CENTER FOR LATIN AMERICAN MONETARY STUDIES

CEMLA Innovation Hub

X Meeting of Heads of Financial Stability
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CEMLA's Innovation Hub

- The Hub was announced in March 2019 and officially launched in June 2019.
- The Hub seeks to:
  - To built capacities in the regional central banks to address issues that arise in areas as Financial Stability and Financial Market Infrastructures with novel techniques from Machine Learning, Network Science and Distributed Ledger Technology (DLT),
  - To incorporate the knowledge gained from each case into a research work with the aim to spread its benefits among central banks.
- The projects comprised a variety of problems as the detection of anomalous behavior of institutions, transactions and time intervals in the payments systems, interbank exposures characterization, measurement of systemic and credit risk and its effects, price rigidity and the study of tiered access to an RTGS system through an DLT-based approach.

Bolivia

Systemic risk and other inter-dependencies among banks in Bolivia*

Jonnathan Caceres-Santos, Anahi Rodriguez-Martinez, Fabio Caccioli and Serafin Martinez-Jaramillo

Abstract

The financial system in Bolivia has registered important changes in recent years. The development of the financial market and the modernization of its infrastructure promoted greater interconnection between financial entities. Here we provide an empirical study of the Bolivian large value payment system between 2014 and 2020 and of the network of interbank exposures between 2018 and 2020. For both systems, we characterize their network structure and we perform a systemic risk analysis.

We find that the connectivity of the payment network has increased over time, and that it displays a core-periphery structure. For this network, we use the SinkRank algorithm to rank banks in terms of their importance in the distribution of liquidity within the network, and we identify two institutions as the most important throughout the period under study.

Concerning interbank exposures, we find that the average number of connections per bank is roughly constant in the period we consider, but that the average size of interbank exposures increases. The latter quantity also displays a period of a few weeks in which the average strength suddenly increases. We carry out a systemic risk analysis was carried out using the DebtRank methodology. In this analysis, we adjust the Tier 1 capital of the banks for exposure to credit risk from the commercial loans portfolio, based on the estimation of unexpected losses, Cáceres (2017). We find that average DebtRank and vulnerability show an increasing trend over time, and we observe spikes in correspondence to those observed for the average strength.

For both networks, we also extract the backbone of most important connections using two different methods. We found some important implications on the results delivered by each of them.

Keywords: Financial networks, Systemic risk, Payment systems.

1 Introduction

The financial system in Bolivia has undergone an important transformation in recent years. The development of financial markets and the modernization of Financial Market Infrastructures (FMIs) like the large value payment system lead to an increase on the level of interconnectedness among financial institutions.

In Bolivia, as in many other countries, the 2007 financial crisis showed the relevance of studying the increasing level of interconnectedness and take it into account for contagion and

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Bolivia. Background and Methodology

- In this use case we performed systemic risk analysis and characterized the network structure of payment system between 2014 and 2020 and for the interbank exposures network between 2018 and 2020.

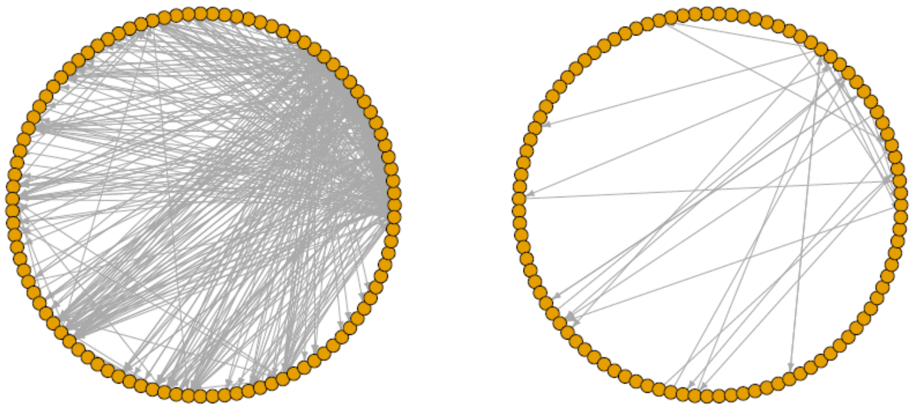
- Systemic risk analysis was carried out using the DebtRank metric for interbank exposures and the SinkRank for the payment system. For both networks, we also extracted the backbone of most important connections using the Pólya and Kobayashi-Takaguchi-Barrat (KTB) filtering methodologies.

- Pólya filter is based on the idea that the networks observed are the aggregate outcome of repeated interactions over time. Each node distributes its weights among its links following a Pólya process with a reinforcement parameter α.

- The KTB filter assumes there is a permanent probability of interaction between a pair of nodes. The method for the calculation of the backbone is based on undirected edges without weights but is a dynamic method.

