Identifying central bank liquidity super-spreaders in interbank funds networks

Network models, stress testing and other tools for financial stability monitoring and macroprudential policy design and implementation
(Mexico City, November 11-12, 2015)

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https://pure.uvt.nl/portal/files/3170308/2014_037.pdf (original version)

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2574686 (new version)

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Take-home message (1/2)

- We find that the Colombian interbank funds market is an inhomogeneous and hierarchical network, close to a core-periphery structure.
- We define an interbank funds *super-spreader* as a financial institution that simultaneously excels at borrowing and lending central bank's money from a network perspective.
- We implement two centrality measures based on feedback centrality: hub & authority centrality.
- We find that a few financial institutions fulfill the role of *super-spreaders*.
- We confirm that the probability of being a super-spreader is mainly determined by financial institutions' size.

Take-home message (2/2)

We contribute by …

- Reporting further evidence on interbank networks' structure.
- Highlighting the importance of central banks as networks' participants.
- Identifying most contributive participants to monetary policy transmission and contagion risk (akin to "money center banks" of Craig & von Peter, 2014)
- Identifying super-spreaders as those that may alleviate inefficiencies from liquidity cross-underinsurance (see Castiglionesi & Wagner, 2013)
- Finding an intersection between liquidity transmission and lending relationships about the role of large institutions (see Cocco et al., 2009; Afonso et al., 2013)
- Supporting central banks' role as credible providers of liquidity against inefficiencies (e.g. rationing) caused by market power (see Acharya et al., 2012)
- Providing new elements for the implementation of monetary policy and for safeguarding financial stability.

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Literature review

- The interbank funds market network topology has been examined for other markets
  - U.S.: Bech and Atalay (2008) and Soramäki et al. (2006)
  - Japan: Inaoka et al. (2004)
  - **Germany: Craig and von Peter (2010 & 2014)**
  - **Italy: Fricke and Lux (2012 & 2014)**

  } **Closest research**

  - Austria: Boss et al. (2004)
  - Netherlands: van Lelyveld et al. (2012) and Pröpper et al. (2008)
  - México: Martínez-Jaramillo et al. (2012)
  - Brazil: Cajueiro and Tabak (2007) and Tabak et al. (2013)
- Main findings:
  - Connective inhomogeneity: approximate scale-free networks (power-law distr. of links)
  - Hierarchy: core-periphery (or *modular scale-free*, as in León and Berndsen (2014))
  - Contradicts standard direct contagion models (e.g. Allen & Gale, 2000; Cifuentes et al., 2005; Gai and Kapadia, 2010)

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The interbank funds and central bank's repo multiplex network

Colombian interbank funds market*

- Non-collateralized lending/borrowing
- Open to credit and non-credit financial institutions (i.e. non-brokered)
- 91 observed participants out of ~140
- Second contributor (15.4%) to local money market (excl. Central Bank repos)

