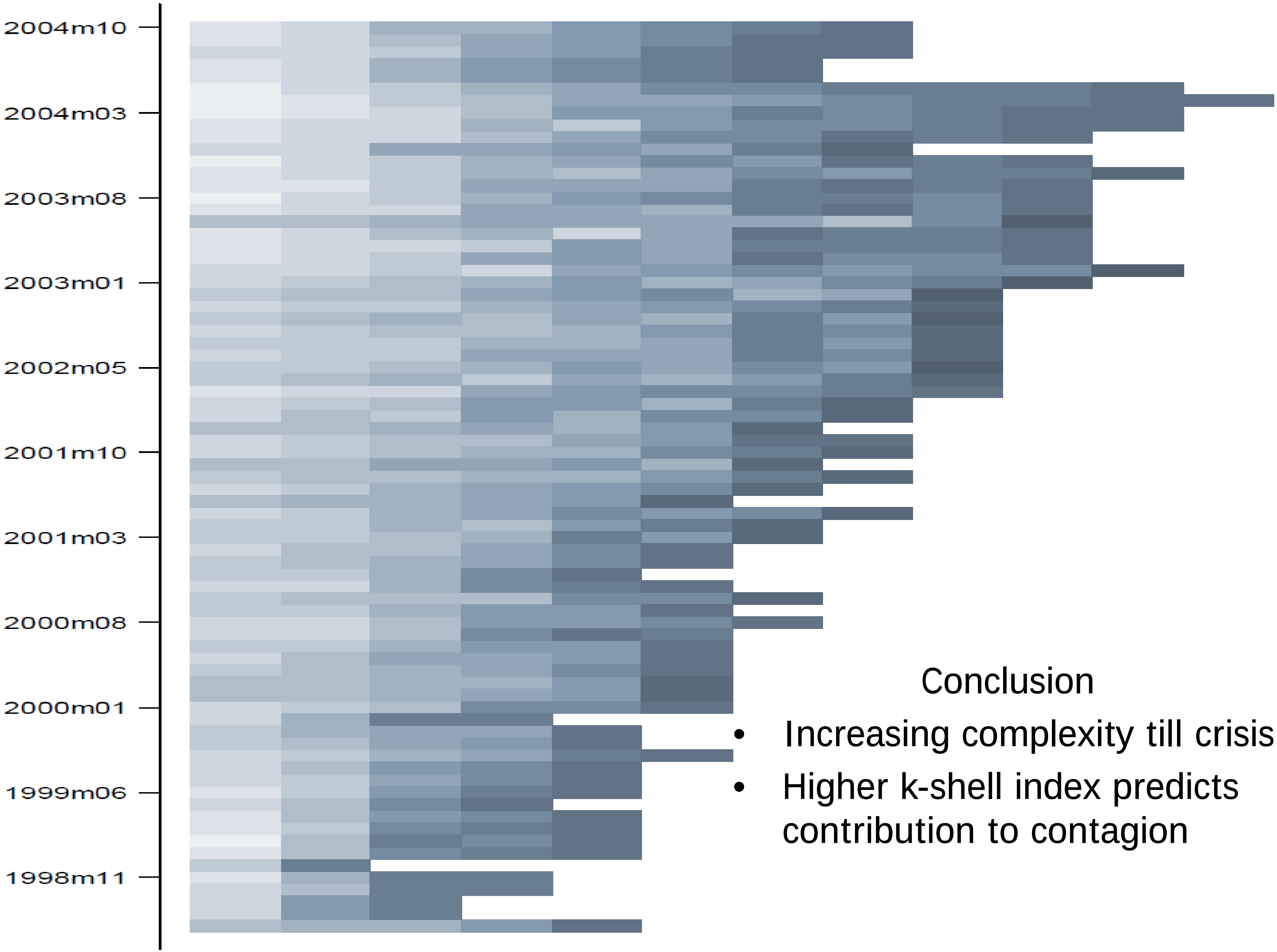
where $y_{ij}-$ gross claims of bank i on bank j
$(y_{ij} > 0)$ evaluates to 1 if bank i has claims on bank j; and 0 otherwise
$(n-1)-$ max number of links a bank can have

