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Which Network Measures explain the Interest Rate Spread in the Mexican Interbank Markets a study by regularized GLMs with Machine Learning

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Dr. Serafín Martínez-Jaramillo joint work with Elizabeth Tellez-Leon, Luis Escobar-Farfan, Ulf Dieckmann and Sebastian Poledna

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Motivation

The importance of interbank markets

Unsecured and secured (repo) interbank markets are very important for the well functioning of the financial system:

- Their importance within the Mexican financial system funding structure.
- Their relationship with monetary policy implementation.
- Represent important vehicles for liquidity transmission.
- The unsecured interbank market has been studied widely as an important contagion vehicle.

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The financial system as a (multilayer) network

- There has been a lot of recent research on financial networks for the purposes of studying systemic risk, performing stress testing or determining the relevance of financial institutions.

- A commonly shared view is that the financial system is highly interconnected.

- However, most of the works use the interbank unsecured market as the only source to measure interconnectedness in the banking system.

- This network doesn’t explain such high interconnectedness of the financial system.

- Financial institutions interact in different markets, which can be thought of as different networks within a meta-structure which can be interpreted as a multilayered network or a multiplex network.

- This gives rise to a rich set of complex interactions among these layers, each with different topological properties.

Martinez-Jaramillo, S., Carmona, C., Kenett D. (2019) “Interconnectedness and financial stability” Journal of Risk Management in Financial Institutions, Vol. 12, 2, pp. 163–178.

Objective

- Our goal is to determine if centrality has a relationship with the interest rates banks pay and charge on the unsecured and the secured (repo) interbank markets.
- A changing set of 40 to 50 banks is analyzed in the period ranging from January 2005 to June 2017.
- Using regulatory transaction-level data we construct monthly aggregated matrices to obtain centrality measures for each bank.
- An econometric model is used to assess the ability of centrality measures to explain the spread charged on every existing pair of institutions.

Our contribution

- It allows us to observe if the centrality, or the notion of influence in the interbank system, is related to the interest rate differentials on each of the analyzed markets.
- We perform our study for two important interbank markets: the unsecured and the repo market.
- We selected a set of variables that cover the most important structural aspects of the financial networks that arise on each market.
- We introduce new variables which measure important features of financial networks from the financial stability point of view: the core-periphery variable and DebtRank.
- The time period is longer than for previous studies to include relevant events for the Mexican financial system.

Related literature and basic concepts

Trading relationships

- Using data from the Fedwire Funds Service, Afonso at al. (2013) found that the liquidity of banks rely less on non-frequent transactions and more on funds from institutions with which they have a stable funding relationship.

- In Han and Nikolaou (2016), the authors investigate the influence that trading relationships have on the terms of trade in the US tri-party repo market, they find evidence that although trading parties perform transactions with a large number of counterparties, they tend to have a small set of counterparties with whom they prefer to trade.

- In Temizsoy et al. (2015), Using data from the e-MID interbank market they find that long term relationships between banks exist and have a positive impact on the rates and volume for both lending and borrowing. Similar results are presented in Bräunig and Fecht (2017) for the German interbank market during the financial crisis.

- Van der Leij and Martinez-Jaramillo (2019) found that there exists trading relationships in the secured (OTC repo) and unsecured markets and these relationships have impact on the terms of trading.

Network structure and interest rates

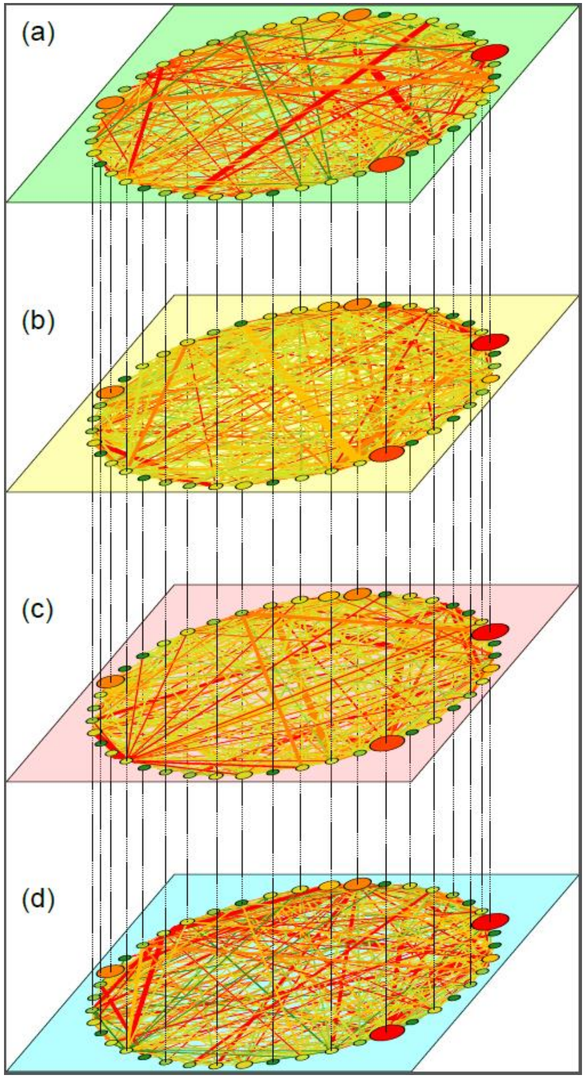
- In Iori et al. (2014) the authors conduct an analysis of the determinants of spreads on the e-MID by taking into account the behavior of banks and market microstructure.

