



ACTUARIAL SOCIETY
S O U T H A F R I C A

Network models of systemic risk in banking

Findings for consideration

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Network models of systemic risk in banking



Agenda

1. Background
2. Methodology
3. Large banks
4. Tipping points
5. Concluding comments

References

My thanks to my supervisors and co-authors, Prof Conrad Beyers & Dr Nadine van der Walt (nee Walters). This modelling builds on Nadine's foundational effort. References identified on these slides are listed at the back of the deck



Summary

Based on a network model of South African banks using contemporaneous financial attributes:

- disproportional domination by South Africa's large banks
- based on assessment of changing patterns of self-similarity, and
- systemic risk indicator is characterised by tipping points with respect to two parameters
- suggesting elevated systemic risk under circumstances approaching these tipping points

Suggestions for further research are presented in both cases



1. Background

Regulatory objectives are increasingly framed on the basis of mitigating market failures:

- financial markets play critical roles in the economies served

Among the roles played are:

- facilitating payments for the exchange of goods and services
- pricing, pooling, managing and transferring risk
- pooling or mobilising resources for capital expenditure and infrastructural- or social development
- mobilising savings and financial liquidity, and
- facilitating trade in goods or services between countries and regions.



1. Background

Regulatory objectives are increasingly framed on the basis of mitigating market failures:

- financial markets play critical roles In the economies served
- they are increasingly integrated, potentially contributing to instability

“[...] a complex adaptive system[...] robust and fragile[...] progressively more complex and less diverse”

Andrew Haldane, Bank of England Director of Financial Stability, speech delivered
at the Financial Student Association, Amsterdam, April 2009, page 3



1. Background

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- they take on a number of forms but are complex, global in reach and intertwined



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- they cause substantial (not easily quantified) damage when they fail
- **these failures (or imperfections) can have a range of forms and consequences**

These include:

- information inequity
- market-power imbalances
- principal-agency conflict
- externalities



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- and the possibility of regulatory failure should not be excluded



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- and the possibility of regulatory failure should not be excluded
- regulation is typically justified on efforts to correct market failure

This calls for:

- a sound understanding of potential failures, and
- clearly defined objectives



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Regulators have come in for criticism from several sources regarding their treatment of systemic risk
These studies aim to contribute to our understanding of fragility in South Africa's banking network



1. Background

The studies described here are part of a series of five:

- I. the systemic domination of large banks
- II. evidence for tipping points in systemic risk levels
- III. assessing systemic risk in South African banks through ΔCoVaR
- IV. exploring the possibility of a contribution to systemic risk by South African insurers
- V. a practical framework for assessing the contribution to systemic risk by insurers



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- ΔCoVaR is the marginal contribution to systemic risk by an institution in distress relative to its contribution at its median state:

$$\Delta\text{CoVaR}_q^{j|i} = \text{CoVaR}_q^{j|X^i=\text{VaR}_q^i} - \text{CoVaR}_q^{j|X^i=\text{Median}^i}$$

- Foundational equations are established for each institution and the system:

$$X_t^i = \alpha^i + \gamma^i M_{t-1} + \varepsilon_t^i$$

$$X_t^{\text{system}} = \alpha^{\text{system}|i} + \beta^{\text{system}|i} X_t^i + \gamma^{\text{system}|i} M_{t-1} + \varepsilon_t^{\text{system}|i}$$

- Quantile regression is used to estimate parameters at $q=5\%$ and $q=50\%$:

$$\text{VaR}_t^i(q) = \hat{\alpha}_q^i + \hat{\gamma}_q^i M_{t-i}$$

$$\text{CoVaR}_t^i(q) = \hat{\alpha}_q^{\text{system}|i} + \hat{\beta}_q^{\text{system}|i} \text{VaR}_t^i(q) + \hat{\gamma}_q^{\text{system}|i} M_{t-i}$$

- ΔCoVaR follows from the estimated parameters:

$$\Delta\text{CoVaR}_t^i(5\%) = \text{CoVaR}_t^i(5\%) - \text{CoVaR}_t^i(50\%) = \beta[\text{VaR}_t^i(5\%) - \text{VaR}_t^i(50\%)]$$

- IV. exploring the possibility of a contribution to systemic risk by South African insurers
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Network models of systemic risk in banking



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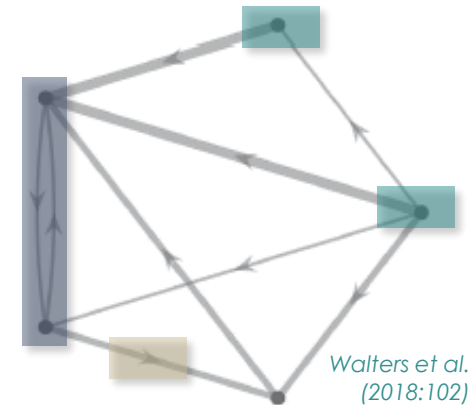
2. Methodology & data

South Africa's banking market is modelled as a network of linked entities using contemporary data

- banks are represented by nodes in the network
- contagion between banks travels along the edges
- the direction of this propagation is significant

This approach is supported by considerable network-based investigation of banking systems:

- links between the structure of the system and the dynamics of contagion
- investigation of the empirical network dynamics in markets
- assessment of the impacts of
 - concentration of risk in large banks,
 - propagation of risk between entities of different sizes
 - nature of lending arrangements between entities
- impacts of a range of contagion channels
- consideration of the regulatory implications of market concentration



Allen and Gale (2000); Anand, Gai, and Marsili (2012); Andries and Galasan (2020); Boss et al. (2004); Borges, Ulica, and Gubareva (2020); Brusco and Castiglionesi (2007); Caccioli et al. (2014); Claessens (2015); Cocco, Gomes, and Martins (2009); Freixas, Parigi, and Rochet (2000); Fricke and Lux (2015); Furceri and Mourougane (2009); Gai, Haldane, and Kapadia (2010); Gai and Kapadia (2010); Garratt, Mahadeva, and Svirydzenka (2011); Gauthier, Lehar, and Souissi (2012); Georg and Brink (2011); Huang, Zhou, and Zhu (2012a); Hüser (2016); Inaoka et al. (2004); In't Veld and Van Lelyveld (2014); Iori et al. (2008); Lee (2013); Krause and Giansante (2012); Lenzu and Tedeschi (2012); Leitner (2005); Martinez-Jaramillo et al. (2015); May and Arinaminpathy (2009); Neveu (2018); Poledna et al. (2015); Upper and Worms (2004); Roukny et al. (2013); Rørdam and Bech (2009); Saramäki et al. (2007); Silva, Stancato de Souza, and Tabak (2016); Tasca, Mavrodiev, and Schweitzer (2014); Teteryatnikova (2014); Upper (2011); Vallascas and Keasey (2012); Walters et al. (2018); Weber (2012)



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- if it is large enough to render it insolvent, $Sa_n > c_n = CET1$, then we investigate its impacts on its peers

We use CET1 (Common Equity Tier 1) as a proxy for available cash in an emergency



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 - if other banks also fail, then we consider how their insolvencies in turn impact the remaining banks
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 - we define this proportion as the systemic default indicator
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 - we continue until the system is stable, counting the proportion of banks that have failed
 - we define this proportion as the systemic default indicator
 - we repeat the simulation exercise 10,000 times and determine the average of this value
-



2. Methodology & data

We consider three different channels of contagion

- other banks are required to assist with capitalisation of the shocked entity

Credit shock

- a proportion u of the loss suffered by the shocked bank in excess of its liquid assets, $Sa_n - c_n$
 - is borne by other banks in proportion to the size of their assets at the time
-



2. Methodology & data

We consider three different channels of contagion

- other banks are required to assist with capitalisation of the shocked entity
- other banks suffer balance sheet impacts attributable to elevated provisions or forced sale

Liquidity shock

- the asset value a_i of bank i is given by $a_i e^{-\eta}$
 - where η is defined separately for short-term, $\eta^{(s)}$, medium-term, $\eta^{(m)}$, and long-term, $\eta^{(l)}$, assets
 - following Walters et al (2018) in the allocation of assets to term-based categories
-



2. Methodology & data

We consider three different channels of contagion

- other banks are required to assist with capitalisation of the shocked entity
- other banks suffer balance sheet impacts attributable to elevated provisions or forced sale
- the value of the assets of other banks fall under market-sentiment effects
- these depend on the proximity of these banks to the shocked bank and scale of assumed impact

Proximity shock

- the asset value, a_i , of bank i , is given by $a_i e^{-\tau/d(i,n)}$
 - where:
 - τ is the extent of the proximity shock, and
 - $d(i,n)$ is the shortest possible distance between the respective nodes of banks i and n ,
 - $d(i,n)$ is an integer impacted by the network structure and overall probability of connections between pairs of banks
-



2. Methodology & data

We use starting parameters consistent with Walters et al (2018)

Market impacts

Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	$\bar{p}$	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



2. Methodology & data

We also use market network models that are consistent with Walters et al (2018)

Core-peripheral structures	Network	Explanation
	Erdős-Rényi	The probability of linkages between nodes in the network is constant across the market.
	Attraction to size	The probability that a large bank triggers difficulty at a smaller bank is high, but the corresponding probability in the event of the initial failure of a small bank is low, also called 'flight to quality'.
	Assortativeness	Banks of similar size have a higher probability of connection. Large banks are more likely to be connected to other large banks and small banks to small banks.
	Disassortativeness	Banks are assumed more likely to be connected to other banks that are of different size. Small banks are more likely to be connected to large banks and the other way around.
	Tiered Type I	Large banks are connected to one another with high probability. Small banks have a low probability of being connected to each other. The probability of large and small banks being connected to one another lies between these extremes
	Tiered Type II	The probability of a small bank being connected to another small bank is low and the probability of a small bank being connected to a large bank is higher, but also relatively low. In contrast, large banks are connected to one another with high probability and the probability of a large bank connecting to a small bank is relatively high as well.