Concepts from econophysics

- Conventional wisdom
  - Centrality of a node in a network predicts the node's potential to spread contagion
- Kitsak et al.
  - Challenge this view for a variety of networks
  - Shows that the K-shell index (result from K-core decomposition) beats any traditional network variable
  - We introduce this concept to the banking literature
  - The measure is unweighted and undirected

K-core decomposition analysis





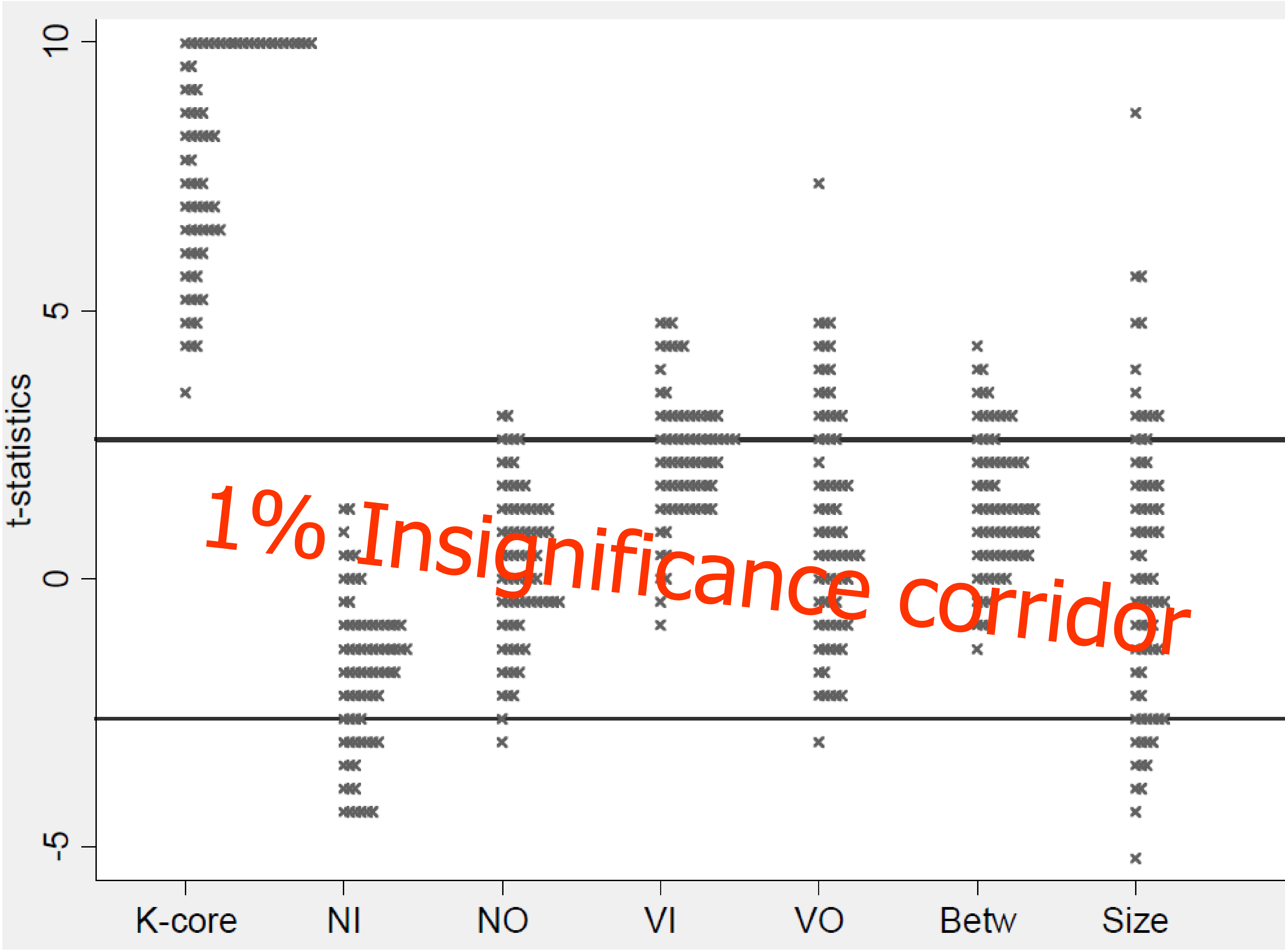
Conclusion

- Increasing complexity till crisis
- Higher k-shell index predicts contribution to contagion