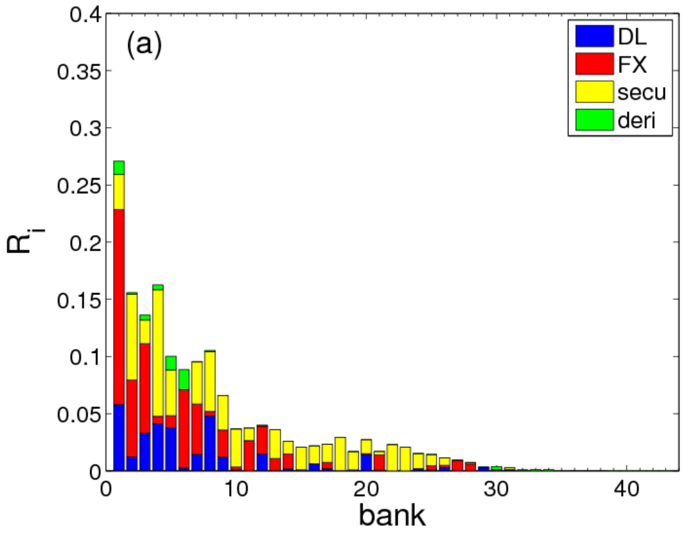
- Gabrieli (2012) previously investigated the role of network centrality on the determinants of interest rates.

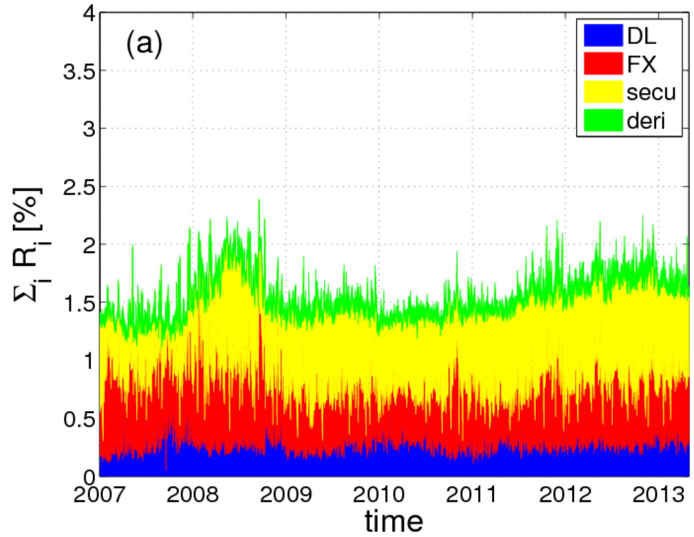
- In Temizsoy et al. (2017), the authors investigate the role of centrality on the rates in the interbank markets. They (using data from e-MID) find that centrality plays an essential role on the rates banks get on the unsecured money market, and even more, that this effect became more significant during the crisis of 2008.

- Most of the previously mentioned works involve interbank unsecured lending markets.

Multilayer networks







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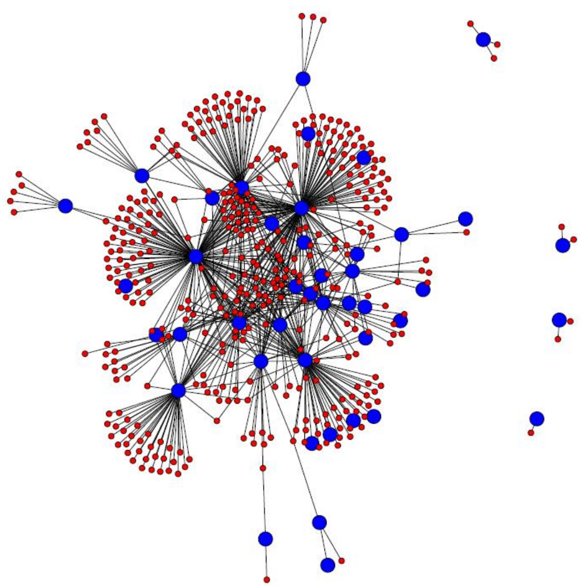
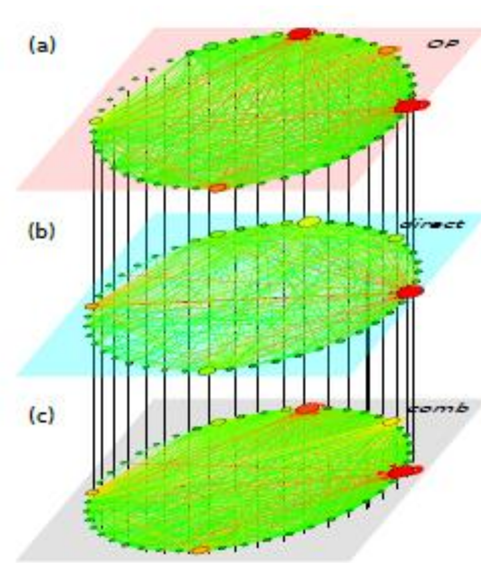
Sovereign and financial risk

- Banks are exposed to systemic risk directly and indirectly
  - Propagates through different channels and mechanisms
- *Overlapping portfolios*
  - Indirect interconnections: Financial institutions investing in common assets. This is an important source of systemic risk and contagion

- *Poledna et al (2019)*[1] propose a network model to quantify systemic risk from direct and indirect exposures

Red: assets
Blue: banks.