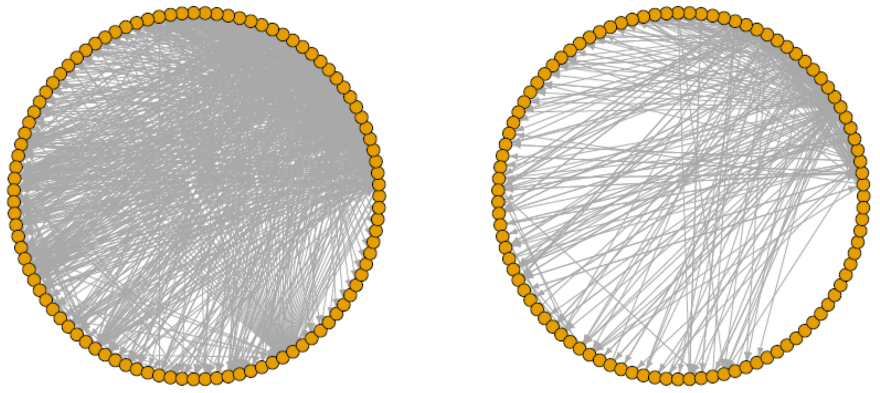
Bolivia. Results

Figure 9: Monthly Original and Validated Payments using Pólya Filter

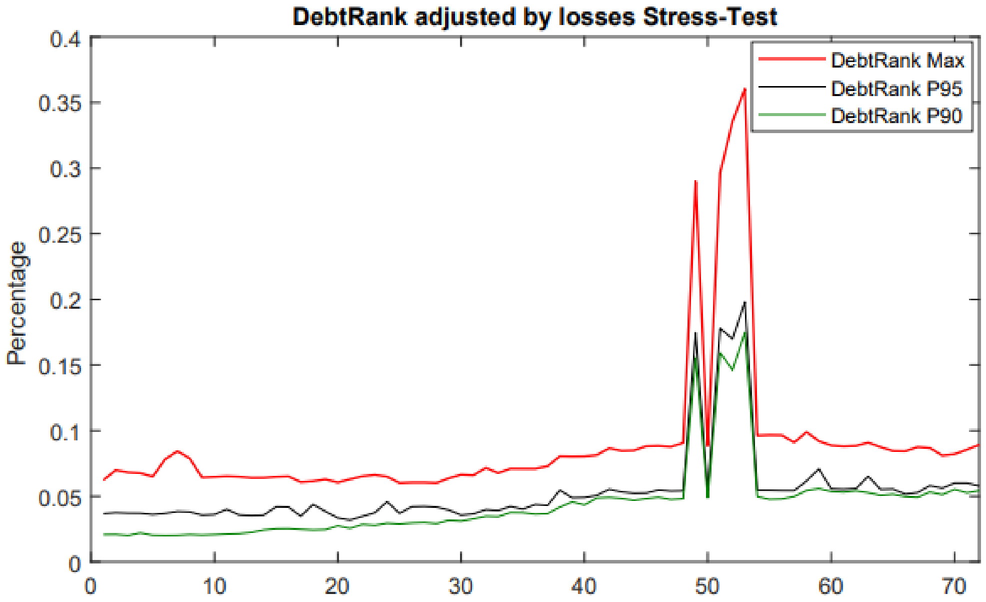


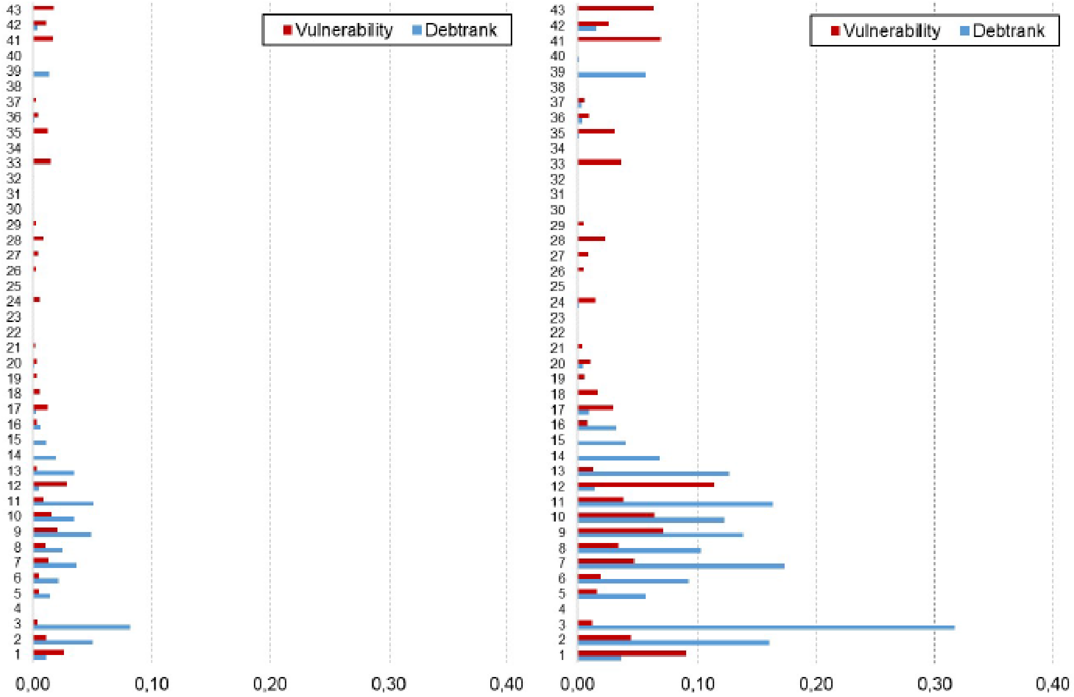
(a) Original August 2018 (b) Validated August 2018

Figure 11: Kobayashi approach
Original and Validated Payments



(a) Aggregated Payments (b) Validated with the 95% confidence level





(a) Period 38^{th} week 2019 (b) Period 41^{st} week 2019

Chile

Tiered Access in RTGS: a DLT-based approach

Musa, M., Morales-Resendiz, R., Tasca, P. (tbc)

July 2020

Abstract

Real Time Gross Settlement systems are the backbone of the financial system. It provides interbank funds transferring and are the prime vehicle to ensure short-term liquidity in financial markets, and they are also a key supporting infrastructure to other payment systems, including those in the retail domain. For years, central banks have owned and managed RTGS systems for strategic monetary and financial stability aims, which relates to access to central bank money, in other words, intraday (and overnight) credit. Fintech developments and the overall digitization of the economy has unveiled the need for central banks to review whether their RTGS access policy contributes to keep retail payments safe and efficient, given new entrants gaining prominent relevance. Such review involves risk and institutional constraints that central banks must also address. We explore how an RTGS operational architecture relying on Distributed Ledger technologies could enable a widened (tiered) access to RTGS account-services, especially for nonbanks, in the search of promoting fair and open competition in the retail domain.

1 Introduction

Real Time Gross Settlement (RTGS) systems embody the backbone of modern financial systems and are the core of other payment infrastructures. They provide a platform for the settlement of (wholesale) time-critical interbank funds transfers and are the prime vehicle for the central bank to ensure short-term liquidity transmission in financial markets. Over the years, central banks have achieved to contribute with the efficiency and safety of the overall domestic payment systems by continue reforming this systemically important payment infrastructure with last-generation technologies and policy developments.

In unison, new financial technologies and the overall digitization of the economy are transforming the economies of payments, especially in the retail domain. For instance, new entrants[1] are gaining presence as payment service providers (PSP) addressing specific market niches that have been poorly served by conventional PSP, say banks. Such PSP may sometimes operate without access to a retail payments infrastructure, posing perils for end-users -individuals and businesses- relying in payment instruments offered by such new entrants. According with the BIS[2], retail payments make up nearly 90 percent of the total volume of payments (i.e. number of transactions), yet less than 1 percent of the total value. Thus, retail payments are very relevant for the entire economy. Nonetheless, the payment infrastructures enabling retail transactions between individuals, businesses are relatively costly for end-users and PSP given the infrastructure

[1] Payment services providers (PSPs) other than banks, including licensed nonbanks and fintech entities (e.g. cross border currency platforms, P2P lending platforms, e-money issuers, etc.), mainly

[2] BIS Annual Report, 2020

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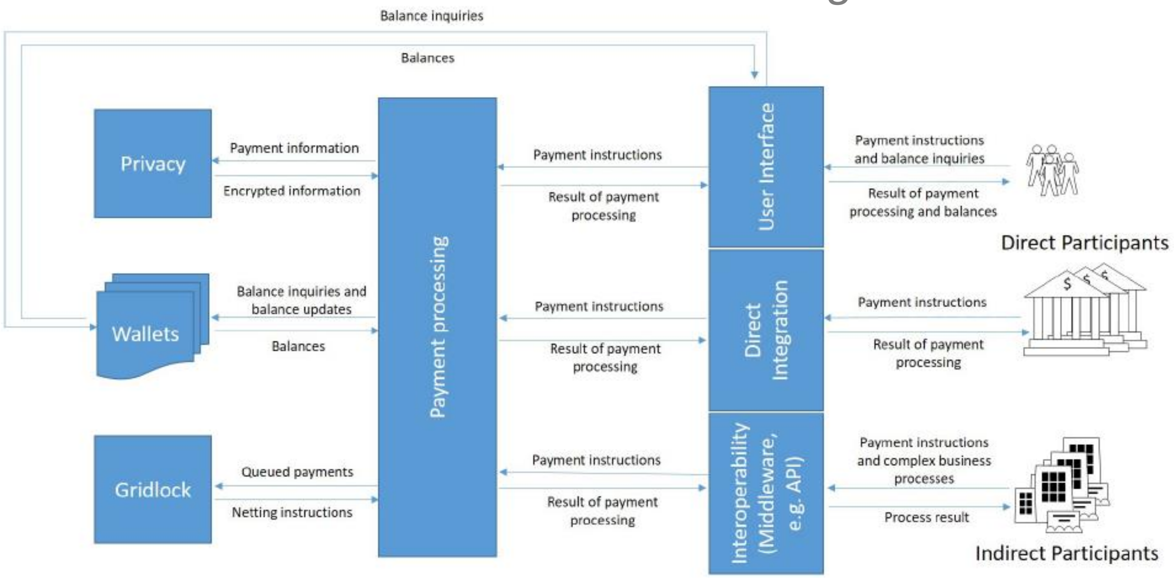
Chile. Motivation

- Fintech developments has unveiled the need for central banks to review whether their RTGS access policy contributes to keep retail payments safe and efficient, given new entrants gaining relevance.
  - CPMI-IOSCO Principles (2012) recommend that relevant actors should have a fair access to core payment infrastructures, under certain risk management conditions
- Distributed Ledger Technologies (DLT) could enable a widened (tiered) access to RTGS account-services, especially for nonbanks, in the search of promoting fair and open competition in the retail domain.
  - DLT have been extensively tested by central banks and the industry as a vehicle to enhance existing payment infrastructures.
- Our goal is very specific and subject to be explored further to conventional technology

Chile. Approach

- We de-structure the RTGS in the elements that could mostly contribute to competition (i.e. tiered access for nonbanks).
- We present DLT operational architecture options that could fit the purpose of providing a tiered access for nonbanks. This is accompanied by a (conceptual) performance analysis of competition indicators.
- We present a DLT-based operational architecture addressing the most relevant interactions of the RTGS elements, taking the competition indicators as well. *(to be completed)*

RTGS de-structuring



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Chile. Further steps

- Selecting the most suitable DLT architecture that meet the goal of wide access for non banks
  - Privacy
  - Processing rules
  - Legal framework
  - Interoperability
- Pinpointing issues which may not fit in the selected architecture
  - Cyber resilience and fraud risk
  - Scalability
  - Costs structure