Colombian Central Bank's repos*

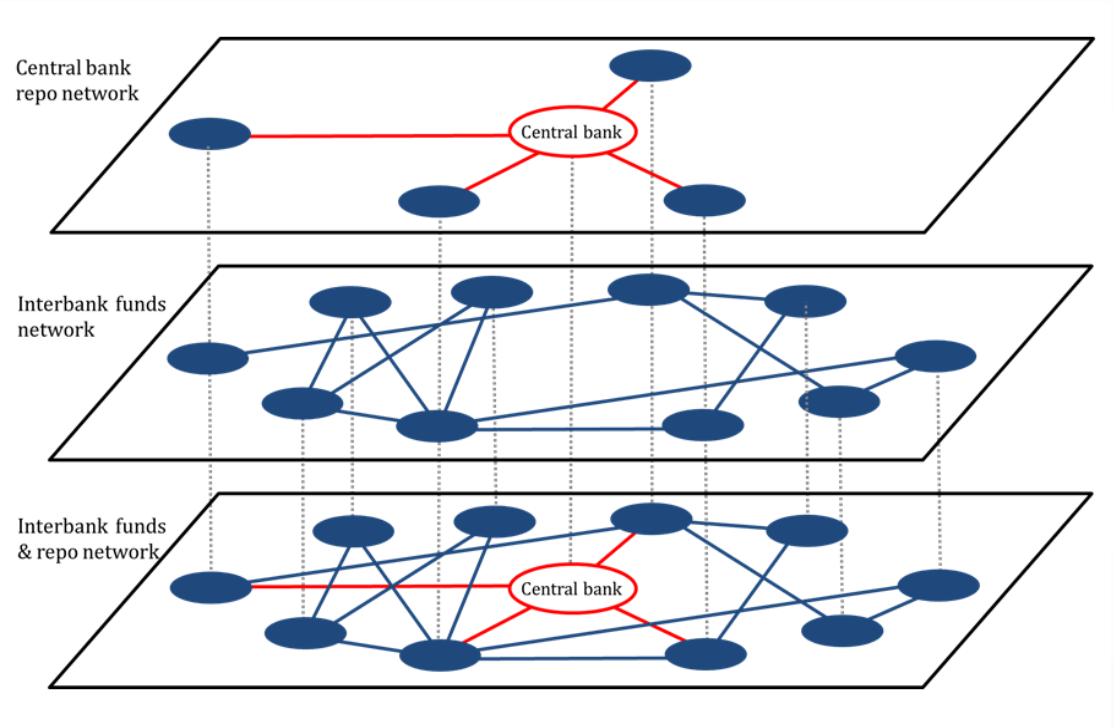
- Collateralized lending/borrowing on monetary considerations via CB's OMOs
- Sovereign securities as collateral
- Open to credit institutions (CIs = 42) and non-credit financial institutions (45)
  - Investment funds (IFs = 20)
  - Brokerage firms (BKs = 18)
  - Pension funds (PFs = 4)
  - Others (Xs = 3)
- Main contributor (46.9%) to local money market

(*) As of December 2013

The interbank funds and central bank's repo multiplex network

Why merging both networks?

- CB intervention determines the efficient allocation of money (Allen et al., 2009; Freixas et al, 2011; Acharya et al., 2012)
- … *a realistic model of interbank markets has to take the central bank into account*. (Georg & Poschmann, 2010)
- Identifying which institutions effectively access central bank's repos may provide useful information



Multiplex: networks containing participants of one sort but with several kinds of connections between them (Baxter et al., 2014)

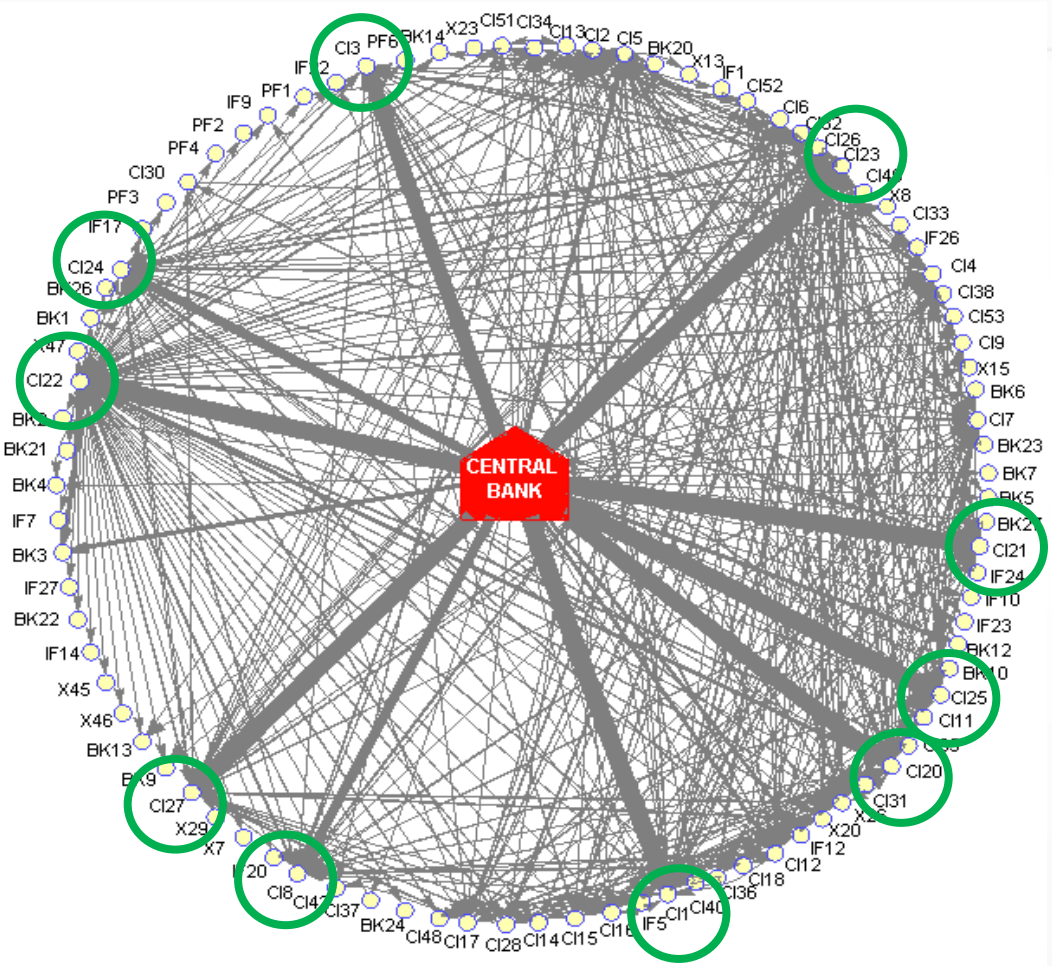
The interbank funds and central bank's repo multiplex network

