Do Interconnections Matter for Bank Efficiency?

Solange M. Guerra

Banco Central do Brasil
The views expressed in this work are those of the authors and do not necessarily reflect those of the Banco Central do Brasil or its members.
Summary of the Presentation

• Introduction and Motivation
• Contributions
• Methodology
• Data
• Empirical Results
• Final Remarks
Introduction and Motivation

- Empirical works have verified that bank inefficiency contributes to the risk of failure (Wheelock and Wilson, 1995; Podpiera and Podpiera, 2005).

- There is some evidence that banking efficiency measures may be helpful in assessing potential future risks in the banking system (Tabak, Craveiro and Cajueiro, 2011).

- The bank efficiency level is important to assess as it may influence risk taking, banking spreads and the soundness of the financial system.
Introduction and Motivation

- On the other hand, banks face uncertainty about liquidity demand from their customers on a daily basis.

- A well functioning interbank market will allow institutions to efficiently trade liquidity (Furfine, 2001).

- Banks are interconnected through a chain of claims within interbank markets.

- Through these interconnections cascade failures may amplify eventual problems in specific banks or sectors.

- A shock to one bank can propagate to the rest of the banking system and may lead to a financial crisis, which may spillover to the entire economy.
Introduction and Motivation

- Banks can have either interbank assets or liabilities. It depends on relative costs and strategies they may want to pursue.
- Banks decide their asset allocation evaluating returns, risk and liquidity needs.
- Furthermore, if a bank is "too interconnected to fail" then it may incur in lower costs in the market if this status is public (common) knowledge.
- However, this may come at the expenses of lower profitability.
- We should expect that network measures help explain bank inefficiency through this channel: cost channel.
Introduction and Motivation

- We also study profit efficiency and argue that there could also be a "profit channel".
- In both cases banks that are highly interconnected can be seen as "special banks" with special implicit guarantees - which could affect their efficiency.
- Additionally, there may be a "risk-taking channel" - banks with that are highly connected in interbank market may be incurring in inefficient risk-taking.
Contributions

• The paper contributes with the literature in several ways:
  • Exploring the role of inter-connectivity on efficiency.
  • Employing methods from network theory to develop individual bank inter-connectivity measures to evaluate their impact on bank efficiency.
  • Investigating whether network topology can explain inefficiency levels.
  • Using a new approach to bank efficiency: risk-taking efficiency.
Methodology - Stochastic Frontier Analysis

We estimate cost, profit and risk-taking efficiency levels using the Battese and Coelli (1995) approach:

\[ Y_{it} = \exp(x_{it} + v_{it} - u_{it}) \]

- \( Y_{it} \) denotes the production for bank \( i \) at year \( t \).
- \( x_{it} \) is the vector of inputs.
- \( v_{it} \) are the random errors.
- \( u_{it} \) are non-negative random variables associated to inefficiency.
Methodology - Inefficiency term

- The inefficiency effect $u_{it}$ is specified as:

$$u_{it} = \delta_0 + \delta_{it} z_{it} + \delta_t b_t + m_{it}$$

- $z_{it}$ is the vector of control variables and bank individual network measures.
- $b_t$ is the vector of network topology measures.
- Control variables: ETA, NPL, Size and ownership dummies (foreign and state-owned).
Methodology - Variables

- We estimate efficiency levels by means of the commonly-used translog functional form for the cost, profit and risk-taking functions.
- There are three outputs: total loans net of non-performing loans, liquid assets and total deposits;
- Two input prices: interest expenses to total deposits and non-interest expenses to fixed assets.
- We use total expenses as proxy for bank cost, and profits before tax as proxy for profit.
- \( Z \) – score is proxy for risk-taking.
Methodology - Variables

- \( Z - \text{score} = \frac{(\text{ROA} + \text{CapitalRatio})}{\sigma_{\text{ROA}}} \)

- The Z-score measures the number of ROA standard deviations that a bank’s ROA plus its leverage have to decrease in order for the bank to become insolvent.

- \( Z - \text{score} \) is inversely proportional to the bank’s probability of default.
Methodology - Network measures
Methodology - Individual network measures

- *Indegree centrality* is the number of creditors that a bank has in a given time. Banks that have higher indegree are those that have higher number of creditors in the interbank market.

- *Outdegree centrality* is the number of debtors. Banks that have higher outdegree are those that have higher number of debtors in the interbank market.

- *Degree centrality* is the number of creditors and debtors. Banks with high degree centrality are those more interconnected in the interbank market.
Methodology - Individual network measures

- *Closeness centrality* measures the average distance of a bank from every other bank in the network. Banks with high closeness centrality measure are banks that are in a short distance to other banks; banks more directly interconnected.

- *Betweenness centrality* of bank A measures all shortest paths between any two banks B and C that pass through A. Banks with high betweenness centrality are those involved in a larger number of intermediation chains. Therefore they are more relevant for financial intermediation.
Methodology - Individual network measures

- **Borrower dominance (Weighted indegree)** is the volume-weighted number of creditors that a bank has in a given time. Banks that have higher borrower dominance are those that present many interbank liabilities.

- **Lender dominance (Weighted outdegree)** is the volume-weighted number of debtors. Banks that have higher outdegree are those more exposed in the interbank market.

- **Betweenness dominance** is similar to betweenness centrality. The difference is that Betweenness dominance is volume-weighted. Banks with high betweenness dominance have many inflows and outflows.
Methodology - Network topology

- *Power law exponent (alpha)* can be interpreted as the inverse probability that the network has banks more interconnected. If the alpha increases then banks that are more connected have a higher number of interconnections and there are less banks that have more connections. This implies that connections at the tail of the connectivity have become more concentrated.