2. Methodology & data

We utilise contemporaneous data on South African banks

- most balance sheet data is available from monthly BA900 reports, available from the SARB
- CET1 is extracted from annual financial statements or supporting documents
 - typically, available quarterly,
 - translated into ratios and
 - interpolated between available data points



2. Methodology & data

We utilise contemporary

- most balance

Regulatory Capital Position (excluding unappropriated profits)

Common Equity Tier 1 capital

Ordinary share capital

Ordinary share premium

Reserves¹

Deductions

Additional Tier 1 capital

Tier 1 capital

Tier 2 capital

Total Capital

Common Equity Tier 1 capital: Instruments and reserves
1 Directly issued qualifying common share capital (and equivalent for non-joint stock)
2 Retained earnings
3
4

	30-Nov-20	31-Aug-20	31-May-20	29-Feb-20	30-Nov-19
Available capital (amounts) R'000					
1 Common Equity Tier 1 (CET1)	2,559,093	2,564,156	2,564,095	2,564,312	2,466,144
1a Fully loaded ECL accounting model	(35,586)	(35,586)	(35,586)	(35,586)	(35,586)
2 Tier 1	2,429,976	2,472,591	2,496,570	2,485,991	2,389,159
2a Fully loaded accounting model Tier 1	(35,586)	(35,586)	(35,586)	(35,586)	(35,586)
3 Total capital	2,561,770	2,600,721	2,613,234	2,613,058	2,485,227
3a Fully loaded ECL accounting model total capital	131,794	128,130	116,664	127,067	96,068

Basel III leverage ratio

Basel III leverage ratio (i)

¹ Excluding unappropriated profit.

R'million	31 December 2019	September 20
Available capital (amounts)		
1 Common Equity Tier 1 (CET1)	39 230	39 5
1a Fully loaded ECL accounting model	39 230	39 5
2 Tier 1	40 150	40 4
2a Fully loaded ECL accounting model Tier 1	39 690	39 9
3 Total capital	53 510	53 830
3a Fully loaded ECL accounting model total capital	53 050	53 370

(ZAR millions)	31 Dec 2015	30 Sep 2015	30 Jun 2015	31 Mar 2015
Qualifying Capital				
Endowment capital	1 420	1 420	1 420	1 420
Retained Earnings	2 536	2 362	2 231	2 053
Other Comprehensive Income	-36	-9	-7	5

3 478
6
3 484
26 229

75,280	75,396
1,408,354	1,375,310

	a Sep-20 T	b Jun-20 T-1	c Mar-20 T-2	d Dec-19 T-3	e Sep-19 T-4
1 Common Equity Tier 1 (CET1)	921 665	962 086	942 131	903 616	897 647
1a Fully loaded ECL accounting model	921 665	962 086	942 131	903 616	897 647
2 Tier 1	921 665	962 086	942 131	903 616	897 647
2a Fully loaded accounting model Tier 1	921 665	962 086	942 131	903 616	897 647
3 Total capital	976 095	1 018 455	981 103	941 143	938 463
3a Fully loaded ECL accounting model total capital	976 095	1 018 455	981 103	941 143	938 463

Examples only, highlights added by author

Sources: HSBC (2016), 'Pillar 3 Disclosure', April 2016

Sasfin (2020), 'Pillar III Risk Management Report 30 Sept 2020

ABSA Group (2019), 'Basel III Pillar 3 Disclosure as at 31 March 2019

Standard Bank Group (2018), 'Risk and capital management report as at 31 March 2018

Albaraka Bank (2019), 'Composition of Capital Disclosure Template, six months ended 2018-12-31

Mercantile Bank (2021), 'Unaudited Quarterly Disclosure in terms of Regulation 43 Relating to Banks

Investec Bank Group (2019), 'Basel Pillar III quarterly disclosure report for the quarter ended 31 Dec 2019



2. Methodology & data

Raw BA900 data is of very good quality, particularly recent data

Date	01-Mar							
Institution	INVESTEC BANK LTD(25054)							
Form Type	BA900							
Table 1								
Description	Item number	Chequej(1)	Savings(2)	Up to 1 day(3)	More than 1 day to More than 1 month	More than 1 month	More than 6 month-TOTAL(7)	NCDs/PNs i (included in col. 7)
DEPOSITS (total of items 2 and 32)	1	4 439 694	6 612 117	156 138 323	24 672 294	87 286 493	87 296 904	366 445 825
DEPOSITS DENOMINATED IN RAND (total of items 3, 6, 12, 13 and 29)	2	4 439 694	6 612 117	149 831 295	24 548 919	83 285 753	86 907 376	355 625 153
SA banksb (total of items 4 and 5)	3	0	0	378 161	1 155 246	649 494	992 337	3 175 238
NCDs/PNsi	4	0	0	0	0	500 608	916 063	1 416 671
Other deposits	5	0	0	378 161	1 155 246	148 886	76 274	1 758 567
Central and provincial government sector depositsc (total of items 7, 10 and 11)	6	0	0	2 247 638	284 620	1 759 024	620 319	4 911 601
Central government of the Republic (total of items 8 and 9)	7	0	0	2 245 378	284 620	1 759 024	620 319	4 909 341
Tax and loan account	8	0	0	0	0	0	0	0
Other	9	0	0	2 245 378	284 620	1 759 024	620 319	4 909 341
Provincial governments	10	0	0	2 260	0	0	0	2 260
Social security funds	11	0	0	0	0	0	0	0
Other monetary institutionsh	12	0	0	18 119	0	0	0	18 119
Other domestic parties (total of items 14 to 20, 25, 26, 27 and 28)	13	4 439 694	6 612 117	146 676 065	22 587 363	75 329 998	82 669 775	338 315 013
Local government	14	0	0	847 383	1 546 791	1 871 288	1 139 831	5 405 292
Public financial corporate sectord (such as IDC, DBSA)	15	0	0	25 566	2 880 874	170 694	0	3 077 134
Public Investment Corporation (PIC)	16	0	0	301 905	2 287 871	4 714 364	1 631 031	8 935 171
Public non-financial corporate sector (such as Transnet, Eskom and Telkom)	17	0	0	2 557 164	238 510	1 285 427	1 144 665	5 225 766
Insurersf	18	0	0	258 924	108 491	323 256	1 628 654	2 319 325
Pension funds	19	0	0	584 221	0	571 528	1 240 667	2 396 416
Private financial corporate sectore (total of items 21 to 24)	20	4 439 694	0	22 395 053	7 316 280	37 112 283	64 034 875	135 298 185
Money-market unit trusts	21	0	0	61	0	0	0	61
Other unit trusts	22	0	0	0	0	0	0	0
Fund managers	23	4 439 694	0	21 534 733	6 394 425	35 412 618	56 952 693	124 734 162
Otherg	24	0	0	860 259	921 856	1 699 665	7 082 182	10 563 962
Private non-financial corporate sector	25	0	666 589	48 953 446	5 525 873	14 169 291	4 884 980	74 200 179
Unincorporated business enterprises	26	0	0	1 168 842	58 452	155 038	69 370	1 451 703
Householdsh	27	0	5 945 528	67 645 948	1 987 236	11 562 560	5 523 081	92 664 353
Non-profit organisations serving households and other	28	0	0	1 937 614	636 985	3 394 269	1 372 621	7 341 489
Table 2								
Description	Item number	Chequej(1)	Savings(2)	Up to 1 day(3)	More than 1 day to More than 1 month	More than 1 month	More than 6 month-TOTAL(7)	NCDs/PNse (included in col. 7)
Foreign sector (total of items 30 and 31)	29	0	0	511 312	521 689	5 547 236	2 624 945	9 205 182
Banks - including foreign group funding	30	0	0	72 955	101 539	4 197 047	550 275	4 921 816
Other non-residents	31	0	0	438 357	420 150	1 350 190	2 074 670	4 283 366
DEPOSITS DENOMINATED IN FOREIGN CURRENCY (total of items 33 to 38)	32	0	0	6 307 028	123 375	4 000 740	389 528	10 820 671
SA banksb	33	0	0	0	26 790	0	0	26 790
SA Central and provincial government	34	0	0	0	0	0	0	0
SA Household sector	35	0	0	829 150	0	0	0	829 150
SA Financial corporate sectorc	36	0	0	410 624	31 337	0	382 666	824 628
SA Non-financial corporate sector and otherd	37	0	0	3 487 455	29 534	4 000 740	6 862	7 524 591
Foreign sector (total of items 39 and 40)	38	0	0	1 579 799	35 714	0	0	1 615 513
Banks	39	0	0	0	0	0	0	0
Other non-residents	40	0	0	1 579 799	35 714	0	0	1 615 513

Downloaded from the web site of the South African Reserve Bank, at
<https://www.resbank.co.za/en/home/what-we-do/statistics/releases/banking-sectorinformation/banks-ba900-economic-returns>, on 3 June,
5 August and 16 September 2020 and 13 January 2021

2. Methodology & data

Relationships between data items need to be mapped

Date

Institution

Form Type

Mar-20

INVESTEC BANK LTD(25054)

BA900

Feb-20

Short term assets

Medium term assets

Long term assets

Formula ref.