The data

- Large-value payment system data (Jan2 – Dec17, 2013), filtered by reported code.
- Only the original transaction is considered (i.e. lender to borrower).
- Intraday repos –with no monetary aim- are discarded.

Salient features

- All types access CB's liquidity.
- Widest links: CB → **a few CIs.**
- **A few CIs** concentrate links and value.
- Most weakly connected: non-CIs.



The direction of the arrow corresponds to the direction of the funds transfer (i.e. towards the borrower), whereas its width represents its monetary value.

The interbank funds and central bank's repo multiplex network

Main features from network analysis on the multiplex*

- Sparse network (~7% of the links)
- Yet, the average financial institution only requires one intermediary to connect; it is "ultra-small" (Cohen & Havlin, 2003)
- Connective structure:
  - Inhomogeneous network (by links and their value)
  - Approximate power-law (scale-free network: robust-yet-fragile)
- Hierarchical structure:
  - Approx. core-periphery (as in Craig & von Peter, 2014)
  - Approx. modular (financial neighborhoods of Battiston et al. (2012) or nearly decomposable systems of Simon (1962)).

Contradicts standard direct contagion models (e.g. Allen & Gale, 2000; Cifuentes et al., 2005; Gai and Kapadia, 2010)

(*) For details please refer to the paper.

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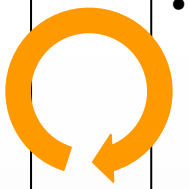
Identifying super-spreaders (1/2)

- An interbank funds market super-spreader is…

A good hub AND a good authority

Hub centrality*

- Eigenvector centrality as originator of weighted links.
- Proportional to the sum of authority centrality of participants it points to (i.e. based on feedback centrality)



Authority centrality*

- Eigenvector centrality as receiver of weighted links.
- Proportional to the sum of hub centrality of participants that point to it. (i.e. based on feedback centrality)

Let e represent eigenvector centrality (Bonacich, 1972)…

$$h = e(\underbrace{\Omega\Omega^T}_{\text{Sends weights "forwards"}})$$

$$a = e(\underbrace{\Omega^T\Omega}_{\text{Sends weights "backwards"}})$$

(*) Based on HITS algorithm by Kleinberg (1998).

Identifying super-spreaders (2/2)

- Super-spreaders : those contributing the most to *LSI,* which measures the **joint*** authority and hub centrality.

$$LSI_i = \frac{\left(\frac{a_i}{\sum_{i=1}^{n} a_i} \times \frac{h_i}{\sum_{i=1}^{n} h_i}\right)}{\sum_{i=1}^{n}\left(\frac{a_i}{\sum_{i=1}^{n} a_i} \times \frac{h_i}{\sum_{i=1}^{n} h_i}\right)}$$

$$0 \leq LSI_i \leq 1$$

$$LSI = \sum_{i=1}^{n} LSI_i = 1$$

- Alternatives? Degree centrality (*local*), strength (*local*), betweenness (*path dependent*), PageRank (*randomness*).

(*) Conjunction operators such as product and min(.) allow for measuring the joint authority and hub centrality.