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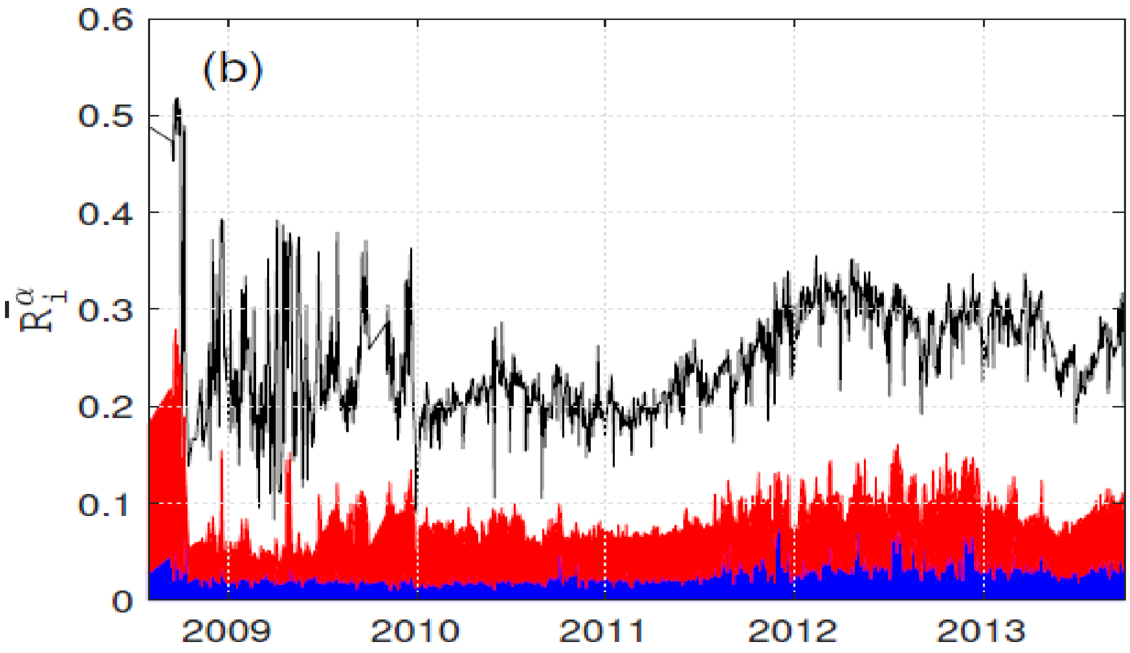
Poledna, S., Martinez-Jaramillo, S., Caccioli, F., Thurner, S., 2019. "Quantification of systemic risk from overlapping portfolios in the financial system", Journal of Financial Stability

Sovereign and financial risk

- The systemic risk metric from direct exposures is considerably lower tan the one from overlapping portfolios.
- When both exposures are considered together the metric is higher that the sum of the individual metrics.
- This metric could be even higher if sovereign exposures are considered.



Blue: direct
Red: OP
Black: combined

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The doom loop

- Existing capital regulation assigns zero risk weight to domestic sovereign securities.
- Government debt holdings are exempted from concentration limits and are even encouraged by the recent liquidity regulation.
- Some jurisdictions have acknowledged the importance of this problem. For example, in Alogoskoufis and Langfield (2018)
- The author concludes that by changing the sovereign exposures treatment in the capital requirements could lessen the impact of this negative feedback loop.
- A non-exhaustive list of related works includes: Farhi & Tirole (2018), Acharya & Rajan R. (2013), Acharya et. al. (2014), Brunnermeier (2015).

Centrality

- The main idea of centrality is to identify important nodes in a network.
- Freeman (1978) introduces the concept of centrality in social networks, which can be extended to financial networks.
- In Bonacich (1987) we can find further discussion on the centrality and the relation of it with the power that a participant has in a network.
- Nowadays the plethora of centrality metrics makes it hard to decide which metric is more useful to identify relevant nodes in a network.
- There are many classes of centrality and among the most important ones we can find: degree, closeness, betweeness, eigenvector, Katz, percolation, cross-clique, Page Rank, DebtRank, SinkRank, etc.
- In Martinez-Jaramillo et al. 2014 the authors perform an empirical study on centrality for interbank exposures and payment systems networks

Some basic notation

- The market network is represented in matrix form. We denote this matrix by W, with its entries $w_{ij} \geq 0$ represents the amount of money that institution i lends to *j* takes from institution i, $w_{ii} = 0$ for all $i \in \{1, \dots, N\}$, where N is the number of institutions represented in W.
- We can define two additional matrices: the outflow matrix W^+ and the inflows matrix W^-. Accordingly, the entry w_{ij}^+ defines a money flow from institution i to institution *j* and the entry w_{ij}^- defines a money flow from institution *j* to institution i, this implies that $W = W^+ + W^-$ and $W^+ = (W^-)^T$.
- Some of the network measures are calculated from the adjacency matrix A, defined by

$$a_{ij} = \begin{cases} 0 & \text{if } w_{ij} = 0, \\ 1 & \text{otherwise.} \end{cases}$$

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Basic concepts

- The core-periphery variable takes a value of one if a bank belongs to the core of the network and a value of zero if it falls in the periphery.
- The core-periphery model splits the nodes in a network into two categories: the core and the periphery. Nodes in the core are highly connected, whereas nodes in the periphery are exclusively connected to nodes in the core.
- This model for tiered banking systems is based on the concept of intermediation, where banks in the core serve as intermediaries for the excess of liquidity in the banking system.
- The DebtRank centrality metric measures the potential contagion that an institution poses to the system.
- A higher DebtRank implies a more systemic institution due to the higher potential losses such an institution can impose on the system.