Level

Output

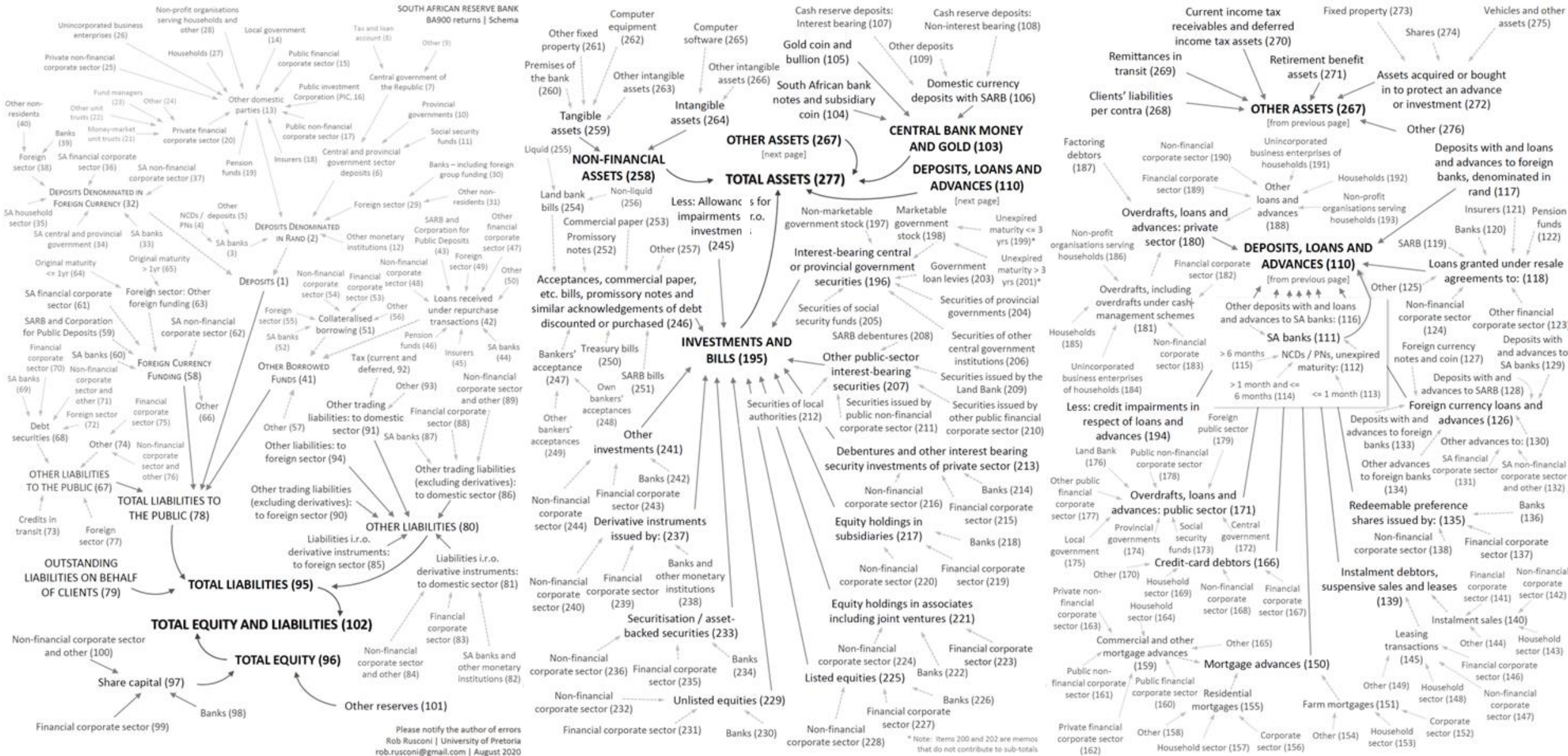
Inputs

Table 1

Description	Item number	Cheque(1)	Savings(2)	Up to 1 day(3)	More than 1 day to 1 month(4)	More than 1 month to 6 months(5)	More than 6 months(6)	TOTAL(7)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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Downloaded from the web site of the South African Reserve Bank, at <https://www.resbank.co.za/en/home/what-we-do/statistics/releases/banking-sectorinformation/banks-ba900-economic-returns>, on 3 June, 5 August and 16 September 2020 and 13 January 2021

Source: author analysis





2. Methodology & data

As an aside, this mapping facilitates summary balance sheets

And, as the difference between balance sheets, income statements

INVESTEC BANK LTD(25054)																																									
March 2020 flows from February 2020																																									
Local government	1 669 266	Other domestic 24 895 181	Central & prov government 38 647	Rand deposits 24 326 277	Deposits 22 289 871	Other borrowed funds 11 207 061	Liabilities to the public 36 166 965	Central bank money and gold 26 104 250	(2) Farm mortgages - 55																																
Public financial corporate	1 642 440									Foreign sector 146 377	Foreign currency deposits 2 036 407	Foreign funding 5 294 458	Liabilities to the public 36 166 965	Deposits, loans and advances 8 153 250	(3) Household - 125 554																										
PIC	1 218 333															Other monetary institutions 15 104	Other liabilities to the public 2 624 423	Other liabilities 2 377 949	Liabilities 38 544 914	(4) Financial corporate 1 129 602																					
Public non-financial corporate	1 109 725																				SA banks 476 277	Debt securities 2 624 423	Outstanding client liabilities -	Equity & liabilities 34 169 664	Non-financial corporate - 1 407 153																
Insurers	114 595																									Credits in transit -	Other reserves 5 275 250	Share capital 900 000	Assets 34 169 664	Unincorporated enterprises 543											
Pension funds	1 476																														Other -	Banks 900 000	Financial corporate sector -	Households - 332 755							
Private financial corporate (1)	11 780 929																																		Foreign sector -	Non-financial corporate sector -	Non-profit organisations - 1 235				
Private non-financial corporate	7 517 928																																					Investments and bills 820 227	(5) Non-marketable govt stock -		
Unincorporated business	48 164																																							Interest-bearing central govt securities (5) - 1 203 546	Marketable government stock - 1 203 546
Households	2 299 708																																								
Non-profit organisations	67 765	Equity holdings in subsidiaries 247 384	Equity holdings in associates, including JVs 966 372																																						
(1) Fund managers	9 608 712			Listed equities 1 051 645	Unlisted equities 394 887																																				
Money-market unit trusts	27					Securitisation / asset-based securities -	Derivative instruments issued by: (6) 2 989 590																																		
Other unit trusts	-							Other investments -	Acceptances and commercial paper 452 608																																
Other	2 172 244									Less: allowance for impairments 4 787	Non-financial assets 275																														
												Clients' liabilities per contra -	Remittances in transit -																												
														Income tax assets - 269 185	Retirement benefit assets -																										
																Assets to protect an advance or investment -	Other 639 154																								
																		Other assets 908 339																							

Source: SARB BA900 returns



2. Methodology & data

This table illustrates the core monthly data required for the modelling

Nov 2015						
Bank	Short term assets	Medium term assets	Long term assets	CET1	Total assets	Test
THE STANDARD BANK OF SA LTD	274 030 094	368 495 593	551 722 158	65 108 668	1 194 247 845	Ok
BIDVEST BANK LIMITED	1 605 584	1 358 691	3 021 341	1 179 348	5 985 616	Ok
HBZ BANK LTD	2 040 525	889 440	1 150 940	267 915	4 080 904	Ok
JPMORGAN CHASE BANK	7 805 570	13 067 093	20 215 888	2 722 093	41 088 553	Ok
ABSA BANK LTD	180 111 598	351 794 163	388 946 679	49 119 105	920 852 439	Ok
THE HONGKONG AND SHANGHAI BAI	22 252 041	25 140 124	1 010 525	3 771 599	48 402 690	Ok
CITIBANK N.A	23 018 296	24 963 794	20 751 712	4 215 327	68 733 802	Ok
UBANK LIMITED	515 978	3 832 852	473 824	399 259	4 822 654	Ok
INVESTEC BANK LTD	76 864 513	107 285 391	185 883 296	30 643 809	370 033 202	Ok
FINBOND MUTUAL BANK	130 407	522 693	754 665	339 402	1 407 765	Ok
CHINA CONSTRUCTION BANK CORP	19 828 359	8 689 894	3 175 706	1 373 654	31 693 959	Ok
MERCANTILE BANK LTD	1 402 513	4 335 101	3 984 276	1 869 740	9 721 890	Ok
STANDARD CHARTERED BANK	17 366 384	13 993 815	2 510 382	2 864 129	33 870 582	Ok
HABIB OVERSEAS BANK LTD	649 304	594 148	8 445	101 471	1 251 897	Ok
NEDBANK LTD	92 679 175	335 468 355	358 630 070	42 412 902	786 777 604	Ok
ALBARAKA BANK LTD	954 186	1 127 913	2 927 144	541 913	5 009 243	Ok
SASFIN BANK LTD	659 726	4 243 850	683 047	906 103	5 586 623	Ok
GRINDROD BANK LTD	2 948 568	3 119 706	2 777 111	558 334	8 845 385	Ok
THE SA BANK OF ATHENS LTD	448 849	748 196	1 361 754	216 048	2 558 798	Ok
BANK OF CHINA LTD JHB BRANCH	23 618 848	7 203 718	814 867	3 649 607	31 637 432	Ok
FIRSTRAND BANK LIMITED	116 050 561	385 989 437	432 692 633	63 420 481	934 732 631	Ok
CAPITEC BANK	20 951 098	40 180 032	1 458 036	12 395 377	62 589 166	Ok
DEUTSCHE BANK AG	3 682 560	7 643 076	8 048 565	1 204 136	19 374 201	Ok
ALL BANKS	909 095 600	1 770 464 246	2 008 044 734		4 687 604 587	Ok

Several banks are excluded on the basis of inadequate CET1 data

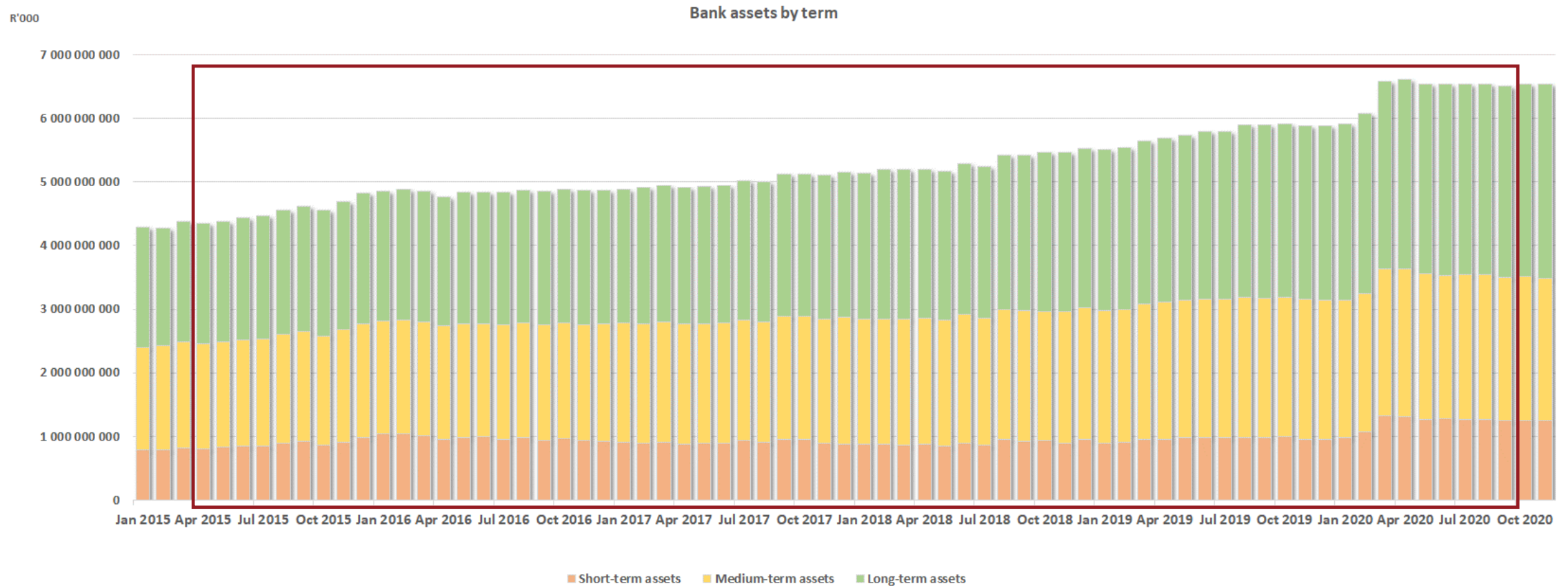
Some 23 banks formed part of the final studies, representing between 98.0% and 98.7% of total market assets