$$C_{it} = \alpha + \beta' Bank_{it} + \lambda_t + \varepsilon_{it}$$

Table 3: Identifying Influential Spreaders

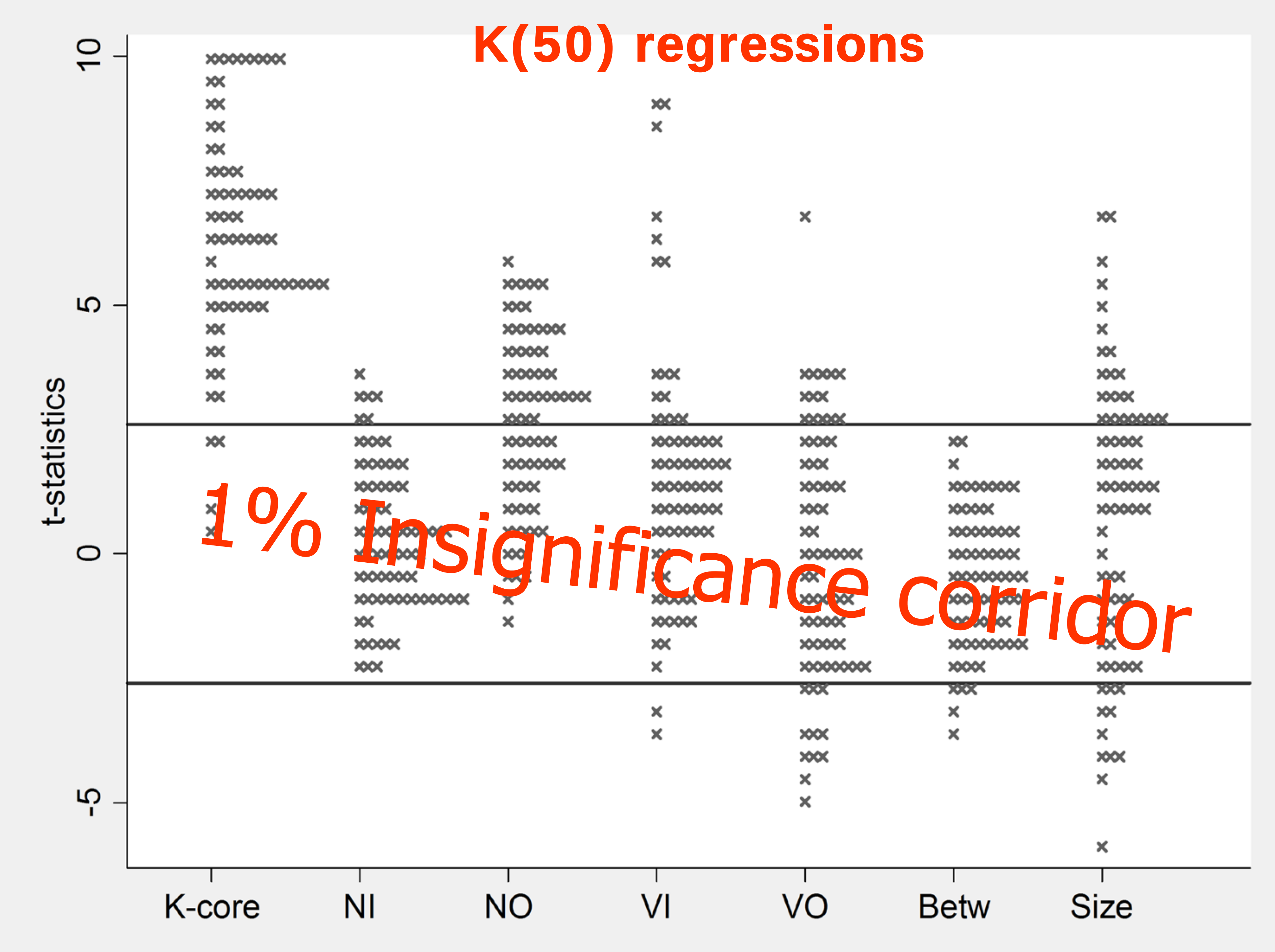
	C = Share of failed banks			C = Share of failed assets		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
NI	1.11***		-0.71***	2.88***		-2.00***
	(8.6)		(-5.6)	(7.7)		(-5.4)
NO	2.32***		0.17*	5.55***		-0.22
	(11.2)		(1.9)	(9.9)		(-1.0)
VI	0.38**		0.30***	1.15**		0.93***
	(2.6)		(3.0)	(2.5)		(2.9)
VO	0.09		0.10*	0.33*		0.35
	(1.6)		(1.7)	(1.7)		(1.6)
Betw	-0.74***		0.56***	-1.89***		1.59***
	(-6.9)		(5.4)	(-6.4)		(5.3)
Size	0.04		-0.02	0.11*		-0.04
	(1.5)		(-1.4)	(1.6)		(-0.7)
K-shell index		0.01***	0.01***		0.02***	0.02***
		(47.6)	(33.2)		(42.6)	(32.1)
Constant	-0.04***	-0.05***	-0.05***	-0.11***	-0.14***	-0.14***
	(-21.6)	(-29.4)	(-29.4)	(-20.5)	(-27.7)	(-27.9)
Observations	56,782	56,782	56,782	56,782	56,782	56,782
AIC	-35266	-39023	-40119	3026	-443.9	-1297
BIC	-34532	-38334	-39376	3760	245.0	-554.1
ML (Cox-Snell) R2	0.268	0.315	0.328	0.233	0.278	0.289
McKelvey-Zavoina's R2	0.328	0.397	0.409	0.287	0.355	0.365