DLT architecture options

		Option 1 Full DLT platform	Option 2 Private (nodes) and a DLT channel	Option 3 Decentralized applications
Protocol Layer	Consensus*	POW – POS - POA	RAFT – POA – BFT - POET	RAFT – POA - BFT – IBFT
	Smart contracts	Not applicable	Applicable *(Solidity – Kotlin)*	Applicable *(Solidity – Kotlin)*
	Privacy	Traditional Privacy enabled by Zero Coin Protocol	Multilateral Node Privacy enabled by Zero Knowledge Proofs	Scalable Zero Knowledge Proofs: Range Proofs – PLONK
	Tiered access	Direct access to a platform	Direct access to a node	Direct access through a DAPP
	Gridlock resolution	Off-chain/On-chain	Forks (On-Chain)/Off-Chain	DAPP functionality (On-Chain)/Off-Chain
	Interoperability**	Parallel chains	Side-Chain protocols	AZTEC-ERC-Ohers
Network Layer	Network	Permissioned / Hybrid	Permissioned / Hybrid	Permissioned / Hybrid
	Accounts and wallet design	1 account/wallet per direct/indirect participant	1 account/wallet per node (direct participant)	1 account per direct participant and one wallet per indirect participant
	Participants interface	Client wallet system / Server wallet system	Client wallet system / Server wallet system	Client wallet system / Server wallet system

Colombia I

Pattern recognition of financial institutions' payment behavior[☆]

Carlos León[a,d,e], Paolo Barucca[b], Oscar Acero[a], Gerardo Gage[c], Fabio Ortega[a]

Abstract

We present a general supervised methodology to represent the payment behavior of financial institutions starting from a database of transactions in the Colombian large-value payment system. The methodology learns a feedforward artificial neural network parameterization to represent the payment patterns through 113 features corresponding to financial institutions' contribution to payments, funding habits, payments timing, payments concentration, centrality in the payments network, and systemic impact due to failure to pay. The representation is then used to test the coherence of out-of-sample payment patterns of the same institution to its characteristic patterns. The performance is remarkable, with an out-of-sample classification error around three percent. The performance is robust to reductions in the number of features by unsupervised feature selection. Also, we test that network centrality and systemic impact features contribute to enhancing the performance of the methodology definitively. For financial authorities, this is the first step towards the automated detection of individual financial institutions' anomalous behavior in payment systems.

JEL Classification: C45, E42, G21

Colombia I. Motivation and Methodology

- In this work was used a supervised methodology that represented the payment behavior of individual institutions by using data from the Colombian large-value payment system.

- The methodology learns the payment patterns from each institutions through the implementation of a feed-forward neural network. The features learned corresponded to financial institutions' contribution to payments, funding habits, payments timing, payments concentration, centrality in the payments network and systemic impact due to failure to pay; leading to a dataset that consisted of 113 features.

- In order to test the robustness of the features and the methodology itself three different experiments were performed. The base experiment uses the full set of features and train and validates the neural network, then the next experiment repeat this procedure but excluded the network and simulation-based features to test its importance; third, with the aim to reduce dimensionality and data noise it was applied Principal Component Analysis before the training and validation of the neural network.

- The architecture of all the experiments consisted of one hidden layer, where its number of neurons was tuned during the training step. Once that the models were trained, its classification performance was tested with out-of-sample data.

Colombia I. Results

Full set of features Model

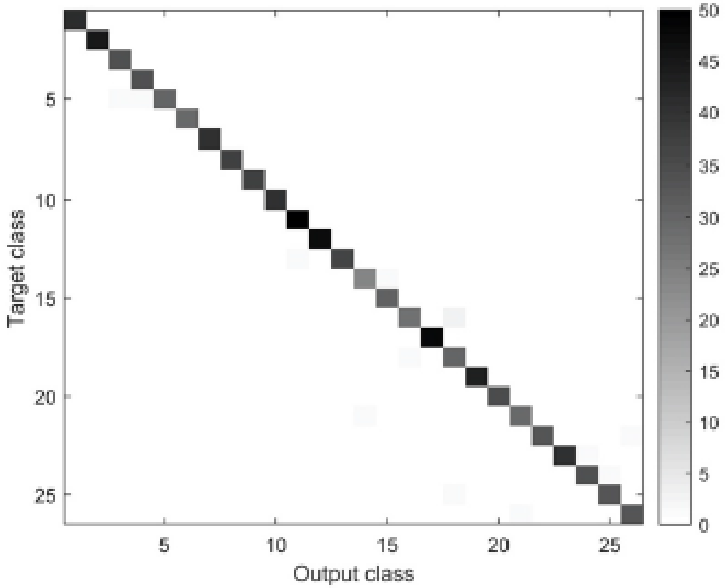
Set	Number of neurons in the hidden layer									
	20	30	40	50	60	70	80	**90**	100	110
Training	1.87 (4.60)	0.99 (0.52)	0.84 (0.41)	0.84 (0.38)	0.80 (0.37)	0.80 (0.82)	0.77 (0.36)	**0.74 (0.34)**	0.81 (0.46)	0.86 (0.85)
Validation	4.94 (4.47)	3.46 (0.69)	3.17 (0.63)	3.02 (0.60)	2.90 (0.62)	2.94 (0.95)	2.80 (0.55)	**2.64 (0.58)**	2.70 (0.65)	2.87 (1.07)
Test	5.20 (4.47)	3.65 (0.72)	3.37 (0.67)	3.25 (0.69)	3.08 (0.58)	2.96 (0.88)	2.88 (0.50)	**2.80 (0.50)**	2.89 (0.62)	3.07 (1.18)

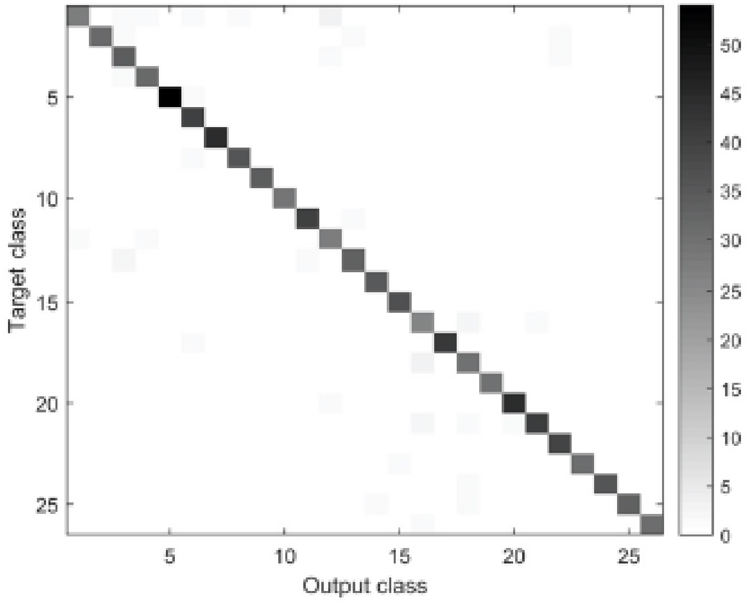
Network and simulation-based features excluded Model

Set	Number of neurons in the hidden layer									
	20	30	40	50	60	70	**80**	90	100	110
Training	2.11 (0.93)	1.49 (0.65)	1.21 (0.51)	1.30 (0.98)	1.10 (0.42)	1.03 (0.43)	**1.09 (0.41)**	1.07 (0.40)	1.08 (0.46)	1.13 (0.73)
Validation	5.76 (1.16)	4.70 (0.79)	4.10 (0.60)	3.94 (1.15)	3.74 (0.66)	3.60 (0.68)	**3.67 (0.64)**	3.57 (0.72)	3.53 (0.83)	3.60 (0.89)
Test	6.00 (1.25)	4.65 (0.72)	4.19 (0.77)	4.15 (1.18)	3.81 (0.61)	3.84 (0.67)	**3.61 (0.57)**	3.71 (0.64)	3.66 (0.72)	3.79 (0.92)

PCA denoising Model

Set	Number of neurons in the hidden layer									
	20	30	40	50	60	70	80	**90**	100	110
Training	4.30 (0.88)	3.73 (0.83)	3.72 (0.67)	3.62 (0.69)	3.39 (0.71)	3.36 (0.68)	3.34 (0.61)	**3.38 (0.61)**	3.32 (0.70)	3.31 (0.68)
Validation	7.05 (0.99)	6.61 (0.88)	6.32 (0.96)	6.16 (0.85)	6.03 (0.75)	5.99 (0.75)	5.80 (0.78)	**5.94 (0.74)**	5.70 (0.79)	5.79 (0.78)
Test	7.52 (0.88)	6.85 (0.76)	6.45 (0.81)	6.25 (0.76)	6.22 (0.84)	6.13 (0.73)	6.05 (0.75)	**6.19 (0.80)**	5.99 (0.85)	6.03 (0.83)





Colombia II

Measuring systemic risk for bank credit networks*

Eduardo Yanquen, Giacomo Livan, Serafin Martinez-Jaramillo,
Daniel E. Osorio and Ricardo Montanez

Abstract

Systemic risk analysis became a very important undertaking in most central banks after the Global Financial Crisis (GFC). This paper describes the Colombian credit system as a bipartite network of lenders and borrowers. We are interested on perform network validation to identify a backbone of links that are statistically significant due to their size (capital) and the characteristics of the lenders and borrowers involved. We used the information contained in these links to perform a prediction exercise. Validated backbones typically contain most of the information in a network and are rather stable over time. Additionally, we also perform a systemic risk study based on the DebtRank centrality metric to uncover the systemic risk profile of the Colombian banking system taking into account their commercial loans, consumer loans and mortgages.