Source: SARB BA900 returns and bank reports



2. Methodology & data

Modelling extended from April 2015 to September 2020 inclusive



Network models of systemic risk in banking



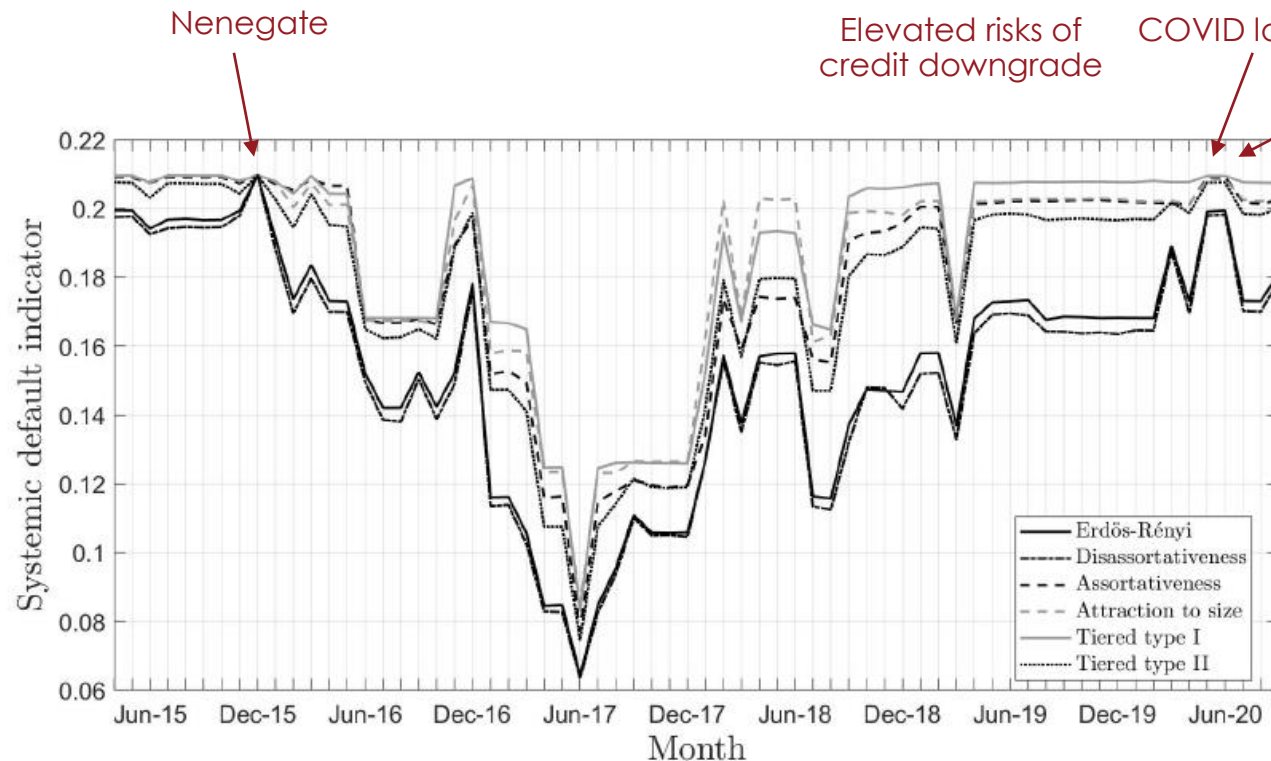
Agenda

1. Background
 2. Methodology
 3. Large banks
 4. Tipping points
 5. Concluding comments
- References



3. Large banks

Overall levels of the systemic default indicator are consistent with contemporaneous events



Results are consistent with Walters et al (2018), which covered the first two years

Correlation tests show intuitive results:

- positive to $\Delta M0$
- inverse to Prime

Patterns with respect to network type are also in line with Walters et al (2018) and consistent over time



3. Large banks

Large banks appear to have a significant impact on the probability of failure of other banks

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10	Bank 11	Bank 12	Bank 13	Bank 14	Bank 15	Bank 16	Bank 17	Bank 18	Bank 19	Bank 20	Bank 21	Bank 22	Bank 23
Bank 1	1	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86
Bank 2	.79	1	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79	.79
Bank 3	.64	.64	1	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64	.64
Bank 4	.40	.40	.40	1	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Bank 5	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 6	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 7	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 8	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 9	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 12	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00
Bank 16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00
Bank 17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00
Bank 18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00
Bank 19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00
Bank 20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00
Bank 21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00
Bank 22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00
Bank 23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1

Table 2: Bank-specific average probabilities of default, random probability of connections

Note. This table shows, for each combination of shocked banks (down the left) and impacted banks (across the top) the probability of bank default across the study period on the Erdős-Rényi network structure and *Assumption Set 1*. Unity values through the diagonal are consistent with the shocked bank always being impacted.

De-composing into channels:

- credit shock has very little impact
- liquidity shock shows tipping points
- proximity demonstrates time-varying tips

At lower probabilities of inter-connectedness, differences between market models expand

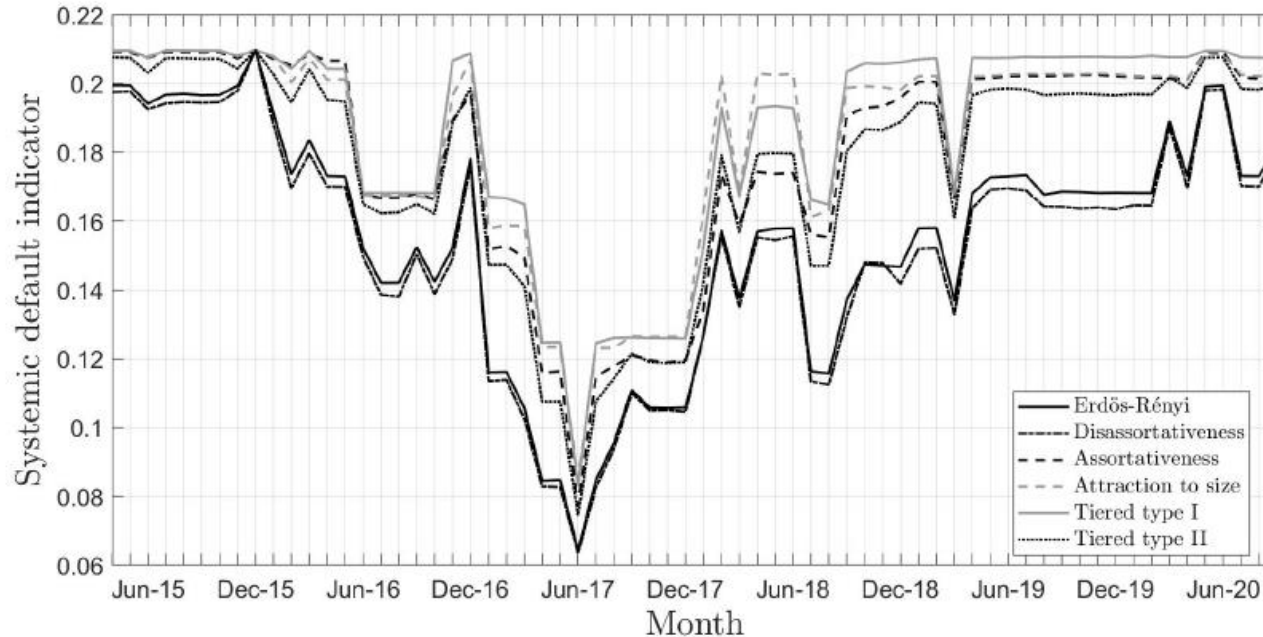
This research focuses on the evidence of changes to self-similarity in market patterns or its narrower form, the power law or Pareto distribution



3. Large banks

Let us test the impacts on the systemic default indicator of removing large banks from the market

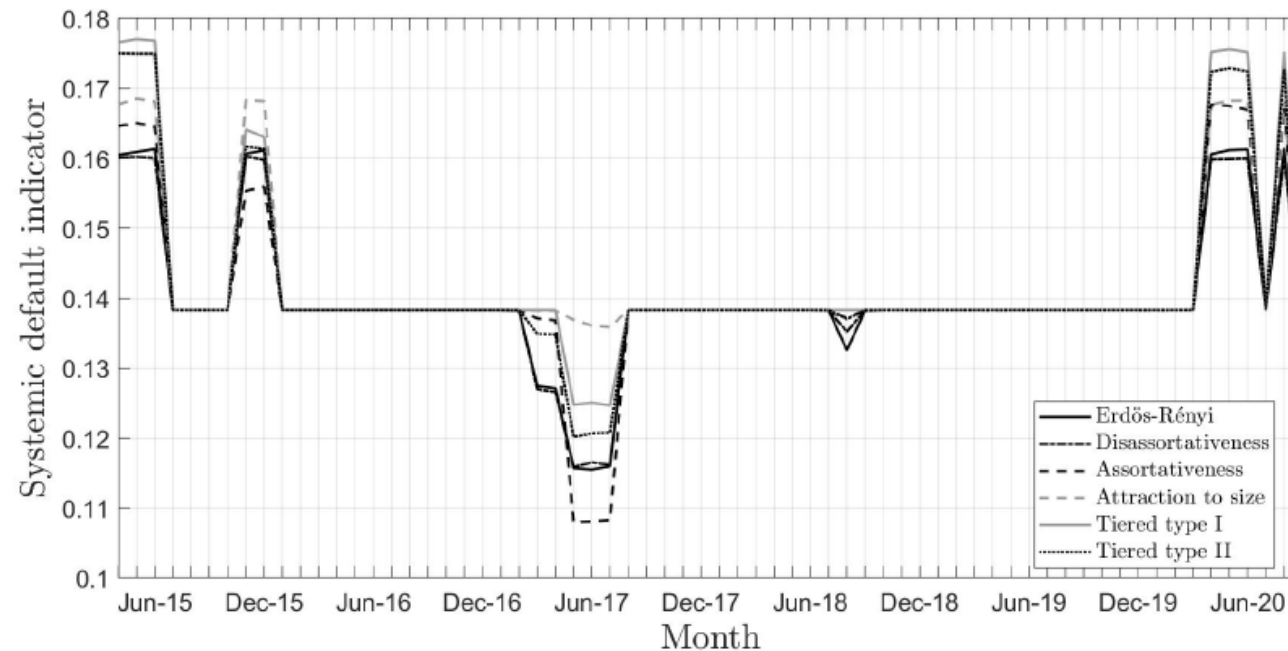
This image includes all banks in the sample





