Connectivity and Systemic Risk in Payment Systems

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DISCLAIMER

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Objectives

• To extract information from the network of the IB payments flows employing network theory concepts:
  – The financial system structure
  – SIFIs
  – Reaction to liquidity shocks
• To propose a framework to help the surveillance of financial institutions from payments data.
Motivation

• There is a significant share of the financial flows that reflect or is related to flows of real world objects or activities;
• Any large scale impairment related to these flows may impact the real economy.
• It is important to identify sources of risk for them, in two layers of structures:
  – Banks and other FIs;
  – Payments System.
The Brazilian Payments System

- Its structure consists of a LVPS run by the Central Bank centralizing the net transfers among FIs from the other payment systems.
Network Analyses: The Data

• Our sample is composed of *Interbank Fund Transfers in the Brazilian Payment System*
  – From both STR and SITRAF
  – Between Financial Conglomerates and Institutions not belonging to a Conglomerate
    • Types I and 2: Commercial Banks, Universal Banks holding a commercial bank portfolio or a Savings and Loans Banks, and Investment Banks.
  – From 2006 to 2011
• The analyses do no consider liquidity provisions by the Central Bank
Layers of Analysis

• Network global structure
  – Distribution of the Degree Centrality: related to the influence that particular types of network structures have on the possibility that a shock suffered by 1 FI spread throughout the system.

• Local interactions
  – Dominance: the relative importance of one institution’s transfers on the other institutions
  – Criticality: how one institution’s transfers relate to their counterparties’ liquid assets. Related to the local transmission of liquidity shocks between FIs.
Degree Centrality results

• The Brazilian IB funds transfer network can be characterized as scale-free (alpha=3.45)
  – Payment system has money centers highly interconnected along with peripheral banks with few connections
  – Scale-free networks are robust to random shocks, but vulnerable to simultaneous shocks to important nodes (Crucitti et al. (2004))

• The institutions that form the IB network core (their degree centrality are in the upper tail of the power law distribution) may be systemically important.
Transfer Volumes

- Degree centrality is not enough to determine systemic importance. A further step to do it is to examine the strength of each connection (volume transferred).

- To do this, we will use an MST, which is the set of edges linking any two nodes with the shortest total distance (with no cycles).

- An MST is a good way to represent only the most relevant transfers.

- *In an MST, each vertex will be connected to those that are closest*
Transfer Volumes

• The first step is to define a distance \( d^w(i,j) \) between institutions \( i \) and \( j \), such as the higher the transfer, the closer they are.

• We define \( w(i,j) = \text{total amount transferred from } i \text{ to } j \)

• From \( w(i,j) \) we define the distance \( d^w(i,j) \) from institutions \( i \) and \( j \) (Cajueiro and Tabak(2007)):
  
  \[ \text{max}_d = \max(w(i,j) + w(i,j)) \text{ for all edges } (i,j) \]
  
  \[ d^w(i,j) = 2 - (W_{ij} + W_{ji}) / \text{max}_d \]

• We will examine the MSTs generated for the IB payments network in three periods:
  
IB payments in June, 2006. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue)
Minimum Spanning Trees – Sep, 2008

IB payments in Sep, 2008. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue)
IB payments in Dec, 2011. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue)
Dominance in Complex Networks

• It is a measure of the centrality of a node that takes into account direction and weight of payments. Introduced by Van Den Brink (2000)

  *It represents the impact the suppression of a node causes in the relative revenues of its neighbors*

• Given institutions $i$ and $j$ and $w(i,j)$ defined as before:

  $$\beta(i) = \sum_j \left[ \frac{W(i,j)}{\lambda(j)} \right]$$

  where $\lambda(j) = \sum_i W(i,j)$

  $\beta(i)$ is the dominance of $i$ over the network
Dominance in Complex Networks
Banks by Type of Control

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Dominance in Complex Networks
Concentration of Dominance

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IB payments in Jun, 2006. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue) – Size of node is given by its Dominance
IB payments in Sep, 2008. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue) – Size of node is given by its Dominance
IB payments in Dec, 2011. Types of control: State-owned (circle, green), Private Domestic (diamond, yellow), Foreign (square, blue) – Size of node is given by its Dominance
Dominate results

- The dominance results also indicate that the 3 banks previously outstanding as money centers (2 private domestic, 1 state-owned) are also the most dominant.

- This is an indication that they are systemically important:
  - They are much more connected than the others, due to the power-law distribution’s high exponent;
  - Their transfers are remarkably higher;
  - Their payments are relevant for each FI receiving them: they are important counterparties for them

- These factors jointly define the set of SIFIs
Criticality of FIs

- Dominance is a measure of importance of FIs, but it does not tell us how shocks could impact the system in a time of crisis
  - In times of Crisis, Liquidity is Important

**Criticality is how one institution’s transfers relate to others institutions’ liquid assets**

- We calculate the criticality for each institution as the sum of the criticalities of its transfers.
- The criticality of a transfer is the transfer’s value divided by the liquid assets of the recipient.
- Daily data
Application: Propagation of Liquidity Shortages

• Given each pair of institutions, we compute the net transfer between them. The net transfer’s criticality is got dividing it by the recipient’s liquid assets.

• We define symmetrically a criticality distance $d_c(i,j)$ such as the more critical the transfer, the closer is the pair of FIs.

• From this distance measure we generate a MST

• When drawing it, we represent the transfers’ direction, with arrows, and its criticality.

    Criticalities above 1 represent that if the transfer is suppressed, this will cause a liquidity shortage on its recipient.
Critical net transfers in the last day of Sep, 2008. Numbers refer to transfers with the highest criticalities. Node size given by its Criticality.
Criticality of FIs - Comments

• The most dominant banks are usually among the most critical ones, but this does not mean that they are necessarily big banks. To be dominant or critical, a bank only needs to be locally big.

  The Criticality measure can help regulators to identify institutions which need to be observed more closely when another institution in the network has liquidity problems.
Conclusions

• The study of the structure of the connectivity of the Brazilian payments system indicates that there is a subset of key players financial institutions.

• We present a methodology that is helpful in assessing systemically important institutions within bank networks. It is also useful in the identification of possible liquidity shortage propagation paths.

• The Brazilian payment system did not show long propagation chains of this type. The amounts needed by a last resort lender are affordable.
THANK YOU

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