1 Introduction

Within the vast literature on financial contagion and network models (see Martinez-Jaramillo et al. (2019) for an introduction), in our opinion, there has been less work done in two important aspects: the first one is the statistical validation of the networks used to perform contagion studies, and second, a lot of attention has been paid to networks which include other players than banks.

The main contribution of this work is the computation of a systemic risk metric for the Colombian banking system and the firms that have credits with such banks. The interesting results come from the usage of detailed credit registry information including commercial, consumer loans and mortgages.

Financial contagion through the interbank market has been well studied. However, less has been done to include information on banks' loans portfolios. In the current situation in which banks will face a likely increase on default rates, it is more important than ever to study possible systemic implications and to use the network information available at central banks.

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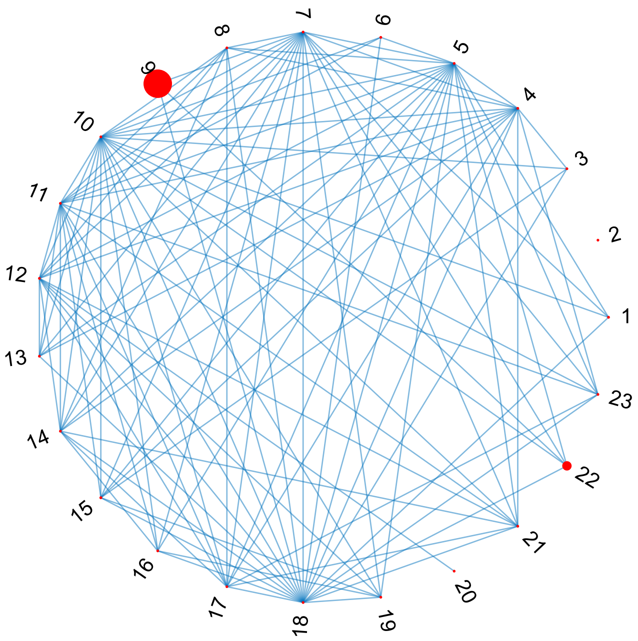
Colombia II. Methodology

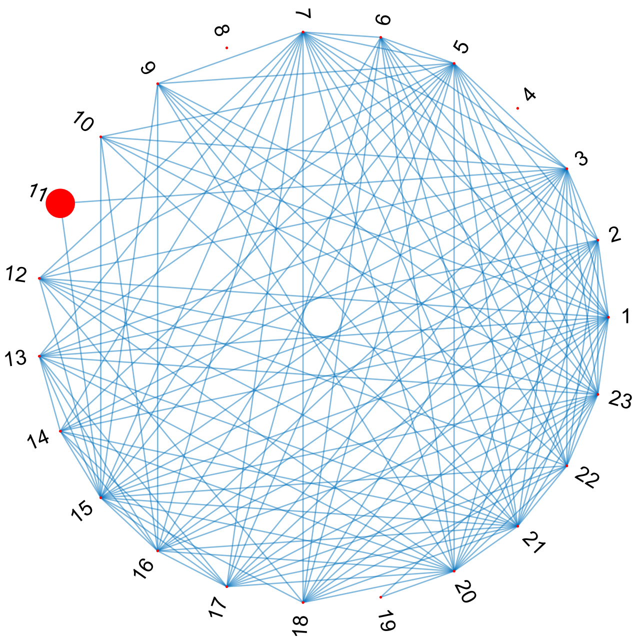
- We analyze the exposures network of the banks and their counterparties that stems from the quarterly regulatory information from the supervisory institutions and the Central Bank of Colombia.
- The relationships among banks include unsecured interbank loans and repos. The relationships between banks and firms include information from different lines of business, such as commercial, microcredits and mortgages.
- We consider the DebtRank methodology for the systemic risk analysis, which relies on equity.
- Since equity cannot be always obtained for all the potential nodes in the network, mostly on the firms side, we are exploring alternative methods that rely only on the structure of the banks-firms bipartite network for the analysis of impact and vulnerability of such agents.
- We are also considering the methodology to quantify the significance of the loans within the network to identify relevant relationships among institutions.

Colombia II. Preliminary results

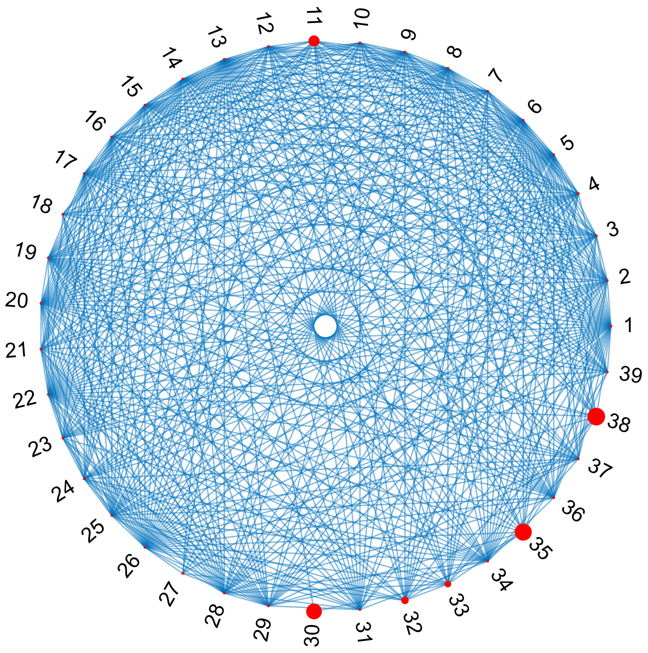
Projection of banks - Mortgage



Projection of banks - Microcredits



Projection of banks - Commercial



Each node of the graph represent a bank, and an edge between nodes means that both banks share at least one common firm in the corresponding sector. The size of the vertices represent the vulnerability of the bank within the network.

Colombia II. Expected Contributions

- We will provide the groundwork for the identification of systemically relevant institutions for the Colombian financial system from a credit risk view, with a strong consideration on the construction of the interbank and the bank-firm relations and for the institutions for which the DebtRank methodology is applicable, by producing the impact, vulnerability, dependency and another relevant metrics.

- We will complement the analysis for the induced networks in which the DebtRank is not applicable. We also expect to describe the cautions regarding the alternative methodology to DebtRank, so we can help anticipate any pitfalls or shortcomings in further implementations. If possible, we expect to build on the methodology to overcome those issues.

- We will report the analysis on the filtered network with relevant information and the comparison with the original network. For some cases, due to the volume of information, it would be important to reduce the volume of arcs for computational purposes.

Ecuador

Classifying payment patterns with artificial neural networks: an autoencoder approach

Jeniffer Rubio, Paolo Barucca, Gerardo Gage, John Arroyo and Raúl Morales-Resendiz

Abstract

Payments and market infrastructures are the backbone of modern financial systems and play a key role in the economy. One of their main goals is to concentrate and manage risks, especially in the case of systemically important payment systems (SIPS) serving interbank funds transferring. We develop an autoencoder for the *Sistema de Pagos Interbancarios* (SPI) of Ecuador to detect anomalies, similar to Triepels-Daniels-Heijmans (2018) and Sabetti-Heijmans (2020). We train three different autoencoder models using daily data structured in three time-intervals for SPI settlement activity to reconstruct its related payments network. We introduce bank run simulations in our models to feature a baseline scenario to identify relevant autoencoder parametrizations for anomalies detection.

The main contribution of our work is training an autoencoder to detect a wide range of anomalies in a payment system, ranging from ~~the~~ unusual behavior of individual banks, both large and medium size, to systemic changes in the overall structure of the payments network. Our work highlights that these novel techniques are robust enough to support payments' and market infrastructures' oversight, and ultimately to monitor financial stability.