The secured and unsecured interbank markets

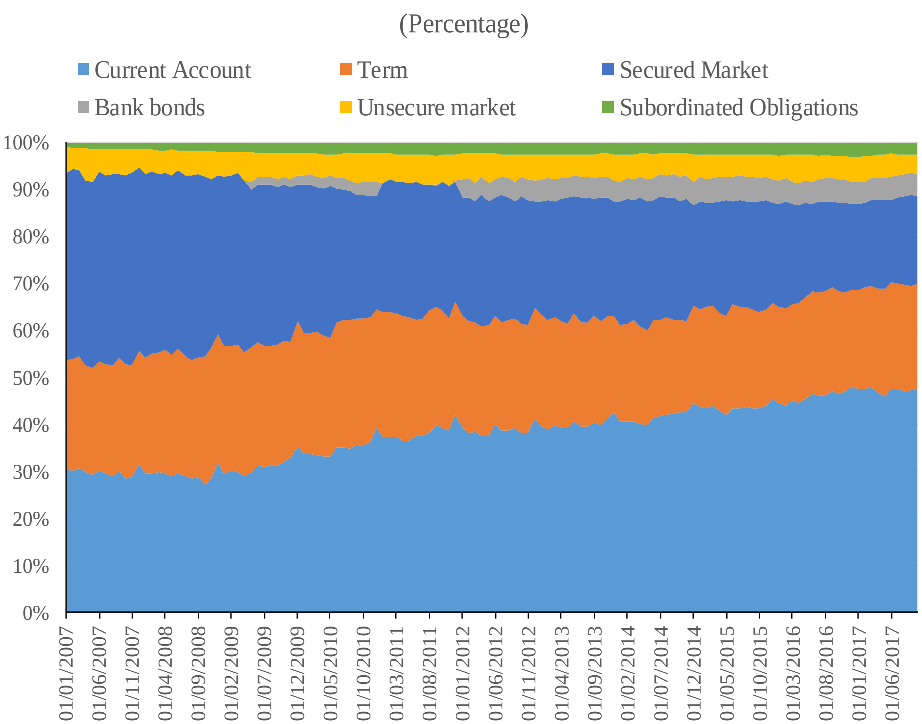
The unsecured market

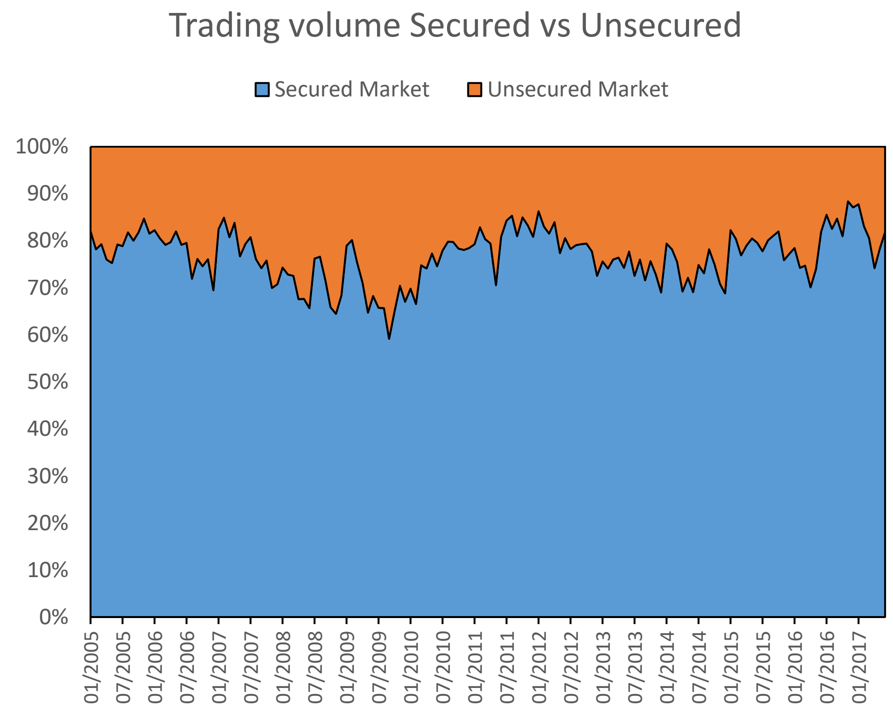
- The data used for this study comprises daily deposits and loans transactions in domestic currency between commercial banks.
- From the whole interbank unsecured market, the overnight segment accounts for about 90% in terms of volume for a typical day;
- In terms of number of transactions (loans) the share is slightly higher about 92%.
- Unlike the experience in other jurisdictions, neither the unsecured nor the repo market in Mexico suffered a sharp decline on activity.

The repo market

- Using a comprehensive dataset from the Mexican central bank, Usi-López et al. (2017) described this market for a long period, including the financial crisis that started in 2007.
- The secured market in Mexico is very active, with around sixty thousand transactions processed every day in 2016, and a daily average volume of 35 million Mexican pesos.
- Most of the activity comes from overnight transactions, which constitutes more than 95% of the total transactions.
- The most important types of counterparties are local individuals and local companies, whose contribution amounts to more than 90% of the total number of transactions.
- However, regarding volume, other counterparties contribute the most – these are investment funds, commercial banks, and brokerage houses, whose contributions, alongside that of the local firms, adds up to more than 60%.