- *Clustering coefficient* is the probability that two banks, which lend to each other, have a common counterparty. A high clustering coefficient indicates a more dense network, with many highly connected banks.
Data

- We use a unique data set of Brazilian interbank market to estimate interconnectivity measures.
- These data include interbank deposits, repos and credit loans.
- Our sample is an unbalanced panel which includes 102 banks that operates in the interbank market.
- The sample represents almost 90% of the banking system in terms of total assets.
- Annual data from 2007 to 2013.
Empirical Results

We fit 5 models for each efficiency frontier: cost, profit and risk-taking.

- No interconnectivity measures (Benchmark model).
- Only interbank network topology measures (Power law or clustering).
- Both banks interconnectivity and network topology measures. We cluster three sets of interconnectivity measures depending on their features:
  - borrower (weighted indegree), lender (weighted outdegree) and weighted betweenness;
  - closeness, betweenness and degree;
  - indegree and outdegree;
### Empirical Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cost</th>
<th>Profit</th>
<th>Risk-taking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>2.129</td>
<td>-4.354*</td>
<td>-5.742**</td>
</tr>
<tr>
<td>Clustering</td>
<td>-1.674</td>
<td>3.220</td>
<td>7.690***</td>
</tr>
<tr>
<td>Windegree</td>
<td>0.655***</td>
<td>0.187</td>
<td>0.356**</td>
</tr>
<tr>
<td>Woutdegree</td>
<td>0.0806</td>
<td>-0.136</td>
<td>-0.777***</td>
</tr>
<tr>
<td>Wbetweenness</td>
<td>2.493</td>
<td>-1.716</td>
<td>2.357*</td>
</tr>
<tr>
<td>Degree</td>
<td>8.511**</td>
<td>1.55</td>
<td>12.32***</td>
</tr>
<tr>
<td>Closeness</td>
<td>-0.12</td>
<td>-0.589</td>
<td>1.541</td>
</tr>
<tr>
<td>Betweenness</td>
<td>18.72*</td>
<td>-4.783</td>
<td>-67.71***</td>
</tr>
<tr>
<td>Outdegree</td>
<td>14.01**</td>
<td>1.612</td>
<td>7.558***</td>
</tr>
</tbody>
</table>

***, **, * stand for 1, 5 and 10 percent significance levels respectively.
Empirical Results

- Network topology and individual interconnectivity measures have different impact on bank inefficiency.
- An increase in concentration of connectivity (higher power law exponent - alpha) decreases profit and risk-taking inefficiencies.
- More dense network increases risk-taking inefficiency.
- This suggests that there may be economies of scale that originate in the interbank market and affect bank inefficiency.
### Empirical Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cost</th>
<th>Profit</th>
<th>Risk-taking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>2.129</td>
<td>-4.354*</td>
<td>-5.742**</td>
</tr>
<tr>
<td>Clustering</td>
<td>-1.674</td>
<td>3.220</td>
<td>7.690***</td>
</tr>
<tr>
<td>Windegree</td>
<td>0.655***</td>
<td>0.187</td>
<td>0.356**</td>
</tr>
<tr>
<td>Woutdegree</td>
<td>0.0806</td>
<td>-0.136</td>
<td>-0.777***</td>
</tr>
<tr>
<td>Wbetweenness</td>
<td>2.493</td>
<td>-1.716</td>
<td>2.357*</td>
</tr>
<tr>
<td>Degree</td>
<td>8.511**</td>
<td>1.55</td>
<td>12.32***</td>
</tr>
<tr>
<td>Closeness</td>
<td>-0.12</td>
<td>-0.589</td>
<td>1.541</td>
</tr>
<tr>
<td>Betweenness</td>
<td>18.72*</td>
<td>-4.783</td>
<td>-67.71***</td>
</tr>
<tr>
<td>Outdegree</td>
<td>14.01**</td>
<td>1.612</td>
<td>7.558***</td>
</tr>
</tbody>
</table>

***, **, * stand for 1, 5 and 10 percent significance levels respectively.
Empirical Results

- These results suggest that not only the interconnection type matters (as a lender or as a borrower), but also that the volume of loans has an opposite effect.

- For instance, a bank could reduce its cost and risk-taking inefficiency having a higher number of creditors (indegree).

- However, depending on the volume of the loans ($Windegree$), the bank could increase its cost and risk-taking inefficiency.

- More direct interconnected bank (degree), as a borrower or as a lender or both, has higher cost and risk-taking inefficiency.
Empirical Results

- The results suggest that individual interconnectivity can increase cost and risk-taking bank inefficiency.

- Individual bank interconnectivity features do not impact profit inefficiency. It seems that banks participate in the interbank market to manage liquidity instead of searching for profitable investments opportunities.

- The results suggest that banks decide their participation on interbank market for other reasons than optimization of the production function.
Empirical Results - Cost Efficiency

![Graph showing empirical results for cost efficiency from 2007 to 2013. The graph displays the mean and standard deviation for different models over the years.]
Empirical Results - Profit Efficiency
Empirical Results - Risk-taking Efficiency
Final Remarks

- Network topology and individual bank interconnections matter for explaining bank efficiency.
- There are several differences in cost or profit efficiency and with regards to risk-taking efficiency.
- It seems that profit and risk-taking efficiency are more affected by the network topology than cost efficiency.
- Individual bank interconnections affect more cost and risk-taking efficiency.
- Further research must be done to investigate if results change for different interbank market instruments and for different cluster of banks.
Thank you!