3. Large banks

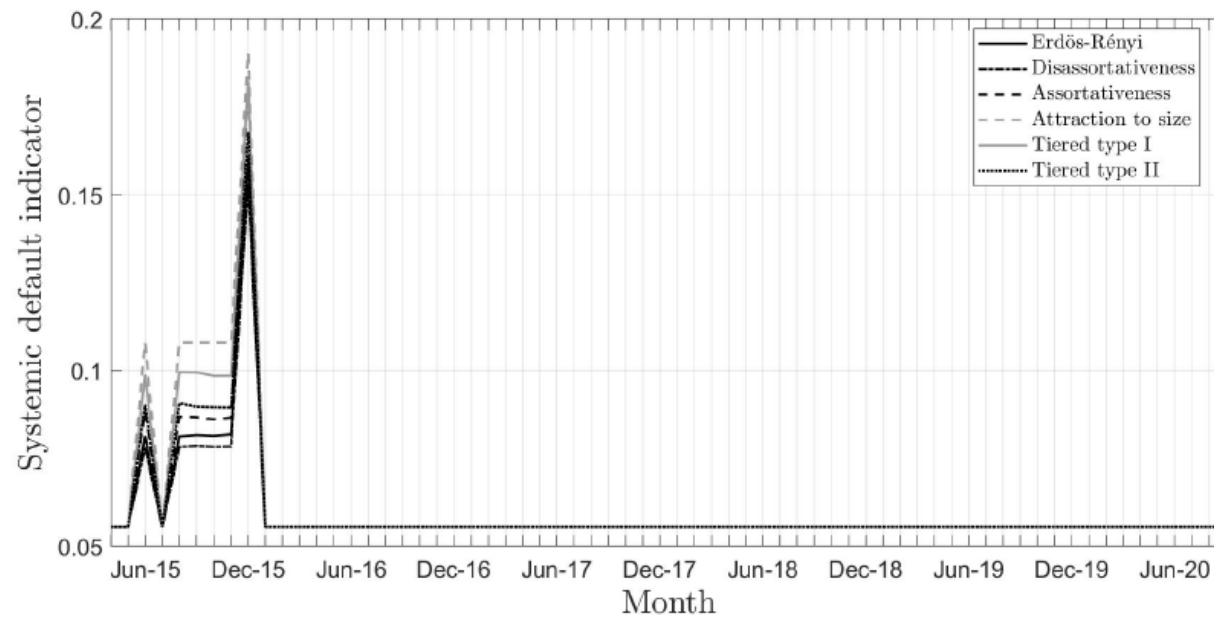
This chart shows the systemic default indicator on the hypothetical removal of the two largest banks





3. Large banks

This chart repeats the analysis following removal of the five largest banks





3. Large banks

Bank-by-bank analysis of the impacts of shocks is more helpful

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10	Bank 11	Bank 12	Bank 13	Bank 14	Bank 15	Bank 16	Bank 17	Bank 18	Bank 19	Bank 20	Bank 21
Bank 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bank 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bank 5	.49	.49	1	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49
Bank 6	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 7	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 8	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 9	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 10	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 11	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 12	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00
Bank 16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00
Bank 17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00
Bank 18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00
Bank 19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00
Bank 20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00
Bank 21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00
Bank 22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00
Bank 23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1

A semblance of self-similarity appears now to be limited to the remaining three of the five largest bank

Table 6: Bank-specific average probabilities of default: *Assumption Set 1*, random connections, 2 banks removed

Note. This table shows, for each combination of shocked banks and impacted banks the probability of bank default across the study period. It is based on *Assumption Set 1*, which combines all channels of contagion, but it removes the two largest banks from the data set. The Erdős-Rényi network structure is assumed. The banks are ranked in decreasing order of assets at the end of the study period.



3. Large banks

Bank-by-bank analysis of the impacts of shocks is more helpful

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6	Bank 7	Bank 8	Bank 9	Bank 10	Bank 11	Bank 12	Bank 13	Bank 14	Bank 15	Bank 16	Bank 17	Bank 18
Bank 6	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 7	.01	1	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Bank 8	.05	.05	1	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Bank 9	.01	.01	.01	1	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Bank 10	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 11	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 12	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 13	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 14	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Bank 15	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00	.00
Bank 16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00	.00
Bank 17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00	.00
Bank 18	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00	.00
Bank 19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00	.00
Bank 20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00	.00
Bank 21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00	.00
Bank 22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1	.00
Bank 23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1

Table 7: Bank-specific average probabilities of default: *Assumption Set 1*, random connections, 5 banks removed

small Note. This table shows, for each combination of shocked banks and impacted banks the probability of bank default across the study period. It is based on *Assumption Set 1*, which combines all channels of contagion, but it removes the five largest banks from the data set. The Erdős-Rényi network structure is assumed. The banks are ranked in decreasing order of assets at the end of the study period.

Here, self-similarity has almost completely disappeared

Hypothetically removing five banks appears to have altered the nature of the market

Evidence is presented that expected patterns of self-similarity do not persist when the five largest banks are removed, suggesting the possibility of a systemic market influence



3. Large banks

Research limitations

- Simplified balance sheet structures
- Interbank exposures are not accounted for
- Parameters are applied inflexibly
- The same proportional reduction is applied to all banks no matter their size
- Variations to impacts result from changes to the mix of assumptions

Proposals for further research

- Consider the hypothetical responses of surviving banks
 - Explore the impacts of removing size effects from the banks included in the study
 - Assess the attributes of the medium-sized banks in more detail
 - Test for sensitivity of results to changes in the network, channels of contagion and parametric assumptions
 - Consider the cost-benefit balance of the options available to the regulatory authorities to reduce the systemic risk of the largest banks
-