Ecuador. Motivation and Methodology

- For this case an oversight tool was developed where the methodology aimed at detecting anomalous behavior within the network of payments generated from its payments system, Sistema de Pagos Interbancarios.

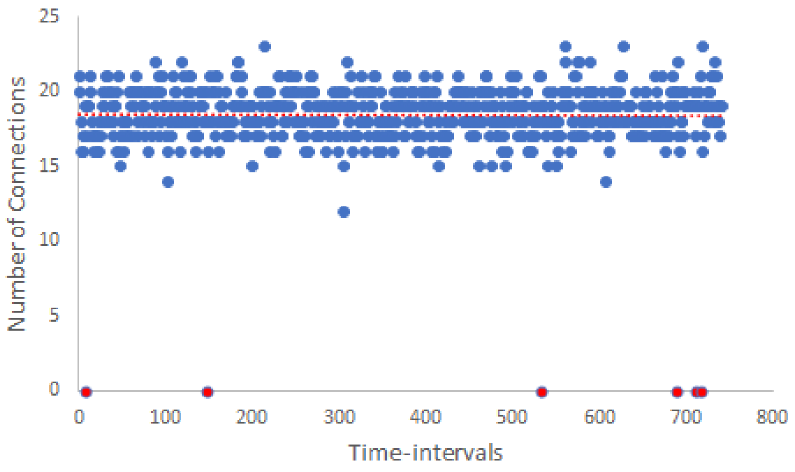
- The technique implemented for this work was the autoencoder, which is an unsupervised feed forward neural network that has as objective the reconstruction of the data that is fed into it

- The first step that follows the autoencoder is the projection of the data to a lower dimension, which leads to the learning of the most important features; then the autoencoder follows a reverse process to reconstruct back the original information. This procedure allows us to label poor quality reconstructions as anomalies, given that this indicates an unseen behavior.

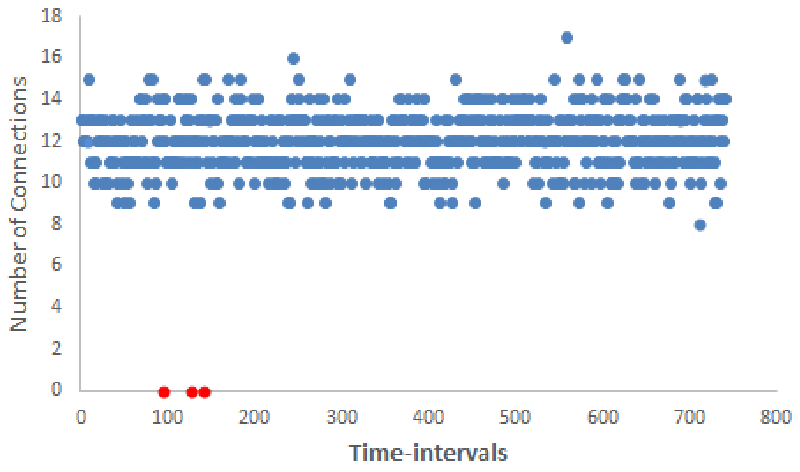
- Before the training of the autoencoder a preprocessing of the data was performed through a log transformation followed by a min-max standardization with the purpose to reduce the skewness of the payments flows and the leverage of the features.

Ecuador. Results

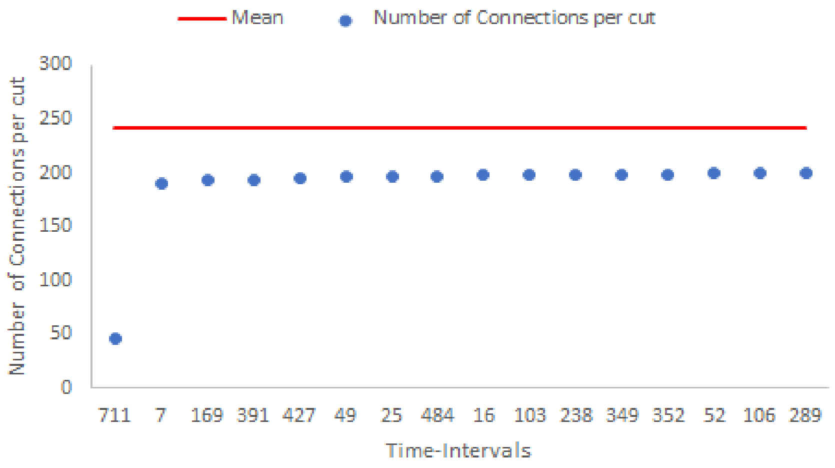
Large-size bank alerts



Medium-size bank alerts



Systemic alerts



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El Salvador

Identifying clusters of anomalous payments in the Salvadorian payments system

Franklim Arevalo, Paolo Barucca, Gerardo Gage, William Rodriguez

Abstract

The automated detection of anomalous patterns in payment systems allows central banks and other supervisory authorities to identify potentially fraudulent transactions, cyber attacks and unexpected behavioral changes from market participants. There is however a limited experience using automated machine learning methods to detect anomalous behavior in payment systems.

In this paper, we present an unsupervised methodology to classify payments into clusters and with that provide a tool to single out anomalies. We apply the methodology in a dataset from the El Salvador payment system, using unlabeled payment data. The methodology is found to be able to identify small clusters based on a minimal set of network features. These features are fed into a k-means clustering algorithm which returns a set of clusters of transactions. Finally, we analyse the statistical distribution of features across clusters, we compute the similarity of the clusterings we obtain from different methodologies, and provide a detailed analysis of the smallest identified clusters.

El Salvador. Motivation and Methodology

- A methodology was developed that under an unsupervised approach classifies payments from the Salvadorian RTGS system into clusters. It was found that the methodology is able to identify clusters where the payments contained can be classified as anomalous based on a set of minimal network features.

- In order to get meaning from the original data it were constructed features of two different types; one hot encoding (OHE) features, which captures the interactions between the RTGS system participants', and network features, which are intended to show properties that the complete payments network pose.

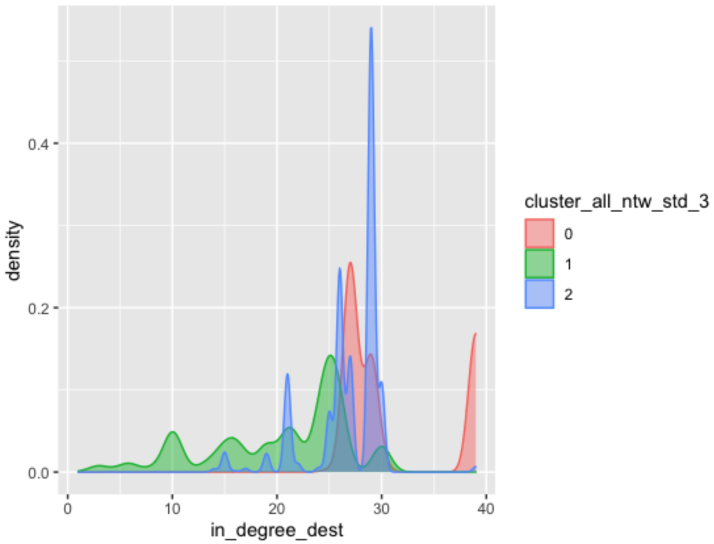
- After the creation of the above-mentioned features different models were trained by varying the set of features studied (OHE, network features or both). For the case of OHE features and all features, given its high dimensionality, it was decided to perform PCA to reduce the noise of the data.

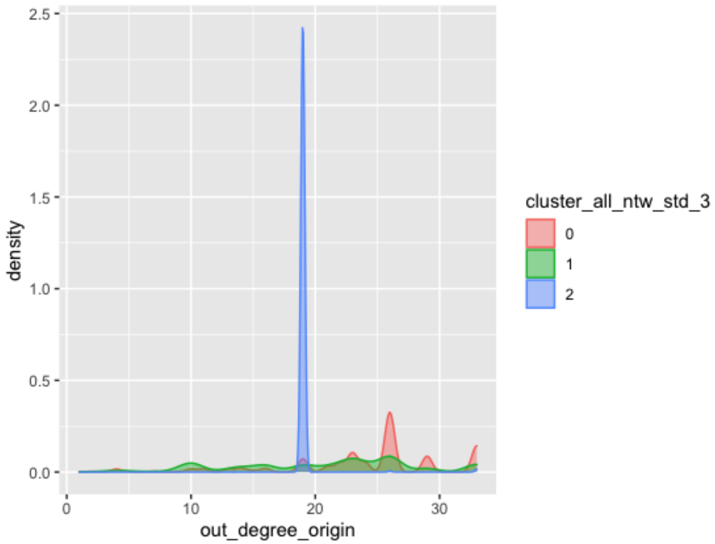
- The last step of the methodology consisted on the clustering of the payments which was done by implementing K-Means. Finally, the clusters obtained for the different models were compared and the payments inside them were analyzed.