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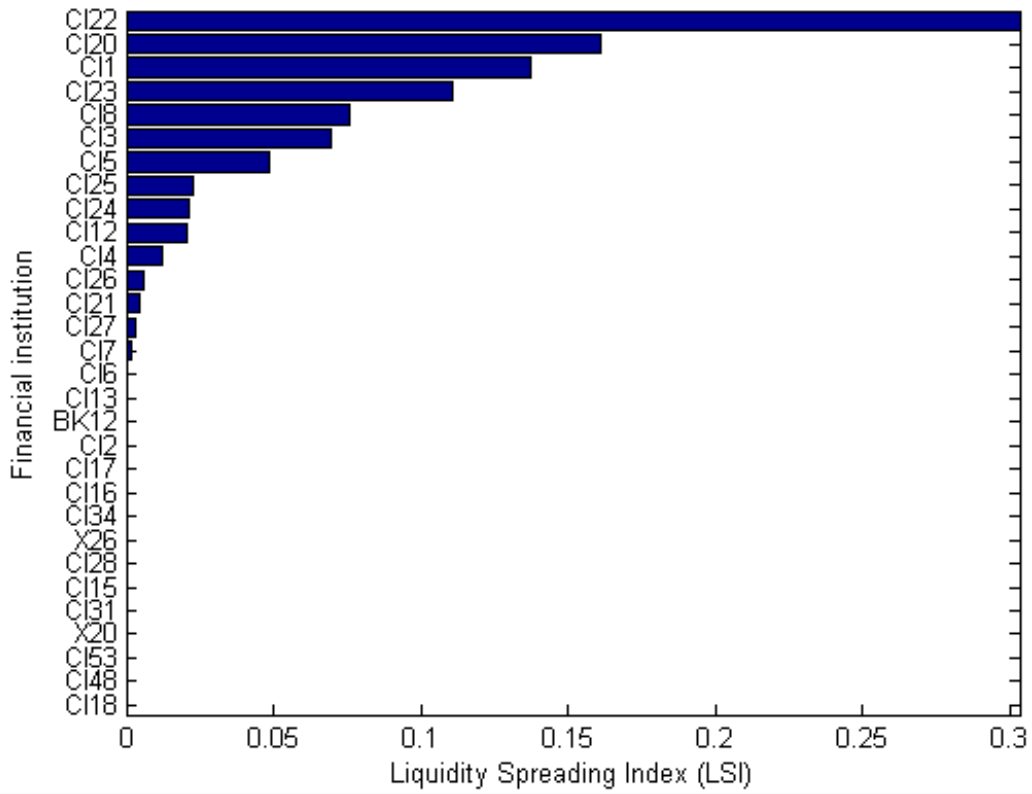
Main results

Top-30 LSI_i (out of 91)