Network models of systemic risk in banking



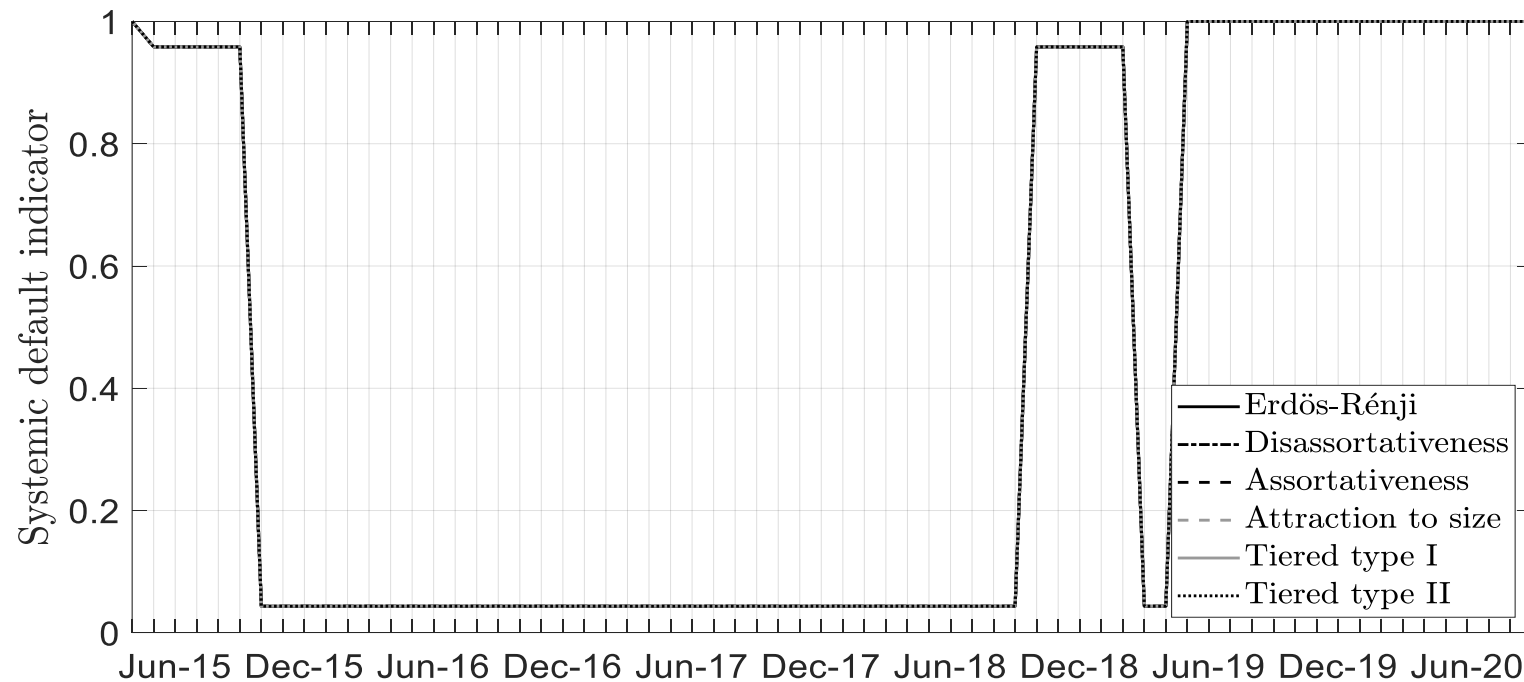
Agenda

1. Background
 2. Methodology
 3. Large banks
 4. Tipping points
 5. Concluding comments
- References



4. Tipping points

Some evidence of tipping points from previous study, under the liquidity shock

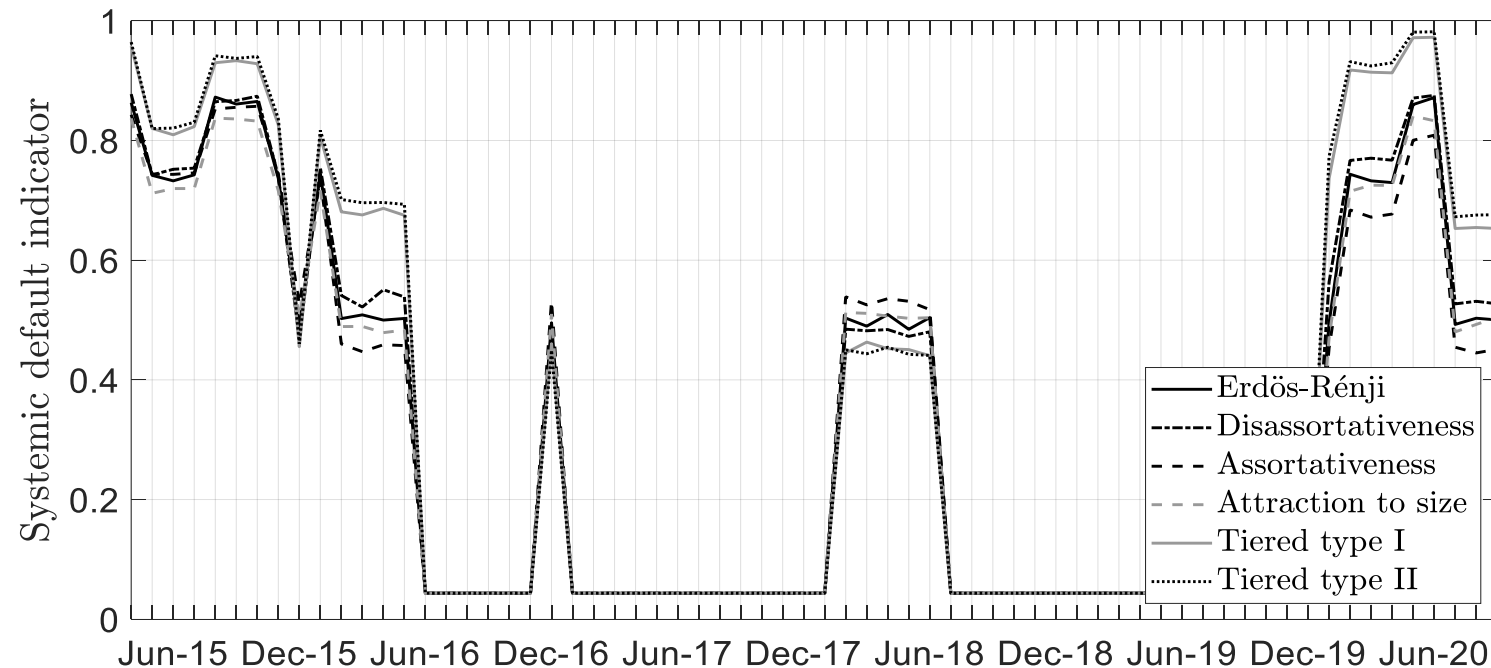




4. Tipping points

The proximity shock also suggests tipping points, but these vary from month to month

We investigate these in more detail





4. Tipping points

The term *tipping points*, with variation, is used in several different ways:

- *bifurcation* is used, in mathematics, physics and chemistry, engineering and medical science
- other expressions include *phase transitions* and *critical transitions*, especially in the physical sciences
- *tipping* and *neighbourhood tipping* form part of the literature on social segregation
- in climate, terms used include *regime shifts* or *abrupt shifts*, *self-reinforcing feedbacks*, *critical transitions*, *climate transitions* or *tipping points* and variations

This study uses the approach of Milkoreit et al (2018:11):

... a tipping point is a threshold at which small quantitative changes in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitatively different state of the system, which is often irreversible.

Ashwin et al. (2012); Beaugrand (2004); Bentley et al. (2014); Bruce & Cowley (1981); Courtney et al. (1995); Crawford (1991); Drijfhout et al. (2015); Founargiotakis et al. (1997); Hoadley (1884); Holling (1973); Karagueuziah et al. (2013); Kuznetsov (1997); Landau (1936); Lenton (2013); Lenton, Held et al. (2008); Lenton, Rockstrom et al. (2019); Milkoreit et al. (2018); Peters & Jaffé (1994); Poincaré (1885); Ren & Watts (2015); Rocha, Peterson & Biggs (2015); Rocha, Peterson, Bodin et al. (2018); Scheffer, Bascompte et al. (2009); Scheffer, Carpenter et al. (2012); Schelling (1971); Schneider et al. (2019); Solé (2011); Steffen et al. (2018); Stinchcombe (1988); Troger & Steindl (1991); Verma et al. (2020)



4. Tipping points

We use the same starting parameters as in the *Large Banks* study, but we vary them one by one

Market impacts	Parameter	Symbol	Channel	Definition	Starting value
	Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
	Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
	Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
	Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
	Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
	P[connected]	$\bar{p}$	proximity shock	The average probability that any pair of banks in the network is connected	0.5
	Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

We limit ourselves in this case to the *random probabilities* network model

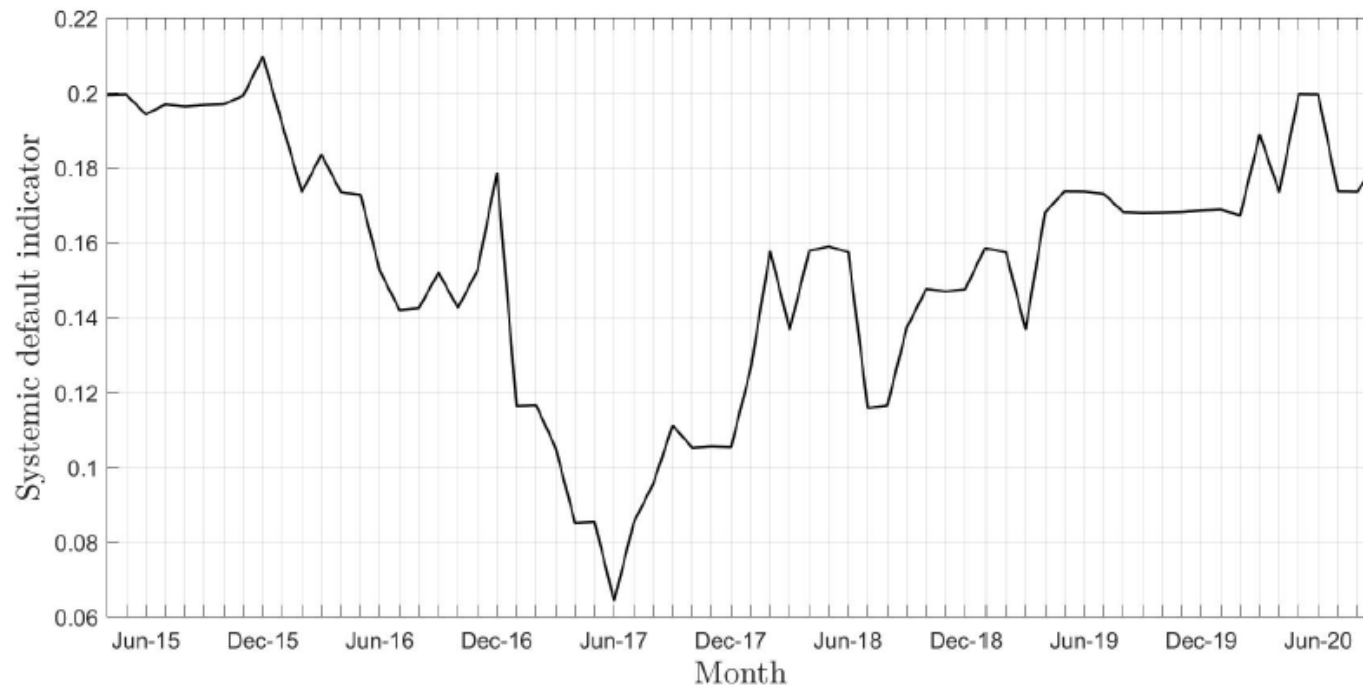
Core-peripheral structures	Network	Explanation
	Erdős-Rényi	The probability of linkages between nodes in the network is constant across the market.
	Attraction to size	The probability that a large bank triggers difficulty at a smaller bank is high, but the corresponding probability in the event of the initial failure of a small bank is low, also called 'flight to quality'.
	Assortativeness	Banks of similar size have a higher probability of connection. Large banks are more likely to be connected to other large banks and small banks to small banks.
	Disassortativeness	Banks are assumed more likely to be connected to other banks that are of different size. Small banks are more likely to be connected to large banks and the other way around.
	Tiered Type I	Large banks are connected to one another with high probability. Small banks have a low probability of being connected to each other. The probability of large and small banks being connected to one another lies between these extremes
	Tiered Type II	The probability of a small bank being connected to another small bank is low and the probability of a small bank being connected to a large bank is higher, but also relatively low. In contrast, large banks are connected to one another with high probability and the probability of a large bank connecting to a small bank is relatively high as well.

Erdős-Rényi (1959); Walters et al. (2018)



4. Tipping points

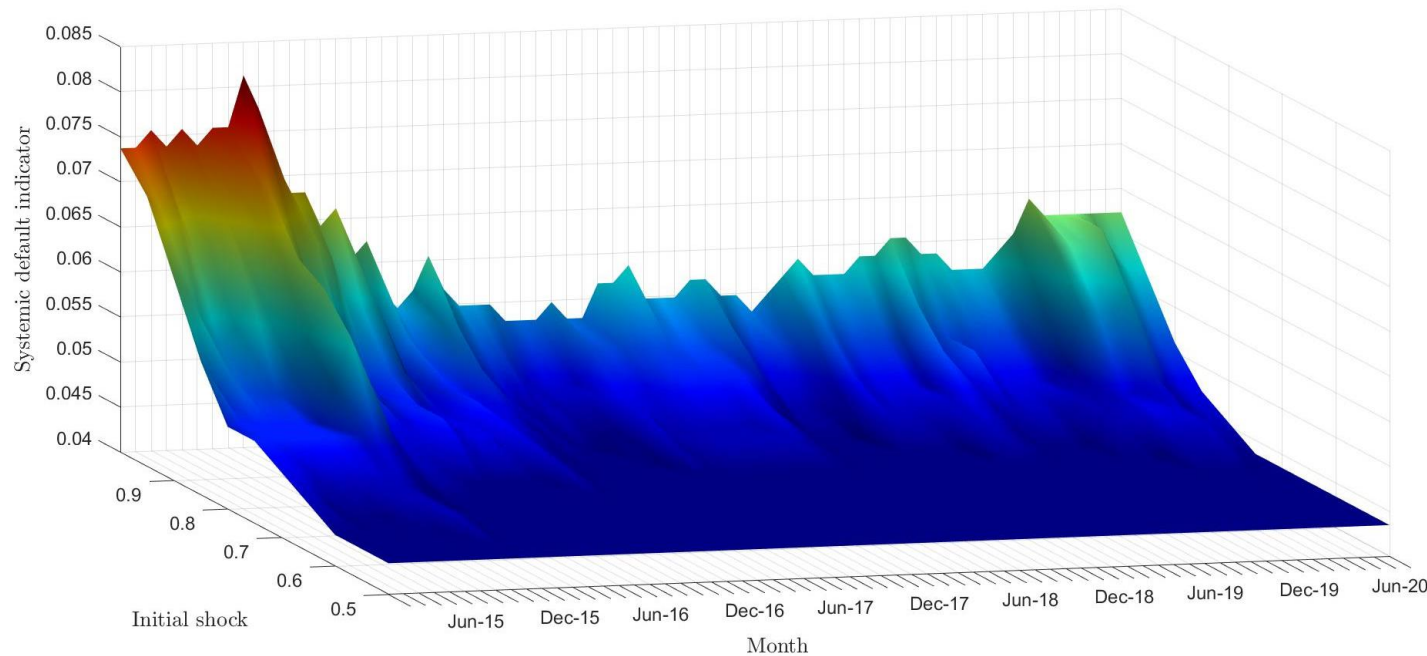
The pattern of the systemic default indicator by time is the same as before, considering only the network model with random probabilities of links between banks