10
5
0
-5
t-statistics
1% Insignificance corridor
K-core
NI
NO
VI
VO
Betw
Size

K-shell index versus size

- K-shell index is unweighted and undirected
- Consider the simple weighted K(α)-index, that consider only the α% largest edges
- Standard K = K(100)
- Calculate K(50)
  - Correlation K(50), K(100) = 0,85
  - In the regressions K(50) is clearly weaker than K(100)
  - But still far stronger than anything else
- More complex weighing schemes give same result



K(50) regressions
1% Insignificance corridor
t-statistics
10
5
0
-5
K-core
NI
NO
VI
VO
Betw
Size

Policy implications

- Basel III capital conservation and countercyclical buffers, fully effective on 1 January 2019.
- Higher loss absorbency requirements for SIFI
- Basel SIFI: an indicator-based approach
  - size,
  - interconnectedness,
  - lack of readily available substitutes
  - Global (cross-jurisdictional) activity
  - complexity.
- it has been suggested that size is the main indicator of systemic importance.

Our analysis challenges this wisdom

- Liquidity runs and preferential detachment are at the heart of banking panics
- By consequence a bank's position in the network (K-shell) may be more important for its "coreness" to the system than size
- Data on the biggest bilateral links may suffice to identify the SIFI (the K(50) results)
- It may be wise for the guardians of financial stability to invest in this

Concluding remarks

- Liquidity hoarding
  - Is relevant to financial stability
  - though theoretical effects are poorly understood
- Supervisors who knows interbank market structure
  - can predict the stability of the interbank market
  - can identify SIFI who are too interconnected to fail
  - Can demand from them higher capital buffers
- The lender of last resort
  - Can solve the problem by timely and targeted injections,
  - As to keep upright the ‘too central to fail’ banks in the heat of the moment.