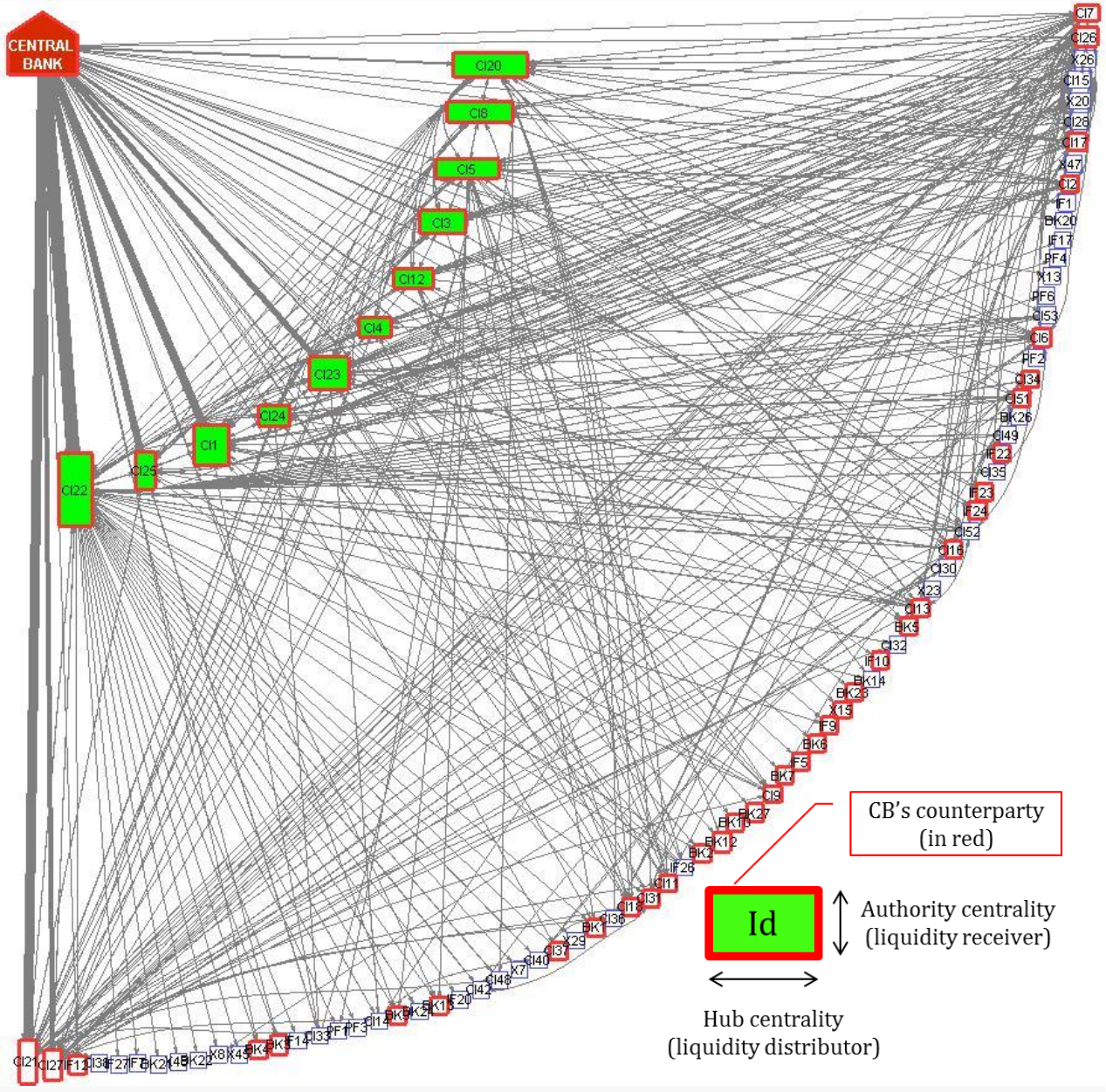


Top-5…
- All CIs
- 79% LSI_i

Top-17…
- All CIs
- 99.98% LSI_i

<u>As expected…</u>

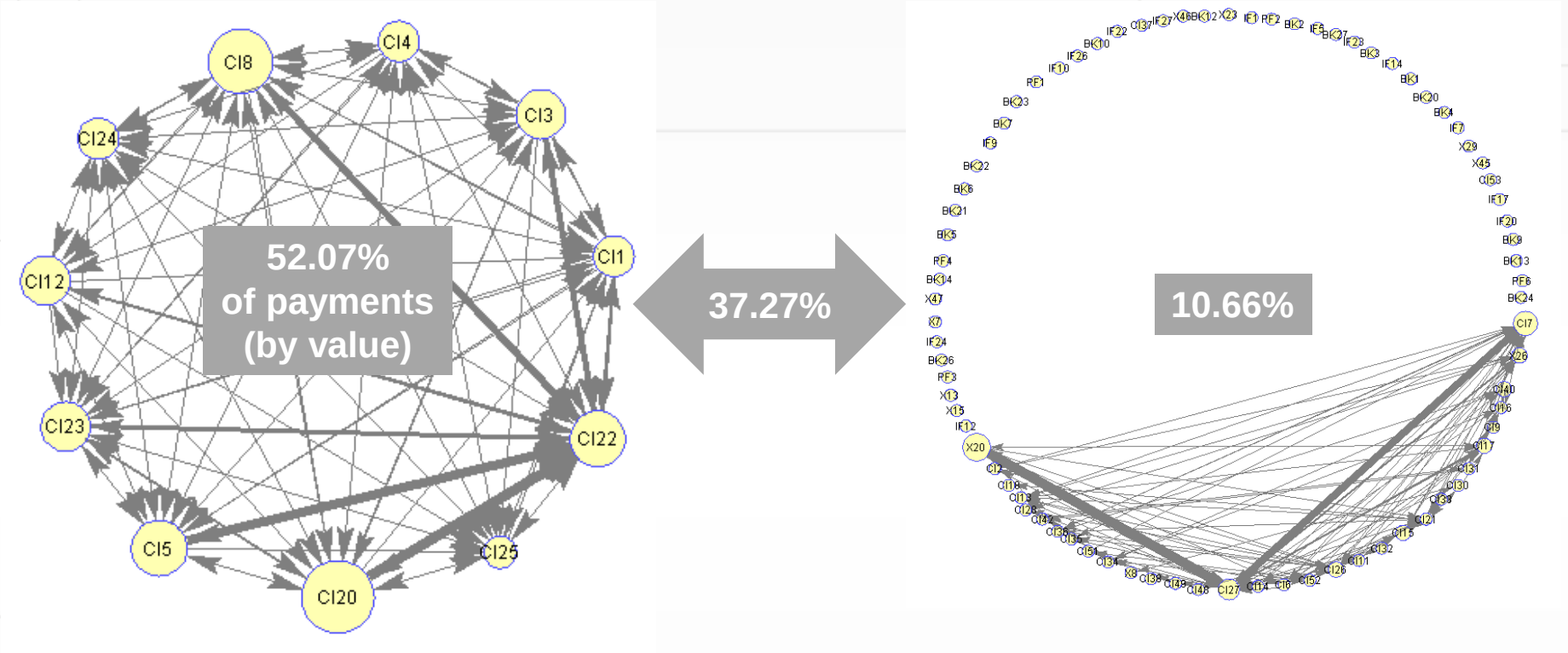
- CIs provide the main conduit for central bank's liquidity within the Colombian interbank funds market.
- Contradicts traditional direct interbank direct contagion models.
- Robust to other samples (2010-12) and frequencies (e.g. weekly, daily).