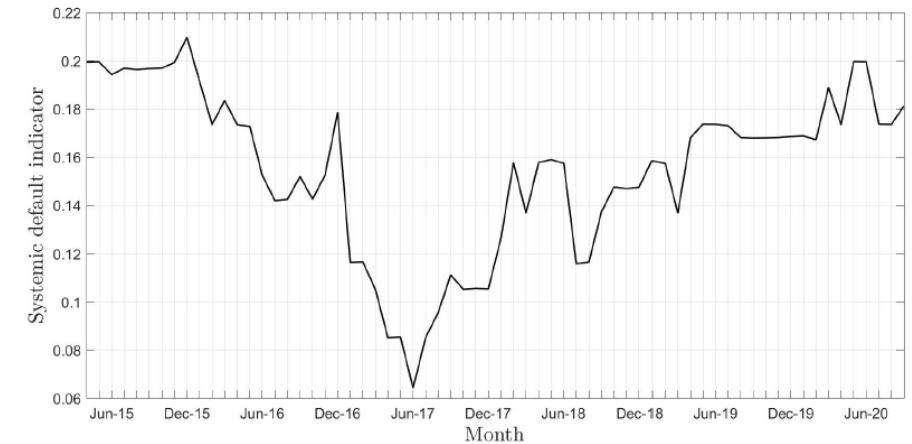


4. Tipping points

We vary the initial shock, testing the credit shock impact only



Changes to the systemic default indicator are relatively smooth with respect to changes to the initial shock, though the impact varies over time

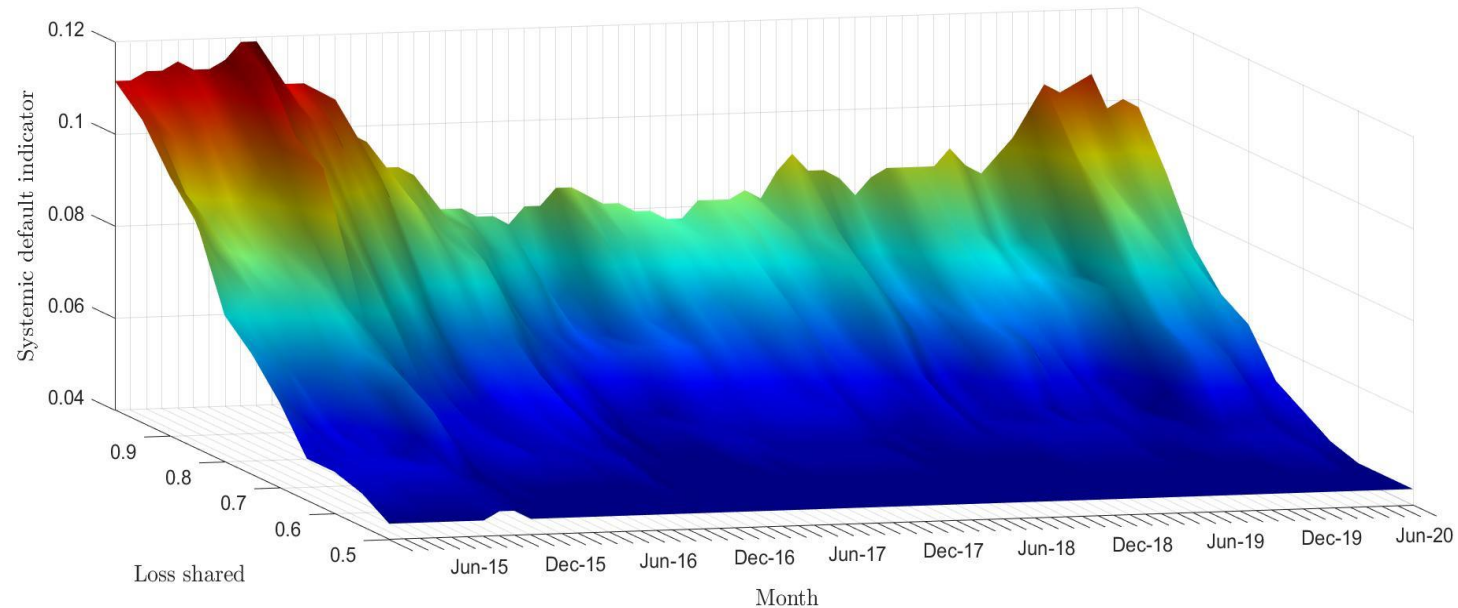


Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	p	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015

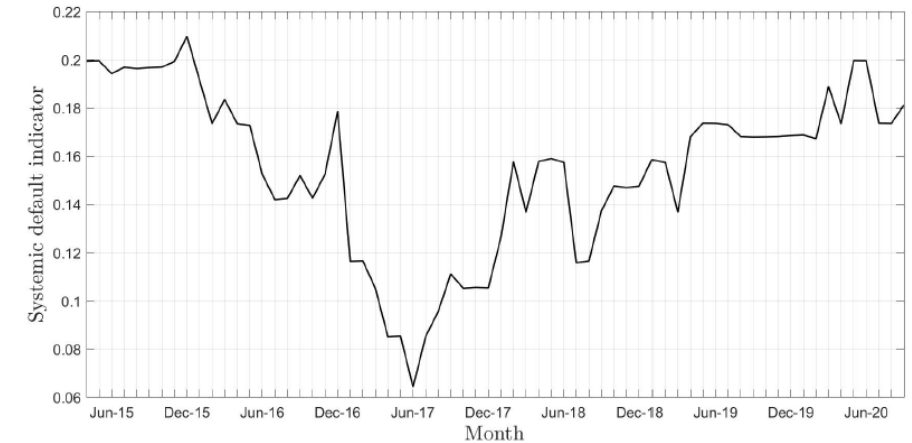


4. Tipping points

Now, we vary the loss shared, still testing credit shock only



Again, the systemic default indicator changes smoothly with respect to the loss shared assumption

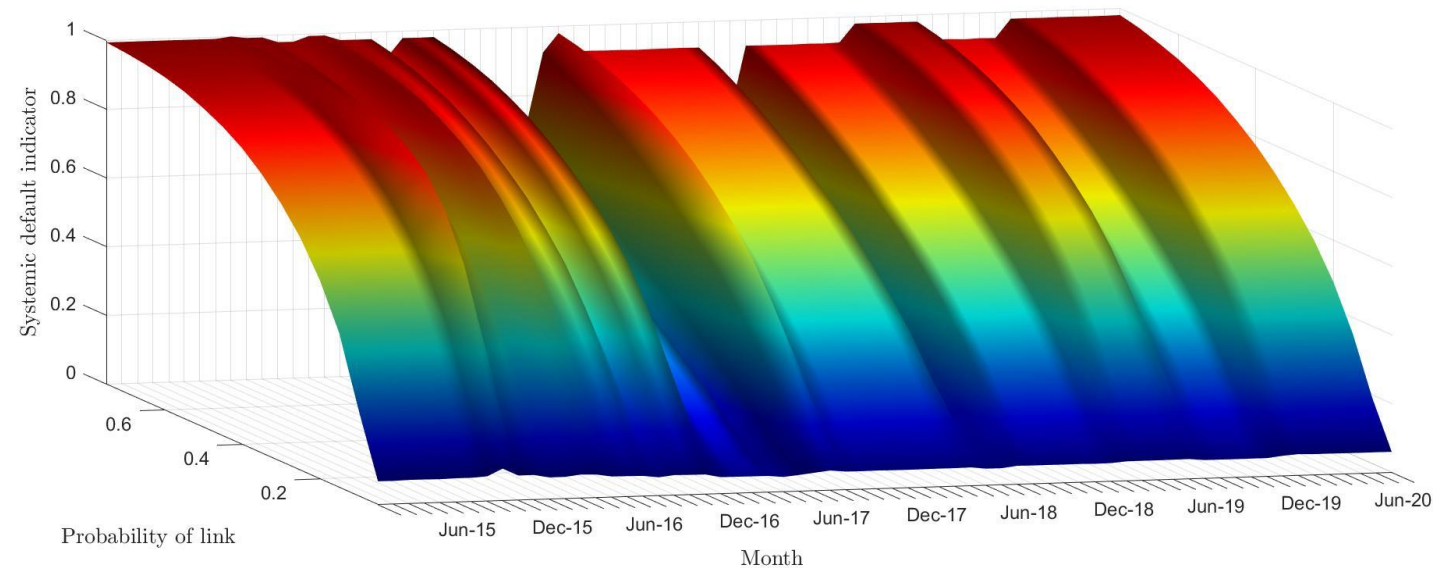


Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	p	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

Next, we consider the impacts of changes to the probability of connection, on proximity shock only