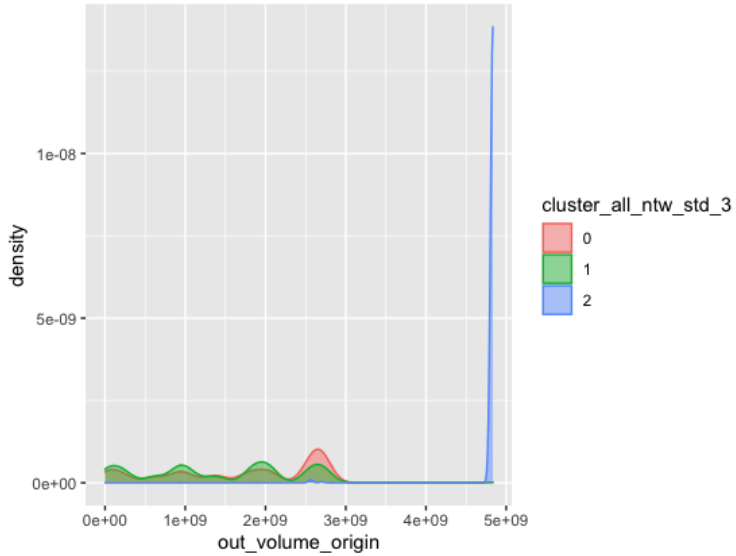
El Salvador. Results

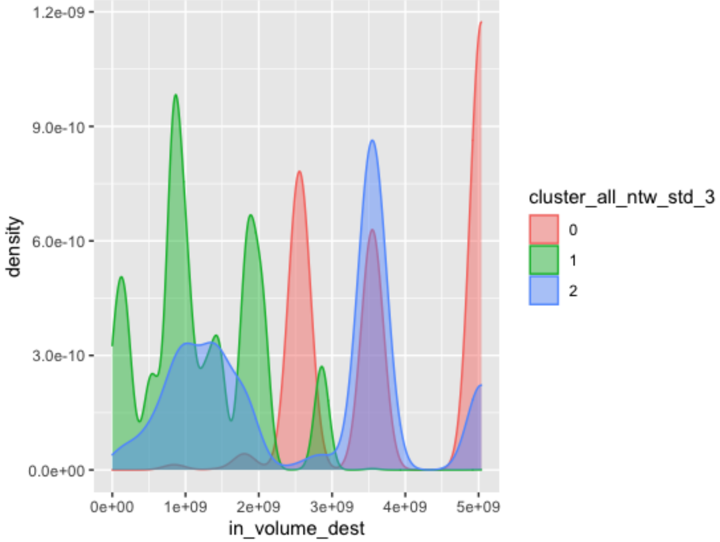
Rand Index table

Models	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Model 1	**1.00**	-0.06	0.19	0.19	0.33	0.19
Model 2	-0.06	**1.00**	0.37	0.37	0.27	0.39
Model 3	0.19	0.37	**1.00**	0.98	0.38	0.96
Model 4	0.19	0.37	0.98	**1.00**	0.39	0.96
Model 5	0.33	0.27	0.38	0.39	**1.00**	0.38
Model 6	0.19	0.39	0.96	0.96	0.38	**1.00**









Peru

A network characterization of the interbank exposures in Peru and systemic risk measurement*

Walter Cuba, Anahi Rodriguez-Martinez, Diego A. Chavez, Fabio Caccioli and Serafin Martinez-Jaramillo

Abstract

After the Global Financial Crisis (GFC) systemic risk measurement became very important for policy makers as well as for academics. We have witnessed an important increase in the number of papers and methodologies proposed. Among such proposals DebtRank arose as a relevant one, as it resorts to network modeling and captures the all important aspect of interconnectedness in the financial system. Additionally, within the network modeling approach, there is the multilayer approach which provides us with additional insights on the decomposition of systemic risk. In this paper we resort to a multilayer network analysis for studying systemic risk in the Peruvian banking system by resorting to DebtRank centrality. The main contributions of this work are: i) we are able to fully characterize the multilayer exposures network of the Peruvian banking system, and ii) we obtain the systemic risk profile of the banking system by different types of exposures.

1 Introduction

After the Global Financial Crisis (GFC) it became very clear that systemic risk measurement was an urgent need. Methodologically speaking, there was an important gap between the risk models developed until then and the models needed to deal with and understand the crisis. This was also true of the regulatory framework, as it became evident that regulation focused on the financial system as a whole was badly needed. Moreover, the identification of systemically important banks (SIBs) became a priority in many jurisdictions. The same happened with non-bank financial intermediaries, also known as Systemically Important Financial Institutions (SIFIs).

The risk of contagion in the interbank market is a key component of systemic risk in any financial system (Bank for International Settlements, 2014). With this in mind, it is imperative to quantify systemic risk and systemic relevance to design adequate regulation and for financial stability monitoring purposes. In Peru, the first attempt to define systemic relevance was made in July 2011, (Espino and Rabanal (2011)); however, only the size component was considered without taking into account the crucial aspect of interconnectedness.

One of the most important aspects that the GFC revealed is the high level of interconnectedness in the financial system. After the GFC, a surge of works on financial networks and contagion using the unsecured interbank lending market took place (Battiston and Martinez-Jaramillo (2018)). However, many of the empirical papers at the time showed little contagion

*Disclaimer: Any errors made in this paper are the sole responsibility of the authors. The authors' views do not necessarily reflect those of Banco Central de Reserva del Peru, Banco de Mexico or CEMLA.

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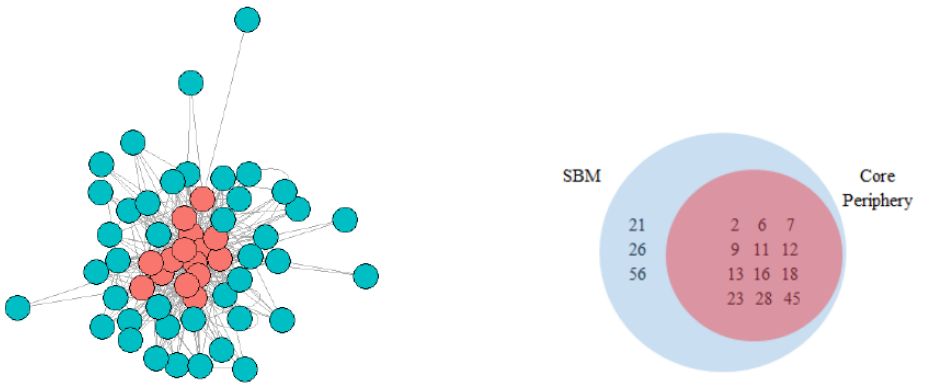
Peru. Background and Methodology

- We analyze the multiplex structure of interbank exposures of the Peruvian banking system, including structural and centrality metrics, as well as the DebtRank systemic risk indicator for the quantification of the systemic importance of financial institutions.
- We use daily data of short-term unsecured exposures network to analyze the network in Peru using structural and centrality metrics.
- The multilayer approach provides us with additional insights on the decomposition of systemic risk. For this analysis we use monthly data for short-term and long-term credit, demand deposits, term deposits, cross-holding of securities and derivatives.
- We use Stochastic Block Model to identify communities of banks.
- Finally, we analyze the impact and vulnerability of banks and their relation between them.