Remarks:

- CIs as main conduits (again)
- Overall inhomogeneity.
- Core inhomogeneity.
- First layer is heavily connected, both ways.
- Second layer is weakly connected, many display a single counterparty during 2013.
- Many in the second layer are connected to the CB, but their spreading capabilities within the interbank funds market are limited.

Main results



The core

- Densely interconnected (93.6%)
- Connections are evenly distributed
- Strength is unevenly distributed
- They all are CIs (11)

The periphery

- Sparse (2.4%)
- Connections and strength are unevenly distributed
- Most participants (48/80) are non-interconnected
- All types (CIs, BKs, IFs, PFs, Xs)

The direction of the arrow corresponds to the direction of the funds transfer (i.e. towards the borrower), whereas its width represents its monetary value.

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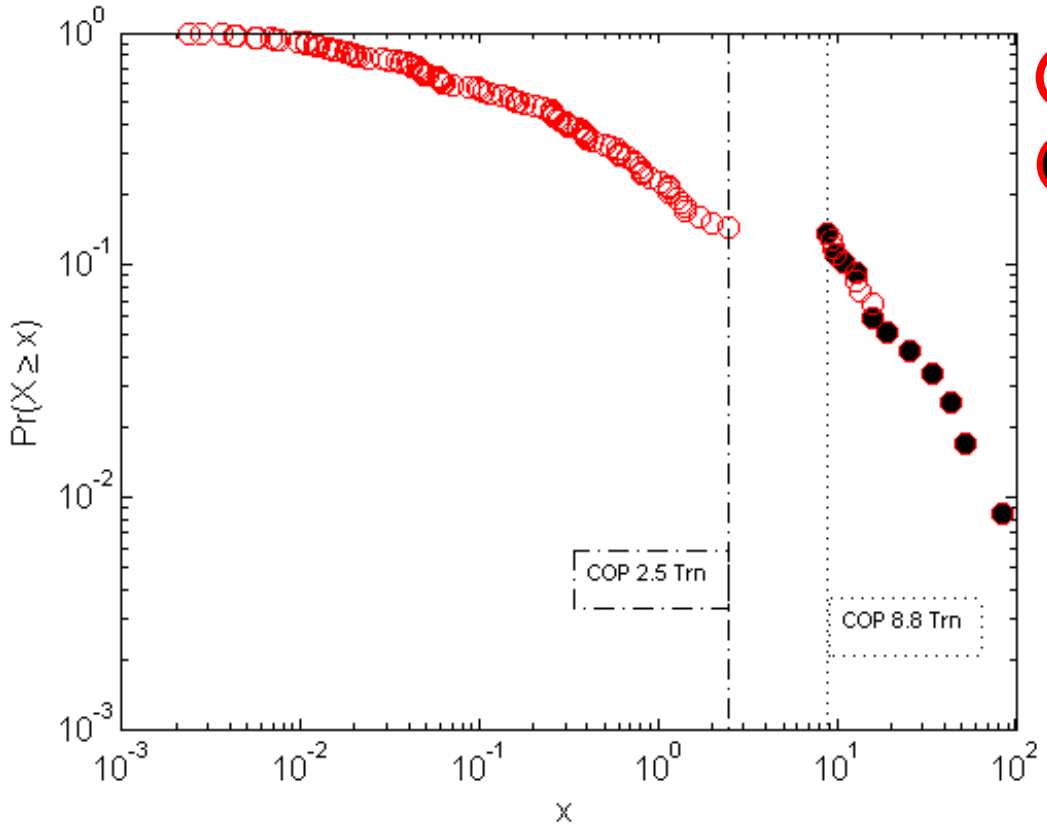
What makes a super-spreader?