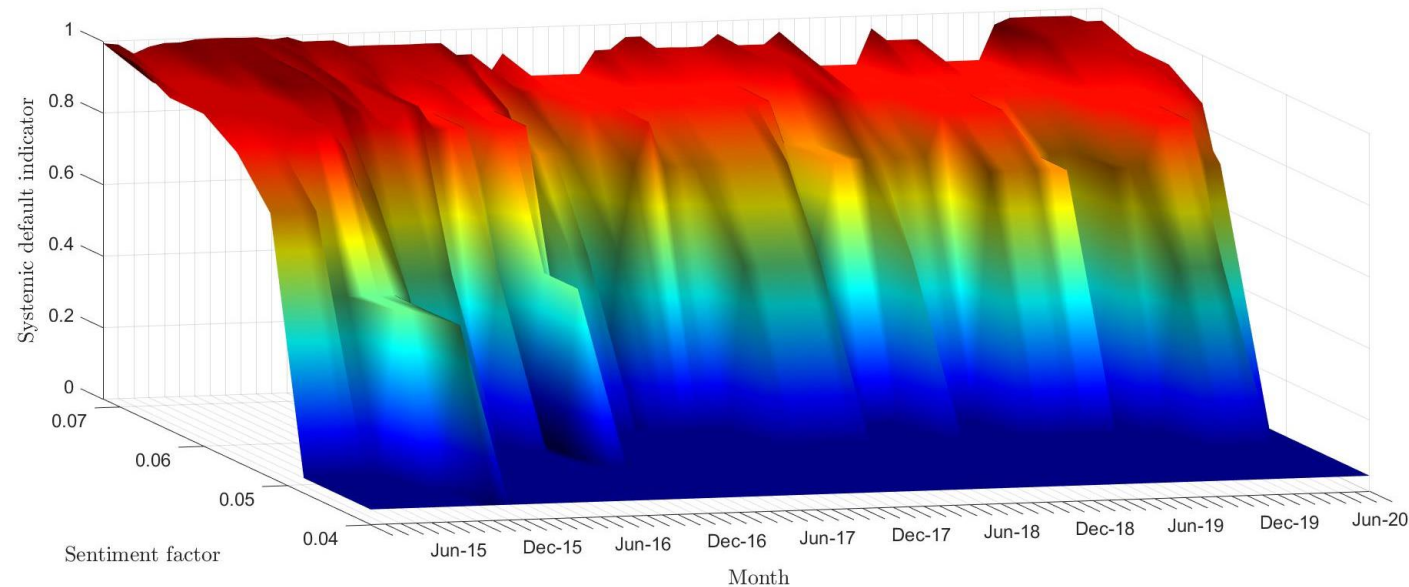
The impact of the probabilities of link on systemic risk via the proximity shock is particularly smooth, proportionally greater at low levels this probability

Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	p	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

We consider the impacts of changes to the sentiment factor, the market reaction a shock , testing the credit shock impact only



This is our first suggestion of a tipping point in the impact of the parameter on systemic risk

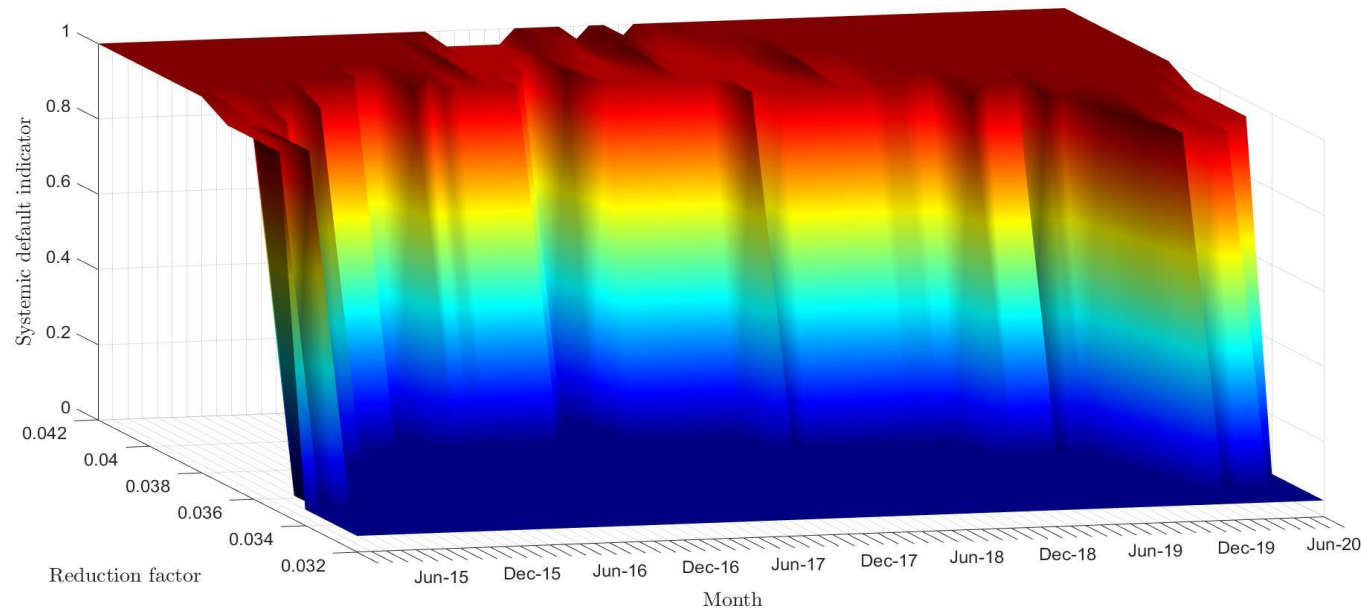
Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	ρ	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

Finally, we test changes to the reduction to the values of bank assets via the liquidity shock

For this illustration, the parameters are changed proportionally at all asset terms



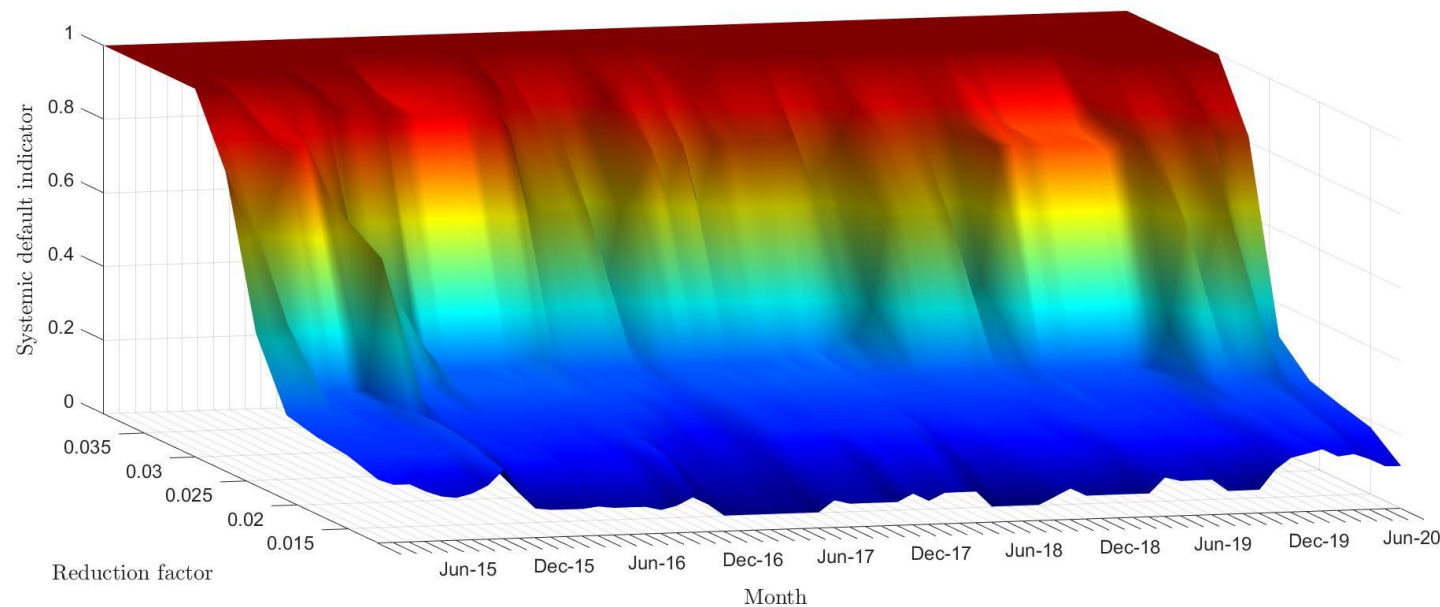
We appear to have evidence of a substantial tipping point whose value fluctuates over time with changes to market conditions

Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
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Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	p	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

Tests determined the impacts of alternative networks and combinations of contagion channels



This shows liquidity shock impacts in combination with all channels

The extreme nature of the tipping point has dampened, but it appears to occur now at slightly lower levels

Parameter	Symbol	Channel	Definition	Starting value
Initial shock	S	all channels	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.4
Loss shared	U	credit shock	The proportion of the assets of the bank affected by the impacted shock that are assumed to have been lost in the event	0.3
Short term	$\eta^{(s)}$	liquidity shock	The scale of the reduction to the value of: ... short-term assets of affected banks	0.015
Medium term	$\eta^{(m)}$	liquidity shock	... medium-term assets of affected banks	0.015
Long term	$\eta^{(l)}$	liquidity shock	... long-term assets of affected banks	0.030
P[connected]	p	proximity shock	The average probability that any pair of banks in the network is connected	0.5
Sentiment factor	τ	proximity shock	The reduction to the value of the assets of banks assumed to be affected by virtue of their proximity to the shocked bank	0.015



4. Tipping points

Research limitations

- Bank-specific detail is not considered
- Variations to SARB responses are not assessed
- The same proportional reduction to the values of surviving banks is applied on second and subsequent defaults of peers
- Simplistic modelling methods are used
- The likelihood of channels is not explored
- The sensitivity tests are rudimentary

Proposals for further research

- Assess the sensitivity of results to changes in the attributes or responses of banks
 - Consider alternative approaches to modelling different responses by the banking regulator
 - Assess the impact of a decay factor that reduces this proportional impact
 - Apply a multi-variate approach and measure the credibility of results
 - Research the probability of contagion channels
 - Further testing of the sensitivity of results to changes in assumptions, especially in the case of multiple channels, would be helpful
-



4. Tipping points

Research limitations (cont.)

- The range of parameters for each assumed channel have not been verified
- A full investigation of the impacts of different market networks has not been undertaken
- Not a great deal is known concerning the nature of South Africa's banking network

Proposals for further research (cont.)

- Carry out tests of the credible ranges of the assumptions for each channel
 - Research the relationship between the tipping points and a range of market networks
 - Assess the available evidence concerning the nature of the banking network in this country
-

Network models of systemic risk in banking



Agenda

1. Background
2. Methodology & data
3. Large banks
4. Tipping points
5. Concluding comments

References



5. Concluding comments

Systemic risk is of significant concern to financial-sector regulators:

- with an intrinsically peer-to-peer system, banks contribute significantly to systemic risk
- network modelling is widely used to assess the systemic risk attributes of individual banks

This study is a network simulation that uses contemporaneous banking data to assess systemic risk

Two findings are presented:

- the large banks appear to exert a disproportional impact on the incidence of systemic risk
- significant tipping points in market indicators of systemic risk with respect to two modelling parameters are identified

Several further areas for further research are proposed

Network models of systemic risk in banking



Agenda

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References

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ACTUARIAL SOCIETY
SOUTH AFRICA

Network models of systemic risk in banking

Findings for consideration

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