An Empirical Study of the Mexican Banking System’s Network and its Implications for Systemic Risk

Martínez-Jaramillo, Alexandrova-Kabadjova, Bravo-Benítez & Solórzano-Margain, August/13
Outline

• Motivation
  • Relevant Concepts and literature

• Data
  • Interbank exposures’ data
  • Payment system’s data

• Topological and other metrics

• Centrality

• Summary
Interconnectedness

• The GHOS, the oversight body of the BCBS, agreed on a consultative document setting out measures for G-SIBs, updated July 2013 [http://www.bis.org/press/p130703.htm](http://www.bis.org/press/p130703.htm).

• The document includes:
  • methodology for assessing systemic importance
  • additional required capital
  • arrangements by which they will be phased in

• Objectives:
  • strengthen the resilience of G-SIBs
  • create incentives to reduce systemic importance
Interconnectedness

• Assessment methodology based on an indicator-based approach:
  • size
  • interconnectedness
  • lack of substitutability
  • global (cross-jurisdictional) activity
  • complexity

• Additional loss absorbency requirements are to be met with a progressive CET1 ranging from 1% to 2.5%.

• An additional 1% surcharge could be applied.
## BCBS assessment methodology for G-SIBs

<table>
<thead>
<tr>
<th>Category (and weighting)</th>
<th>Individual indicator</th>
<th>Indicator weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-jurisdictional activity (20%)</td>
<td>Cross-jurisdictional claims</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Cross-jurisdictional liabilities</td>
<td>10%</td>
</tr>
<tr>
<td>Size (20%)</td>
<td>Total exposures as defined for use in the Basel III leverage ratio</td>
<td>20%</td>
</tr>
<tr>
<td>Interconnectedness (20%)</td>
<td>Intra-financial system assets</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Intra-financial system liabilities</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Securities outstanding</td>
<td>6.67%</td>
</tr>
<tr>
<td>Substitutability/financial institution infrastructure (20%)</td>
<td>Assets under custody</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Payments activity</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Underwritten transactions in debt and equity markets</td>
<td>6.67%</td>
</tr>
<tr>
<td>Complexity (20%)</td>
<td>Notional amount of over-the-counter (OTC) derivatives</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Level 3 assets</td>
<td>6.67%</td>
</tr>
<tr>
<td></td>
<td>Trading and available-for-sale securities</td>
<td>6.67%</td>
</tr>
</tbody>
</table>
Network models and payment systems.

• Studies describing payment systems around the world:
  • Soramki et al. (2006)
  • Bech & Atalay (2008)
  • Becher et al. (2008)
  • Rordam & Bech (2008)
  • Propper et al. (2008)
  • Wetherilt et al. (2010)

• Other related works
  • Empirical analysis of the Italian interbank market, Iori et al. (2008)
  • Simulation to model interbank lending and study contagion, Iori et al. (2006)
  • Coupled stochastic processes, Battiston et al. (2012)
  • Cascade processes on networks, Lorenz et al. (2009)
  • Core-periphery model Craig and von Peter (2010)
  • DebtRank, Battiston et al. (2012)
Data

- Daily data from January 2005 onwards
  - A time window contemplating data from the 3rd of January 2005 to 31st December 2010;
- Interbank’s data:
  - Comprises exposures derived from deposits & loans, derivatives (counterparty risk), cross holding of securities (issuer risk) and foreign exchange transactions (settlement risk).
  - Three type of networks:
    - Interbank (complete network);
    - Interbank – CLS (FX transactions cleared through CLS bank are not considered);
    - Interbank – FX (All the FX related exposures are not considered).
- SPEI’s data
  - Network built accumulating the daily payments between each pair of banks in both directions;
  - Three types of networks:
    - Low value (payments below 10 million MXN);
    - Large value (payments above 10 million MXN);
    - Total value (all payments).
Network measures and systemic risk

• Topological measures
  • Degree
  • Clustering coefficient
  • Reciprocity
  • Affinity
  • Completeness Index