Distribution of Colombian financial institutions' size*
(Double logarithmic scale)



Non super-spreader (i.e. periphery)

Super-spreader (i.e. core)

Remarks

- The average size of super-spreaders is about 33 times that of other financial institutions.
- **Super-spreaders ~ large CIs.**

(*) Size corresponds to the 2013 average asset value reported by the Colombian Financial Superintendence; filled circles correspond to super-spreaders

What makes a super-spreader?

A probit regression model

$$pr(LSI_i = 1 | X) = \Phi(X'\beta)$$

$$LSI_i = \begin{cases} 1 \text{ if } i \text{ is a super-spreader} \\ 0 \text{ otherwise} \end{cases}$$

- Size
- Leverage
- ROA
- Borrowing concentration
- Lending concentration

Discarded independent variables: non-performing loans (CI-only variable); Equity (redundant with ROA); Equity (redundant with size & leverage); Cash balance in CB's accounts & investments (multicollinearity with size); value of CB repos (multicollinearity with size).

What makes a super-spreader?

Variable [a, b]	LSI_i	h_i	a_i
Size (*size*) [c]	2.758 (2.40)**	2.456 (3.16)***	3.848 (3.38)***
Leverage (*lev*) [d]	1.002 (0.41)	0.322 (0.85)	-0.101 (-0.51)
Financial performance (*roa*) [e]	-0.377 (-0.29)	-0.320 (-1.26)	0.128 (0.77)
Borrowing concentration (*borr*) [f]	0.010 (0.03)	-0.765 (-3.43)***	0.324 (1.44)
Lending concentration (*lend*) [g]	-0.069 (-0.11)	0.091 (0.42)	-0.009 (-0.05)
Constant	-2.144 (-1.24)	-0.294 (-0.89)	0.282 (0.77)
Observations	77		
Observations = 1	11	27	25
Pseudo R-squared	.741	.559	.420
% of correctly classified [i]	.935	.883	.844

- Size is the sole significant determinant of the probability of being a super-spreader
- Large institutions are good authorities (i.e. borrowers) and good hubs (i.e. lenders)

- Neither leverage nor profitability are good determinants of being a super-spreader

- Concentration of lending and borrowing are not good determinants of the probability of being a super-spr.
- Yet… a good hub tends to concentrate its borrowing (but not its lending)
  - Is this a CB-related issue? (YES!)
  - Lack of Stigma?
  - No better use for collateral?
- Lending concentration is a poor determinant

Overall, the fit of the model is adequate.

What makes a super-spreader?

Variable [a, b]	LSI_i	h_i	a_i	k_i [h]	s_i	b_i
Size (*size*) [c]	2.758 (2.40)**	2.456 (3.16)***	3.848 (3.38)***	168.48 (1.80)*	3.644 (2.34)**	1.585 (2.43)**
Leverage (*lev*) [d]	1.002 (0.41)	0.322 (0.85)	-0.101 (-0.51)	0.065 (0.31)	-0.233 (-1.34)	0.988 (0.95)
Financial performance (*roa*) [e]	-0.377 (-0.29)	-0.320 (-1.26)	0.128 (0.77)	0.157 (0.72)	0.005 (0.03)	-0.458 (-0.80)
Borrowing concentration (*borr*) [f]	0.010 (0.03)	-0.765 (-3.43)***	0.324 (1.44)		-0.392 (-2.09)**	-0.664 (-2.42)**
Lending concentration (*lend*) [g]	-0.069 (-0.11)	0.091 (0.42)	-0.009 (-0.05)	NA	-0.194 (1.11)	-0.069 (-0.21)
Constant	-2.144 (-1.24)	-0.294 (-0.89)	0.282 (0.77)	67.48 (1.80)*	0.870 (1.55)	-1.591 (-2.27)**
Observations	77					
Observations = 1	11	27	25	65	37	16
Pseudo R-squared	.741	.559	.420	.506	.342	.560
% of correctly classified [i]	.935	.883	.844	.870	.779	.896