Funding structure





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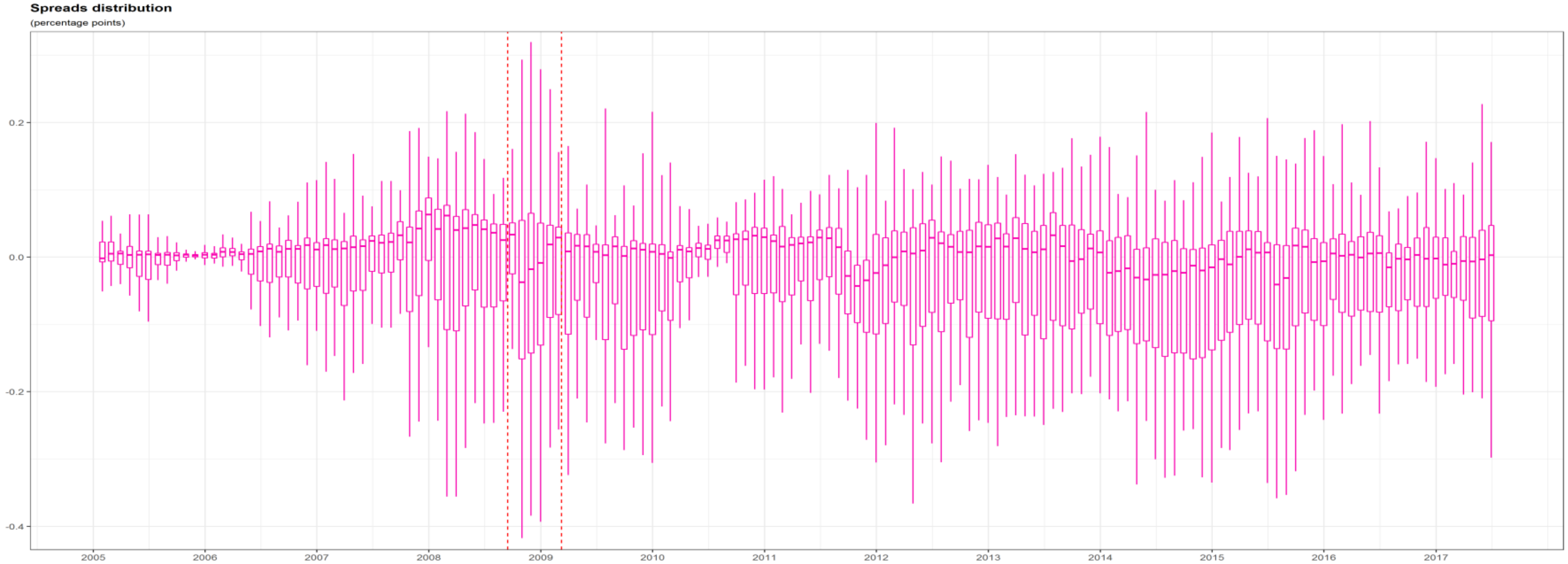
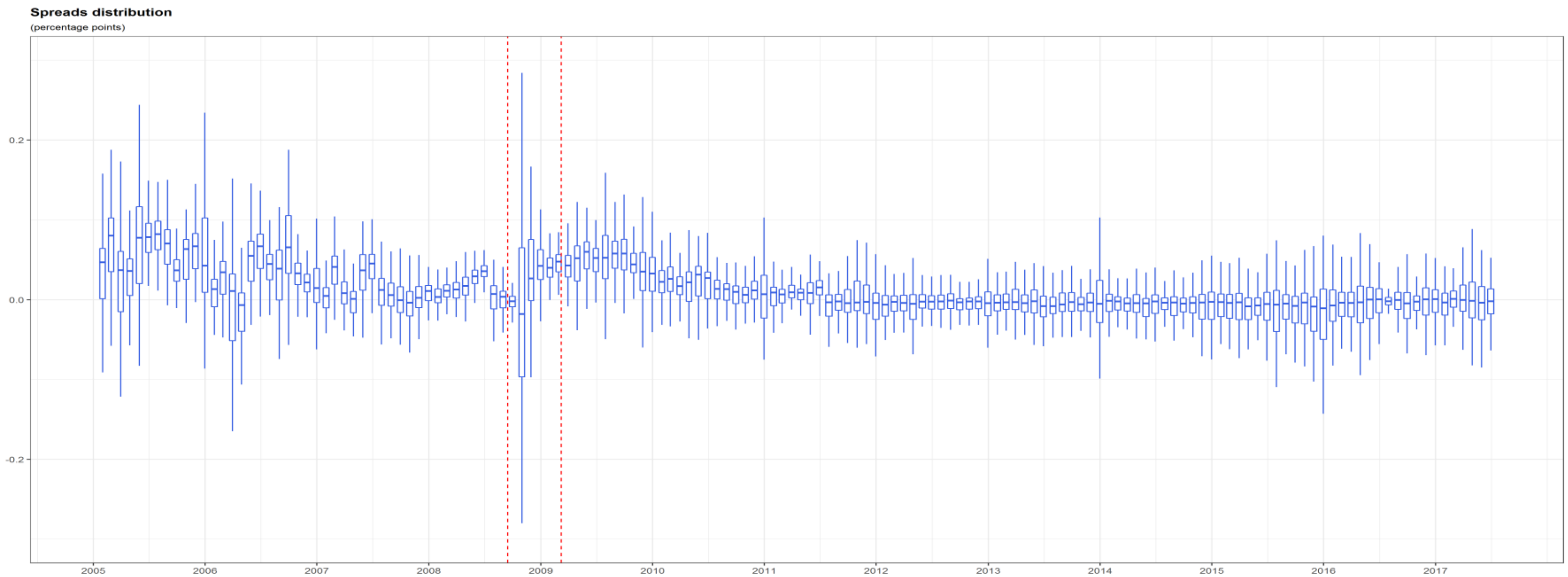
Spread distribution

Unsecured market



Secured market



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Model & results

Model specification

As in Temisoy et al. 2017, the dependent variable in the model is the monthly volume-weighted average interest rate spread for each pair of institutions i, j, which is defined as:

$$S_{ij,t} = \frac{1}{\sum_{n=1}^{N_{ij,t}} V_{ij,n}} \sum_{n=1}^{N_{ij,t}} \left(r_{ij,n} - r_m^{-d}\right) * V_{ij,n}$$

where

$$r_m^{-d} = \frac{\sum_{n=1}^{N_{ij,d}} \sum_{j=1} \sum_{i=1} r_{ij,n} * V_{ij,n}}{\sum_{n=1}^{N_{ij,d}} \sum_{j=1} \sum_{i=1} V_{ij,n}}$$

$r_{ij,n}$ and $V_{ij,n}$ are the transaction level interest rate and volume, respectively, for each pair of banks i, j for $i \neq j$.

$N_{ij,t}$ is the number of transactions for the bank pair i, j at period t for $i \neq j$

r_m^{-d} is the daily volume-weighted average rate over all transactions carried out by the bank pairs;

We consider the following centrality measures:

ACCESSIBILITY_B	CLOSENESS_L	DEBTRANK_B	DEGREE_L	EXPECTEDFORCE_B	KATZ_CENT_L	PERCOLATION_B
ACCESSIBILITY_L	CLUSTERING_B	DEBTRANK_HAT_B	DEGREE_OUT_B	EXPECTEDFORCE_L	KATZ_CENT_W_B	PERCOLATION_L
AFFINITY_B	CLUSTERING_L	DEBTRANK_HAT_L	DEGREE_OUT_L	HHI_IN_B	KATZ_CENT_W_L	SINKRANK_B
AFFINITY_L	CORE_PERIPHERY_B	DEBTRANK_L	EEC_B	HHI_IN_L	PAGERANK_B	SINKRANK_L
BETWEENESS_B	CORE_PERIPHERY_L	DEGREE_B	EEC_L	HHI_OUT_B	PAGERANK_L	STRENGHT_L
BETWEENESS_L	CROSS_CLIQUE_B	DEGREE_IN_B	EIGENVECTOR_B	HHI_OUT_L	PART_B	STRENGHT_B
CLOSENESS_B	CROSS_CLIQUE_L	DEGREE_IN_L	EIGENVECTOR_L	KATZ_CENT_B	PART_L	

Where B means the institution is the borrower in the spread and L for lender

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Model specification

- Control variables:
  - AM_PM_Ratio: Percentage of operations that occur in two different partitions of a day of activity, it is defined as:

$$\frac{Morning\ Operations\ -\ Evening\ Operations}{Total\ Operations\ in\ the\ Day}$$

  - TRANSACTION_RATIO: It is used to identify significant relationships in the market, is defined as the ratio between the number of transactions of a given pair of institutions and the total number of transactions in the market.
  - Capital ratio.
  - Delinquency ratio.
- A multicollinearity test was performed to eliminate redundancy in the data.