• Other measures
  • Flow
  • Herfindahl-Hirschman Index (HHI)
  • Preference Index
  • Strength
Overview of the networks’ topology

SPEI

Interbank Market
Overview of the networks’ topology

SPEI

Interbank Market
Overview of the networks’ topology

- Both networks present dissasortative mixing; namely, nodes with high degree have connections to nodes with low degree.
Comparison among networks

<table>
<thead>
<tr>
<th>Mean</th>
<th>Interbank</th>
<th>Interbank - CLS</th>
<th>Interbank - FX</th>
<th>Large Value</th>
<th>Low Value</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Size</td>
<td>26.7</td>
<td>26.7</td>
<td>22.4</td>
<td>30.8</td>
<td>33.0</td>
<td>34.2</td>
</tr>
<tr>
<td>CI</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Average Degree</td>
<td>9.0</td>
<td>8.7</td>
<td>5.7</td>
<td>10.1</td>
<td>13.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Reciprocity</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Average Distance</td>
<td>1.7</td>
<td>1.8</td>
<td>2.0</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Total Arrows</td>
<td>279.7</td>
<td>262.2</td>
<td>145.0</td>
<td>290.2</td>
<td>405.9</td>
<td>470.9</td>
</tr>
<tr>
<td>Average Strength</td>
<td>7.1</td>
<td>6.4</td>
<td>4.3</td>
<td>24.0</td>
<td>1.24</td>
<td>25.2</td>
</tr>
<tr>
<td>Total Volume*</td>
<td>125.5</td>
<td>110.8</td>
<td>77.2</td>
<td>415.8</td>
<td>22.41</td>
<td>438.7</td>
</tr>
</tbody>
</table>
Centrality

- Concept commonly used in social networks
- Several important interpretations
  - power
  - influence
  - independence
  - control
- Characteristics of a relevant financial institution (Henggeler-Müller (2006)):
  - possesses many linkages to other members (degree)
  - Amount of assets, liabilities or flow is very large (strength)
  - its failure could transmit contagion rapidly (closeness)
  - its counterparties are also relevant (ecc & pagerank)
  - there are many paths which passes through it (betweenness)
Centrality measures

• **Degree centrality**
  - A node is more important if it is connected to many other vertices.

• **Strength centrality**
  - A node is important depending on the sum of its interbank assets and liabilities.

• **Betweenness centrality**
  - A node with high betweenness centrality can stop or distort the information that passes through it.

• **Closeness centrality**
  - A node with high centrality would depend less on others but can transmit problems to others easily.

• **Entropic Eigenvector Centrality (Bonacich (1972))**
  - Based on Perron’s eigenvector ($e^{PF}$);
  - Considers the relevance of its neighbors.

• **PageRank centrality (Page et al. (1999))**: 
  - Based on the Google’s algorithm;
  - Considers the relevance of its neighbors.
A principal components unified measure of centrality

- Different measures contain relevant information;
- Preserve most information provided by such measures;
- From the policy making perspective, it is important to have only one;
- Measure of importance enabling to rank vertices.
Comparison between Ranks
Debt rank considers possible cascade effects (contagion) in addition to the network topology.
PC vs Contagion and Assests ranking (Interbank)

Centrality and asset size are not the same but centrality and contagion are very similar.
## Congruence

<table>
<thead>
<tr>
<th>Number of banks</th>
<th>Low vs. large value</th>
<th>Exposures vs. SPEI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top 1</td>
<td>Top 3</td>
</tr>
<tr>
<td>27</td>
<td>0.53</td>
<td>0.97</td>
</tr>
<tr>
<td>28</td>
<td>0.60</td>
<td>1.00</td>
</tr>
<tr>
<td>29</td>
<td>0.48</td>
<td>1.00</td>
</tr>
<tr>
<td>30</td>
<td>0.58</td>
<td>1.00</td>
</tr>
<tr>
<td>31</td>
<td>0.57</td>
<td>1.00</td>
</tr>
<tr>
<td>32</td>
<td>0.52</td>
<td>1.00</td>
</tr>
<tr>
<td>33</td>
<td>0.33</td>
<td>1.00</td>
</tr>
<tr>
<td>35</td>
<td>0.62</td>
<td>1.00</td>
</tr>
<tr>
<td>36</td>
<td>0.62</td>
<td>1.00</td>
</tr>
<tr>
<td>37</td>
<td>0.60</td>
<td>0.98</td>
</tr>
<tr>
<td>38</td>
<td>0.26</td>
<td>1.00</td>
</tr>
<tr>
<td>39</td>
<td>0.43</td>
<td>0.94</td>
</tr>
<tr>
<td>40</td>
<td>0.51</td>
<td>1.00</td>
</tr>
<tr>
<td>41</td>
<td>0.52</td>
<td>0.98</td>
</tr>
</tbody>
</table>
### Congurence: SPEI vs Interbank