- Results are robust to other centrality measures (degree, strength, betweenness)
- Also, robust to other samples (2011 & 2012) (in paper's appendix)

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Summary

We contribute by …

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- Supporting central banks' role as credible providers of liquidity against inefficiencies (e.g. rationing) caused by market power (see Acharya et al., 2012)
- Providing new elements for the implementation of monetary policy and for safeguarding financial stability.

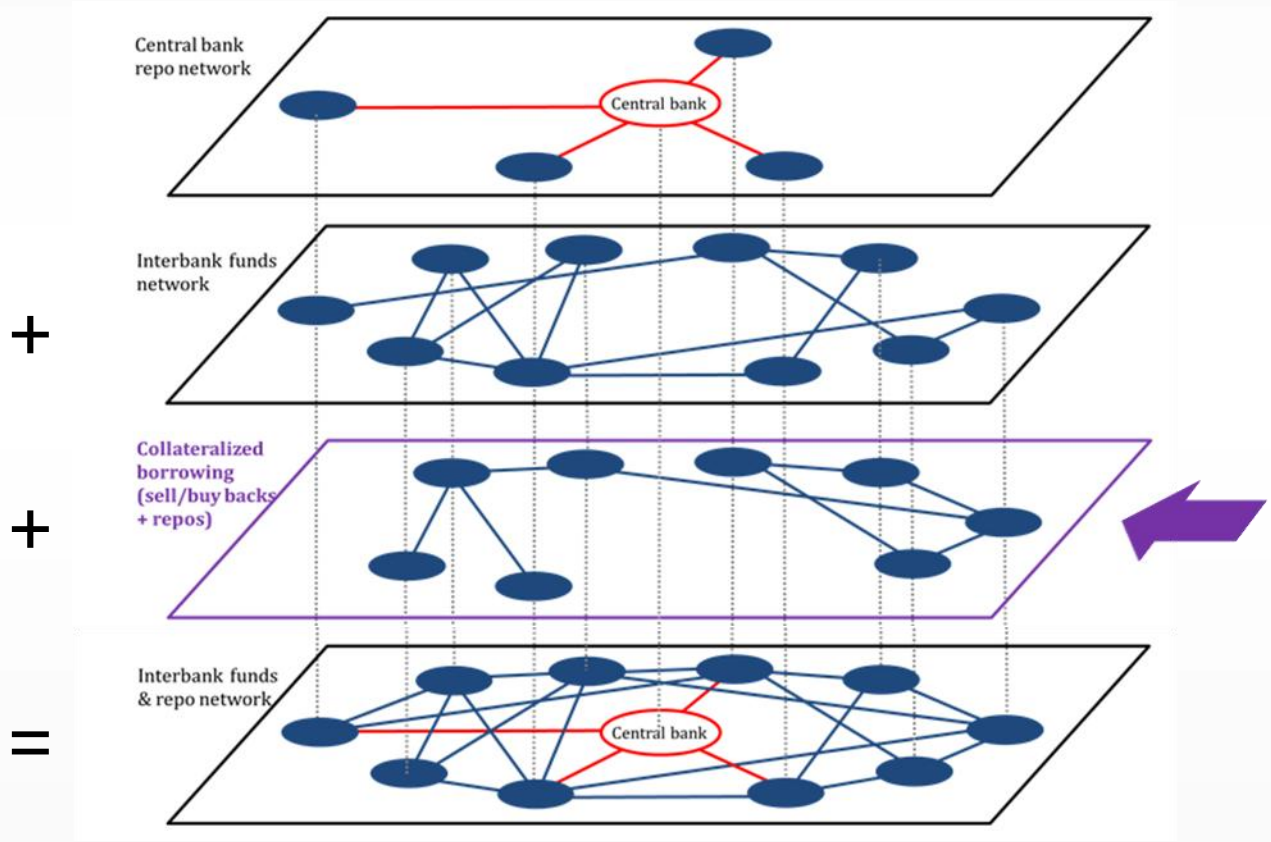
How about causality…?

Size  Super-spreader

Feedback effect?

Forthcoming…

The entire money market



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