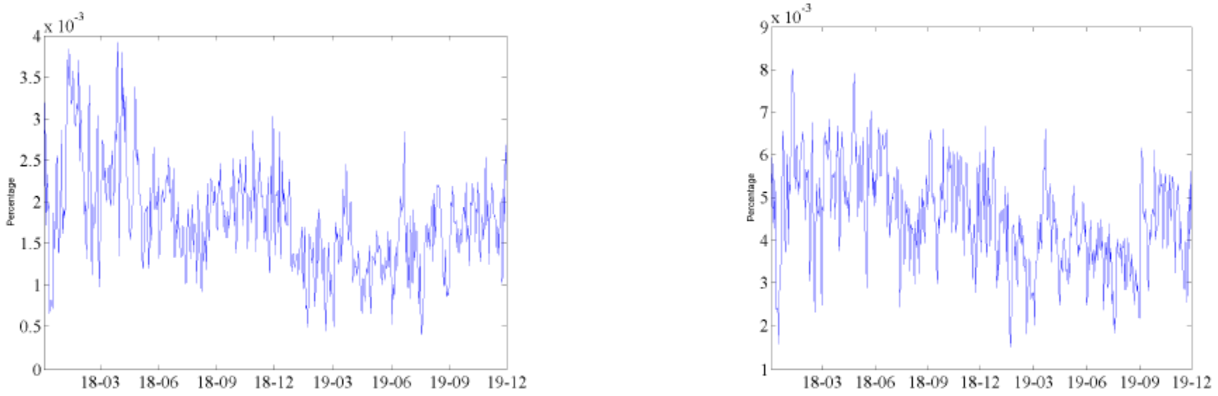
Peru. Results

Figure 13: Stochastic Block Model



(a) All layers network by cluster (b) Similarity with core-periphery model

Figure 16: Daily DebtRank



(a) Average DebtRank (b) Average Vulnerability

Figure 17: Multilayer DebtRank for multiple dates

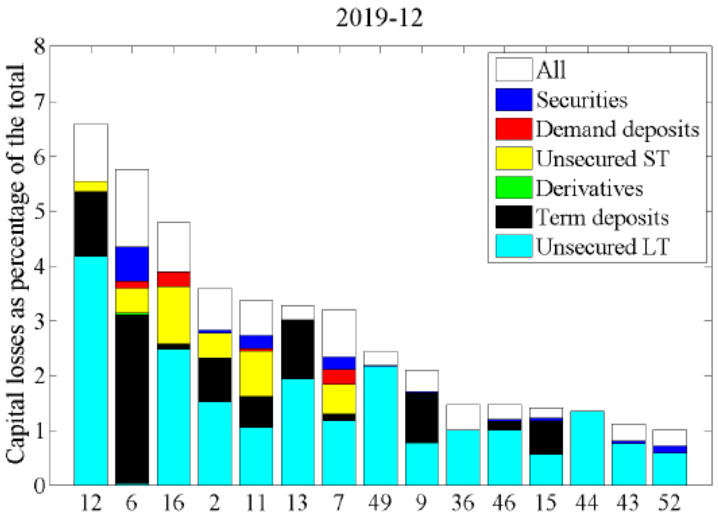
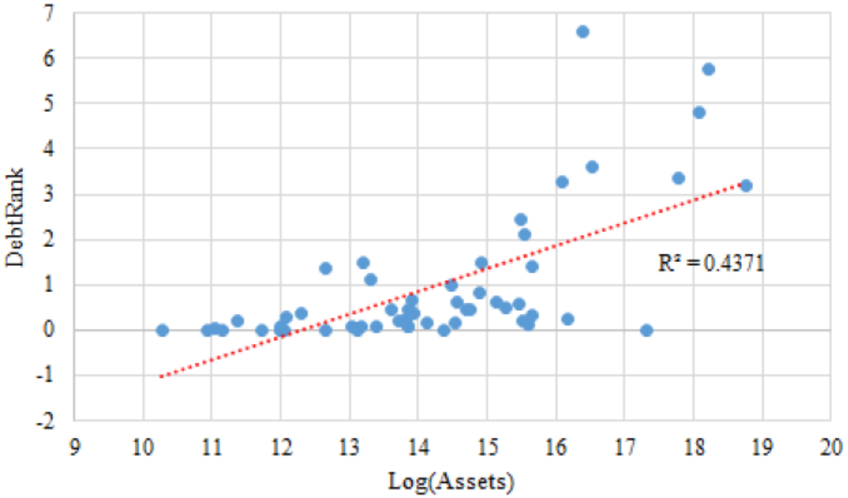


Figure 20: DebtRank vs Assets



Uruguay I

Credit risk and its systemic effects*

Victoria Landaberry, Fabio Caccioli, Anahi Rodriguez-Martinez, Andrea Baron, Serafin Martinez-Jaramillo and Rodrigo Lluberas

Abstract

Interconnectedness among financial institutions has been recognized as one of the most important factors for the amplification of the Global Financial Crisis (GFC). Since then, many different research approaches have been developed in order to study systemic risk and its relationship with interconnectedness. In this work, we propose to use a systemic risk metric for an extended network which includes the interbank network, the banks-firms bipartite network and the intra-firm exposures network in Uruguay. This is one of the first works, to the best of our knowledge, in which the intra-firm exposures network is estimated with such an accuracy by using information from a firm survey and is used for the computation of a systemic risk metric. Given that the survey only asks for the three most relevant debtors and creditors, we have to complete the full intra-firm exposures matrix by resorting to two well-known methods: the Maximum entropy and the Minimum Density; additionally, we use an additional method which takes into account the known entries of the matrix obtained from the survey. Our results show an important under-estimation of systemic risk if the information of intra-firm exposures is ignored. Moreover, even if the marginal liabilities or assets are used as an indicator of systemic importance for firms is used, important network effects are ignored. The paper has several contributions among which the most important one is the precise estimation of the contribution of intra-firm exposures to the overall systemic risk.

1 Introduction

The increasingly complex and interrelated connections in the financial system are considered to be one of the main sources of risk amplification and propagation of shocks. This was made evident in the worst possible way during the GFC after the fall of Lehman Brothers.

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We would like to acknowledge and special thanks to Ricardo Montañez for his important contribution and support in the develop of this paper.

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Uruguay I. Background and Methodology

- We use a systemic risk metric for an extended network which includes the interbank network, the banks-firms bipartite network and the intra-firm exposures network in Uruguay.
- This is one of the first works, in which the intra-firm exposures network is estimated with such an accuracy by using information from a firm survey and is used for the computation of a systemic risk metric.
- The firm level survey conducted to 240 Uruguayan firms by the Central Bank of Uruguay in October 2018 contains information for the three most relevant debtors and creditors, we have to complete the full intra-firm exposures matrix by resorting to two well-known methods: the Maximum entropy and the Minimum Density.
- Additionally, we use a reconstruction method and a fitness model which takes into account the known entries of the matrix obtained from the survey, then we assign weights to the links using the RAS algorithm.
- We build a network of effective exposures of banks towards firms. We could perform a stress test on the bipartite network of effective exposures, for instance projecting the network and using DebtRank.

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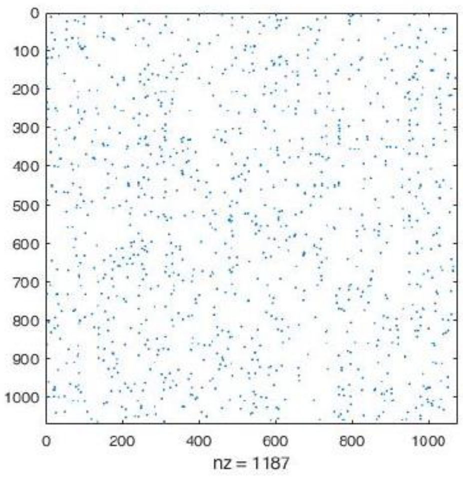
Uruguay I. Results

Figure 7: Survey matrix



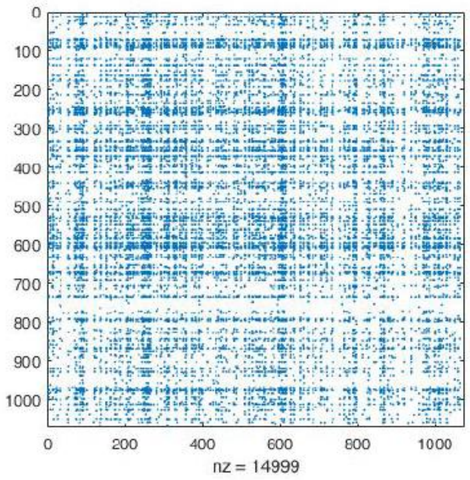


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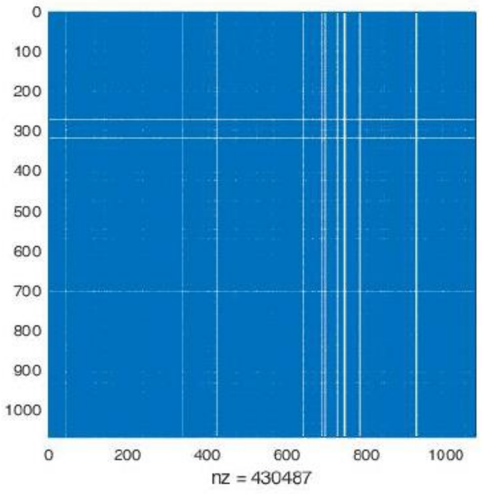
Figure 8: RAS matrix