<table>
<thead>
<tr>
<th></th>
<th>Interbank Exposures Network</th>
<th></th>
<th>SPEI Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Top 3</td>
<td>Correlation</td>
<td>Top 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C&lt;sub&gt;B&lt;/sub&gt;</td>
<td>(17%, 20%)</td>
<td>(0.29, 0.31)</td>
<td>(0.36, 0.37)</td>
<td>(32%, 36%)</td>
</tr>
<tr>
<td>C&lt;sub&gt;C&lt;/sub&gt;</td>
<td>(43%, 48%)</td>
<td>(0.93, 0.93)</td>
<td>(0.52, 0.53)</td>
<td>(93%, 95%)</td>
</tr>
<tr>
<td>C&lt;sub&gt;D&lt;/sub&gt;</td>
<td>(43%, 48%)</td>
<td>(0.845, 0.898)</td>
<td>(0.537, 0.549)</td>
<td>(93%, 95%)</td>
</tr>
<tr>
<td>EEC</td>
<td>(41%, 45%)</td>
<td>(0.47, 0.49)</td>
<td>(0.4, 0.42)</td>
<td>(64%, 69%)</td>
</tr>
<tr>
<td>P&lt;sub&gt;R&lt;/sub&gt;</td>
<td>(46%, 51%)</td>
<td>(0.67, 0.68)</td>
<td>(0.5, 0.51)</td>
<td>(92%, 94%)</td>
</tr>
<tr>
<td>P&lt;sub&gt;C&lt;/sub&gt;&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>(26%, 30%)</td>
<td>(0.72, 0.73)</td>
<td>(0.44, 0.45)</td>
<td>(79%, 83%)</td>
</tr>
<tr>
<td>P&lt;sub&gt;C&lt;/sub&gt;&lt;sup&gt;(6)&lt;/sup&gt;</td>
<td>(40%, 43%)</td>
<td>(0.74, 0.75)</td>
<td>(0.49, 0.5)</td>
<td>(91%, 94%)</td>
</tr>
<tr>
<td>C&lt;sub&gt;S&lt;/sub&gt;</td>
<td>(46%, 51%)</td>
<td>(0.62, 0.63)</td>
<td>(0.49, 0.5)</td>
<td>(88%, 91%)</td>
</tr>
</tbody>
</table>

Table: 95% confidence intervals for the congruence measures in the interbank exposures and total SPEI networks
Principal Component Ranking

SPEI 2005-2010

VIII Annual Seminar on Risk, Financial Stability and Banking
Overview of the SPEI Network

Large value network

Low value network

01.03.2005

15.12.2010
Summary

- The payments system network is more connected than the interbank exposures network;

- Importance (centrality) in the payments network is different than in the exposures network;

- The unified centrality measure could be a suitable option for the methodology proposed by the BCBS to determine G-SIBs;

- Bank’s relevance (interconnectedness) changes depending on the type of payment (low or large) and depending of they are actina as lenders of borrowers;

- Bank’s relevance change over time;

- Determining systemic importance based only on asset’s size could be misleading;

- Topology of the network is not enough to characterize systemic importance.
Future work

- Network formation models;
- Studying other financial networks, like the securities settlement network, the repo network;
- Bank’s behavior in distress;
- Bank’s funding strategies;
- Link to economic variables
Thank you