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Model specification

- Least-Squares models with fixed effects were estimated, alongside a GMM model with instrumental and control variables. Finally we also estimated a GLM resorting to the following regularization techniques: Ridge, Lasso (least absolute shrinkage and selection operator) and Elastic Net.

- The final fitted model is specified as:

$$\Delta S_{it} = \beta_1 \Delta S_{it-j} + \beta_2 \Delta X_{it} + \beta_3 \Delta C_{it} + \Delta u_{it}$$

  i, denotes banks, t indexes time.

  S_{it} is the spread of the interest rate at time t.

  X_{it} contains the financial network metrics.

  C_{it} represents the controls variables: AM/PM, capital, delinquency and transaction_ratio.

  u_{it} are the unobserved residuals.

- The estimation of the GMM model used variables of control and lagging values as instruments. The standard errors were estimated with Robust- White period weights from final interaction.

- We estimated the Sargan's J test for each model GMM weighting matrix, white period, innovations have time series correlation structure that varies by cross-section.

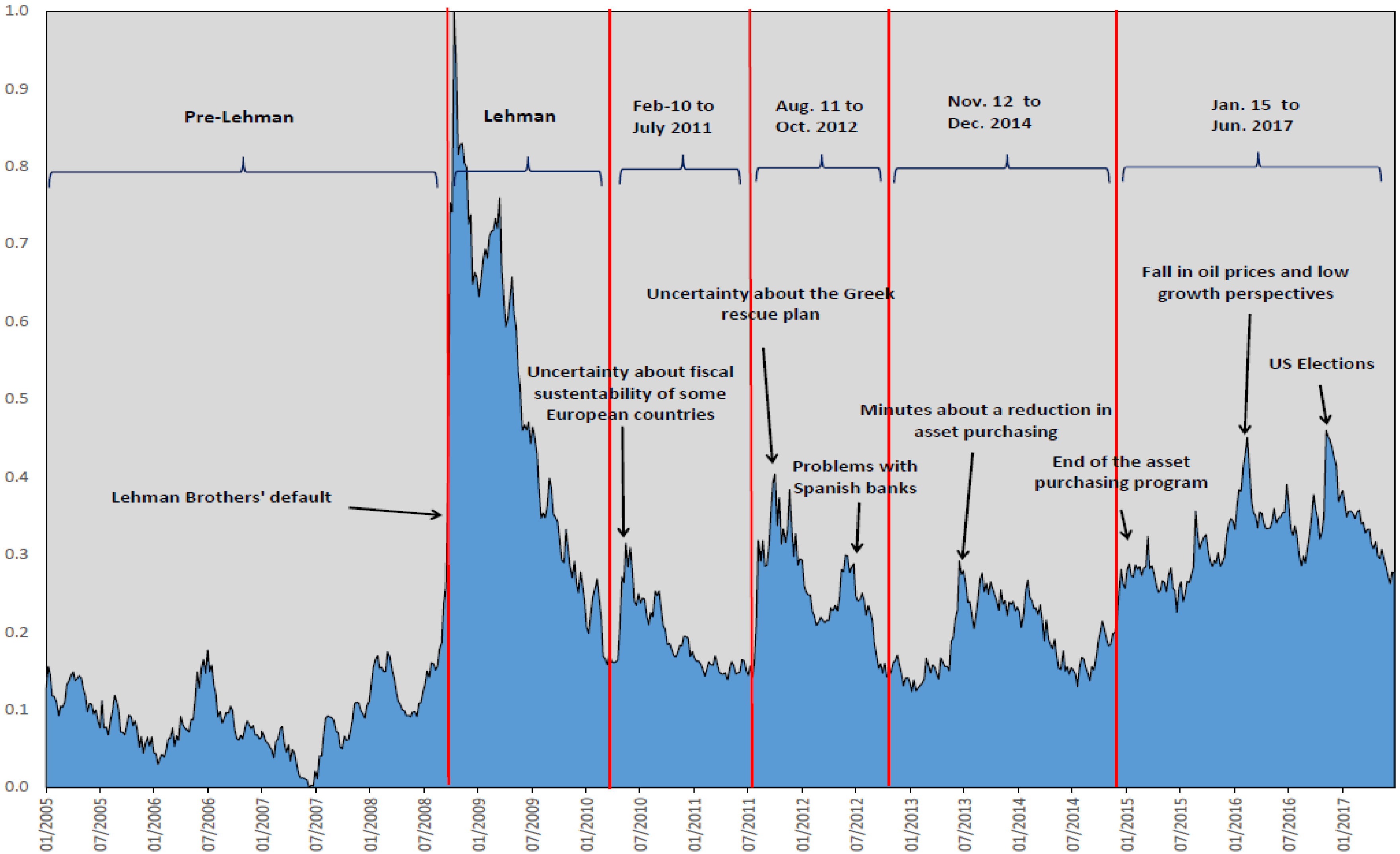
Results of the econometric model

Many different specifications were estimated for both markets:

- Full sample period
- Pre-Lehman default period
- Crisis period
- European crisis (relatively calmed period for Mexico)
- Uncertainty about the rescue program for Greece
- Minutes about the reduction in the assets purchase program (relatively calmed period for Mexico)
- End of the asset purchasing program (more stressful period for Mexico)

- This periods where validated by resorting to a stress index used at the Mexican central banks and performing Chow break point tests to validate such periods.

Sample periods



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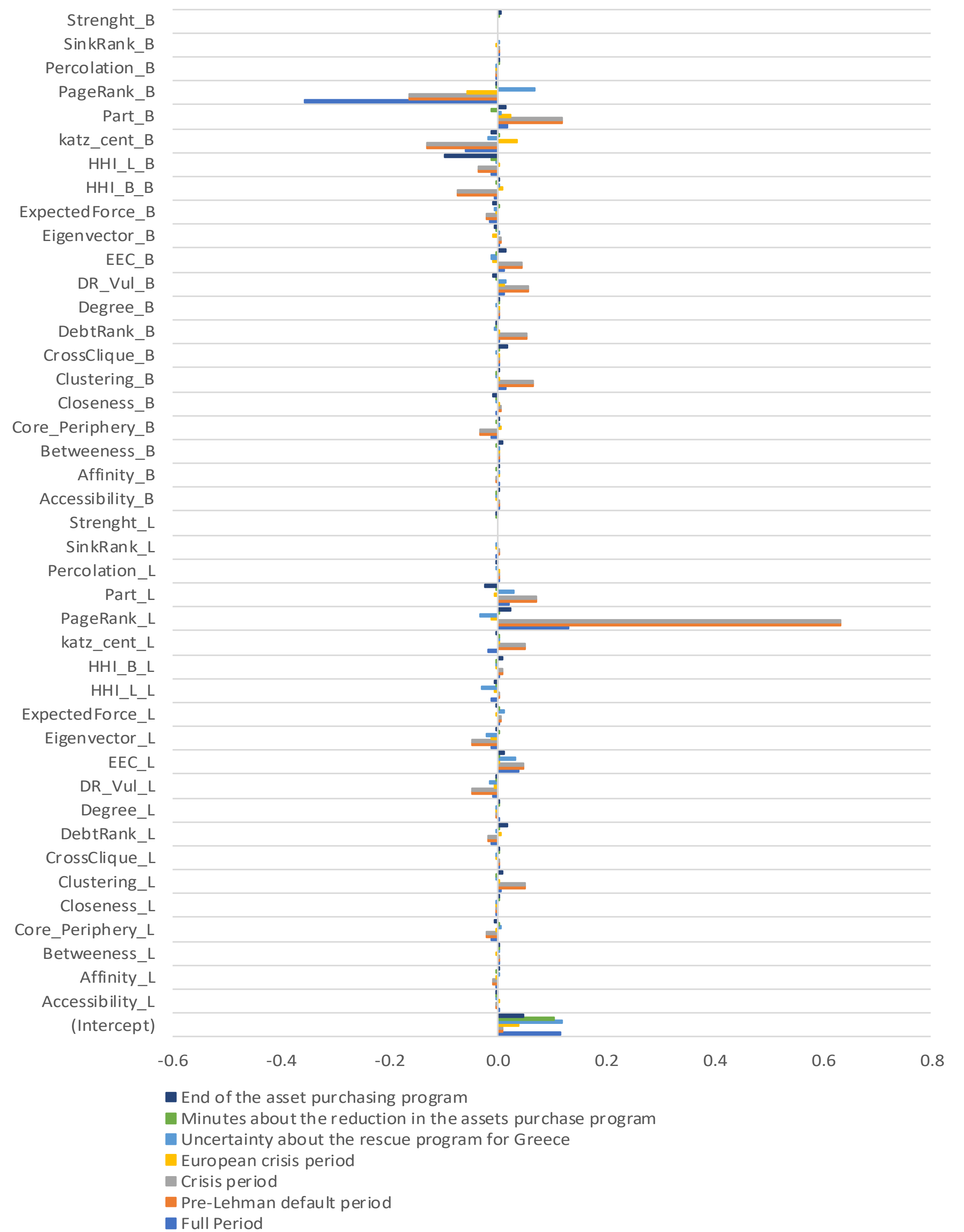
Secured



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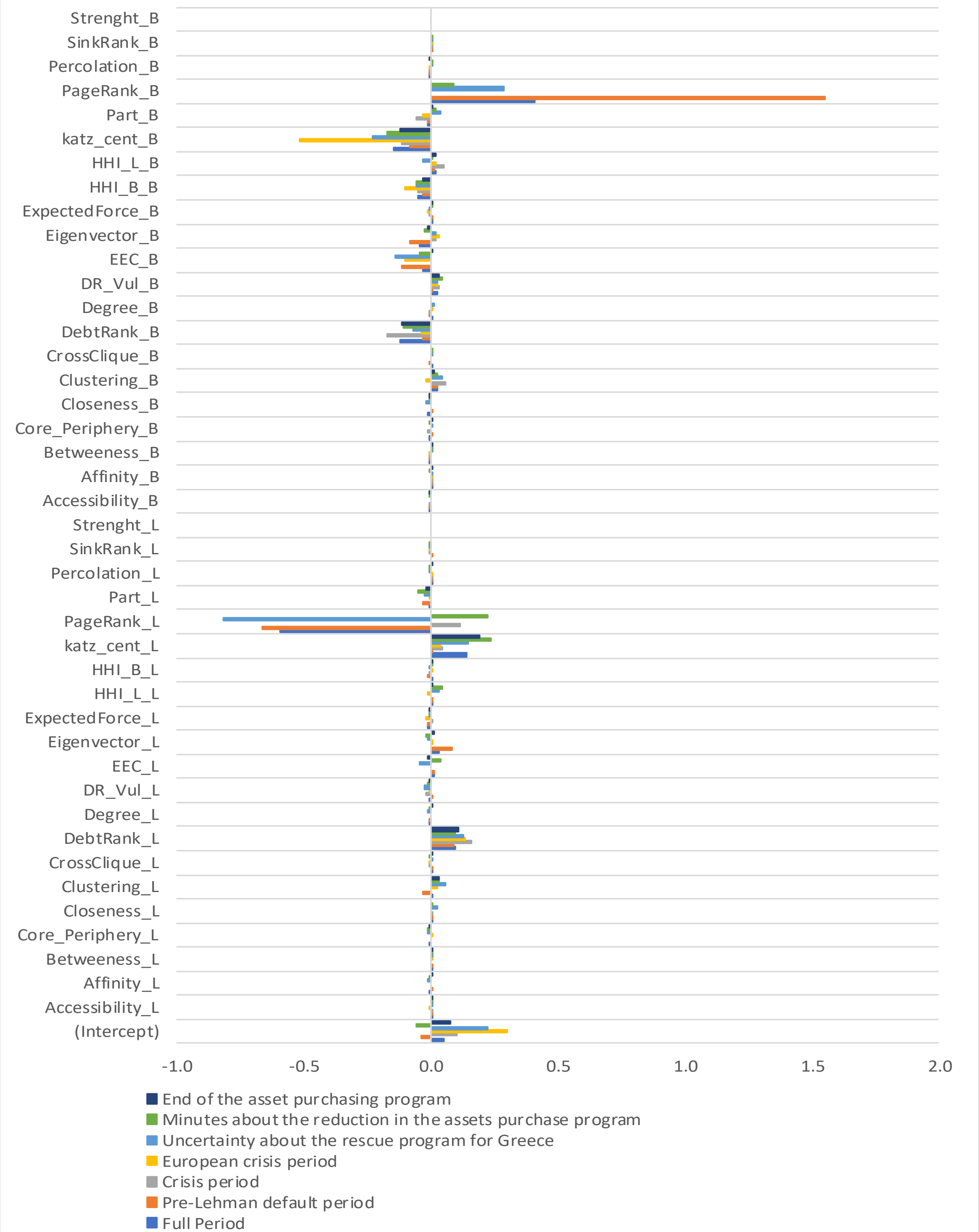
Secured

- During the first three periods, most of those 8 metrics of centrality are highly significant.
- Borrowing and lending network metrics compatible with the TITF hypothesis, in general in all the periods in this market, being central was linked to cheaper access to liquidity and better lending conditions.
- This being a collateralized market, systemic risk centrality metrics (DebtRank) are less important

Unsecured



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Unsecured

- During the first three periods, most of those 8 metrics of centrality are highly significant.
- Borrowing and lending network metrics compatible with the TITF hypothesis, in general in all the periods in this market, being central was linked to cheaper access to liquidity and better lending conditions.
- Only PageRank (topological metric) signals in a very different direction to DebtRank (systemic risk metric).
- This stresses the importance of consider several centrality metrics and in particular with economic interpretation.

Conclussions

Is centrality important?

- It seems that there is a strong relationship between centrality and the term conditions in the unsecured and secured lending markets
- On the full sample estimations the evidence was inconclusive regarding the Too Interconnected to Fail (TITF) hypothesis for both markets.
- Splitting the sample for different periods lead to similar results
- There is evidence of a relationship between centrality and spreads on both markets

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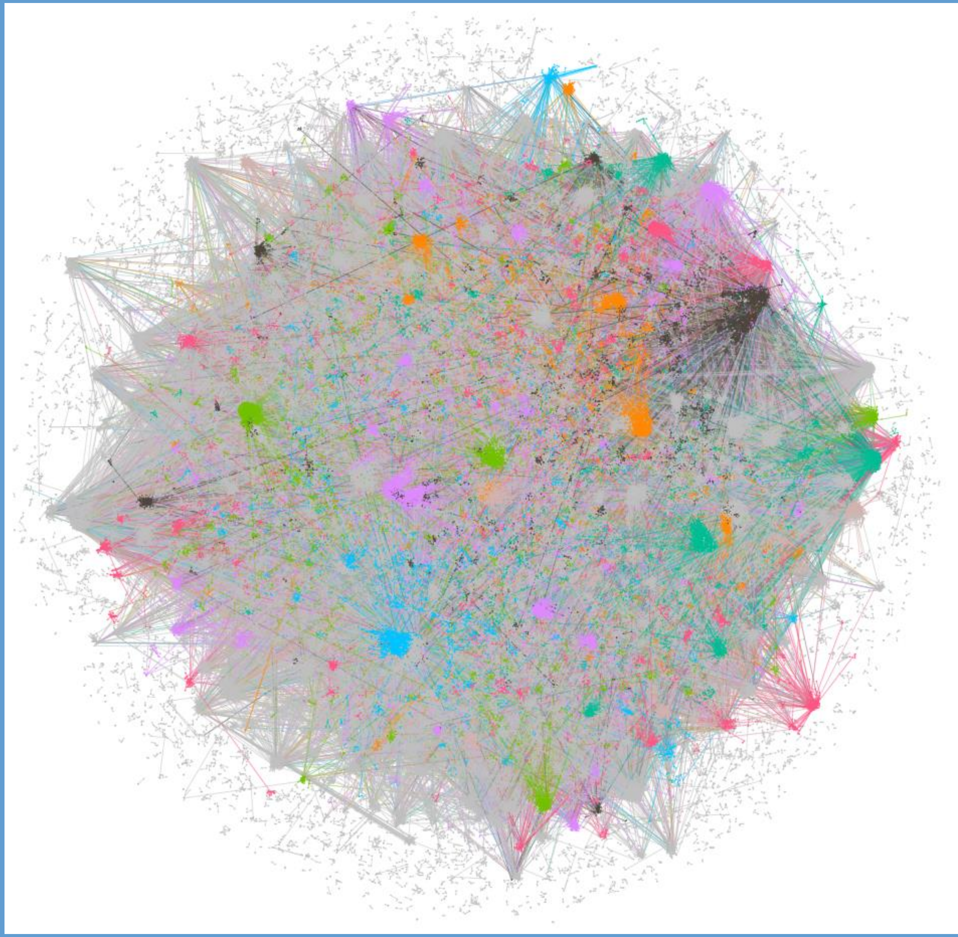
Conclusions

- The network structure in the unsecured and secured markets appears to be informative on the spreads
- It seems that higher centrality is related to benefits in terms of rates for borrowers and lenders, in particular for the unsecured interbank market and in certain periods of time.
- There are many more aspects of the modeling of financial stability and systemic risk which can be tackled by using network theory and models
- There are many other relevant markets and institutions for which similar studies can be done
- The research agenda is still open with many opportunities for developing new (multilayer) network models and use their structural metrics on econometric studies.



Thanks a lot for your attention.