Figure 9: Maximum entropy matrix



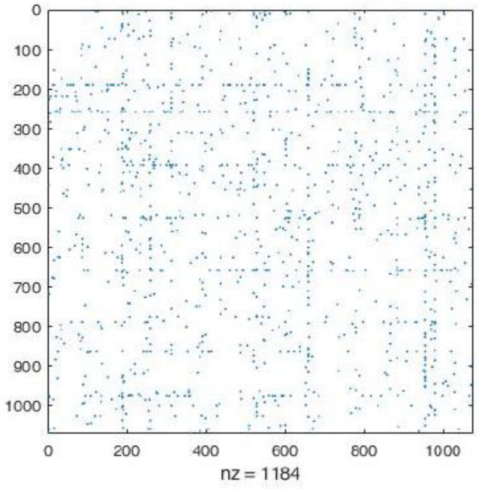


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Figure 10: Minimum density matrix

Figure 11: Intersection RAS, Survey and Anand matrix

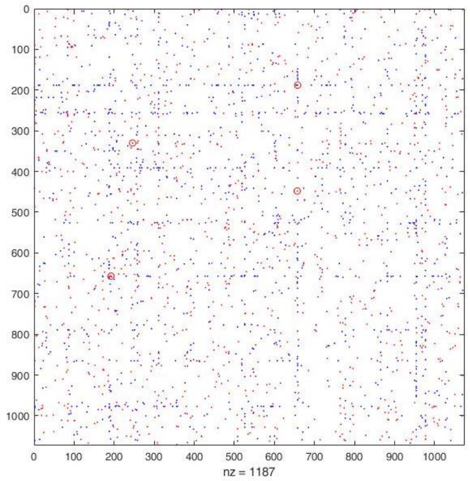
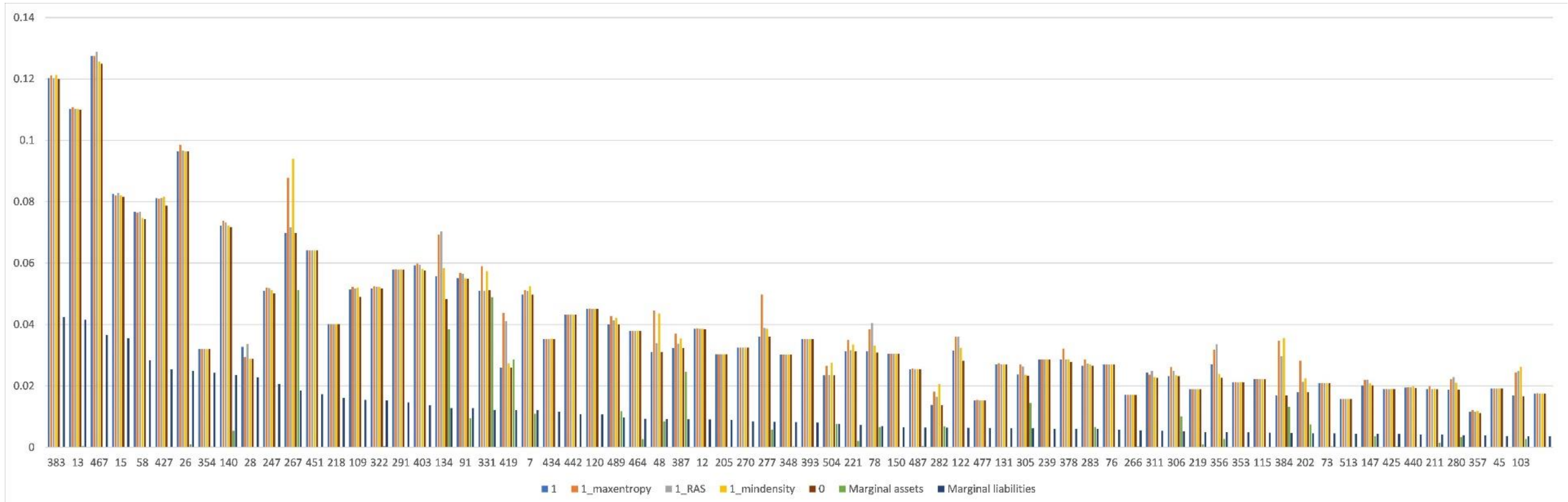


Figure 21: Ranking by Marginal Liabilities



Uruguay II

Price rigidity, sales, and the business cycle: a time series principal component analysis*

Fernando Borraz[†] Giacomo Livan[‡] Anahí Rodríguez-Martínez[§]

Pablo Picardo[¶]

Abstract

It is often argued that sales are a channel for price flexibility. Firms can use them to change effective prices keeping sticky reference prices. We use a rich database of retail prices from Uruguay to characterize prices' flexibility, the behavior of sales, and their relationship with local market conditions like labor market indicators. We find a positive and significant relationship between sales and unemployment. We also perform a time series principal component analysis to study these relationships. Results show that all product sectors share a common correlation structure and the highest correlation and significance is achieved between employment variation and the first principal component, mostly in the second week of the following month.

Keywords: price rigidity, sales, unemployment, principal component analysis

JEL classification codes: E31, E32, E24, C38

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Uruguay II . Methodology

- We use a rich database of retail prices from Uruguay to characterize prices' flexibility, the behavior of sales, and their relationship with local market conditions like labor market indicators.

- The database is a weekly panel that includes prices of 23,902 products from August 5th, 2014 to December 25th, 2019. It is updated on a regular weekly basis and it can also be scraped through the supermarket website. The categories are: food, fruits and vegetables, drinks, drinks with alcohol, cleaning products, personal care, tobacco and other products.

- First, we use a fixed effect panel regression to analyze the relationship between sales and unemployment. We find a positive and significant relationship between sales and unemployment.

- As the economy worsens with increases in unemployment, the supermarket uses sales to a greater extent as a mechanism for price flexibility and to stimulate revenue in a negative scenario.

- We also estimate the same panel regression but with the price change probability as the dependent variables (instead of the sale probability). We find a negative and significant relationship between the probability of price change and unemployment. This result indicates that price change becomes infrequent in the worst stage of the business cycle.

Uruguay II . Results

Table 1: Regression for the sale probability with product and time fixed effects

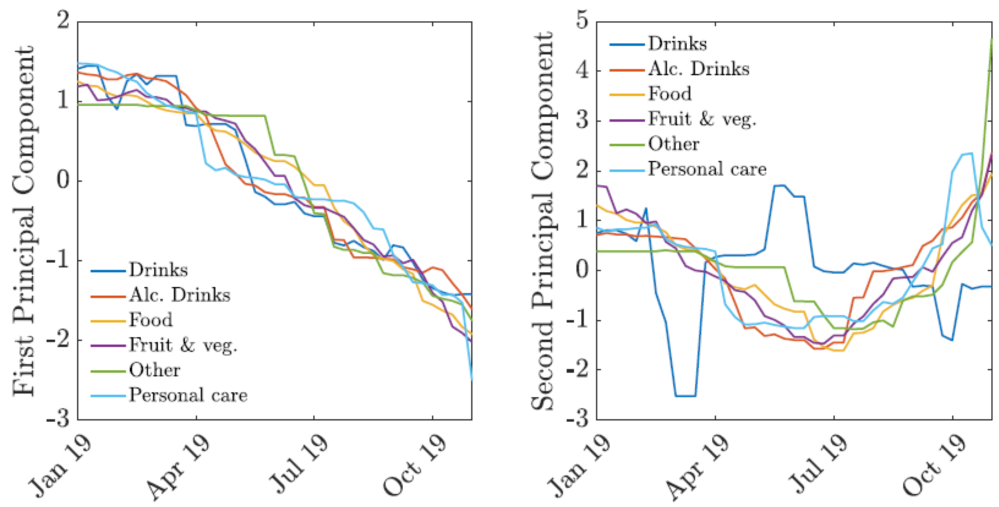
	Dependent variable:
	Probability of being on sale
Unemployment	0.006***
	(0.001)
Observations	685,343
R^2	0.279
Adjusted R^2	0.253
Residual Std. Error	0.184 (df = 661377)
Controls:	FE (products & time), clustered errors at product & time level
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 2: Regression for the price change probability with product and time fixed effects

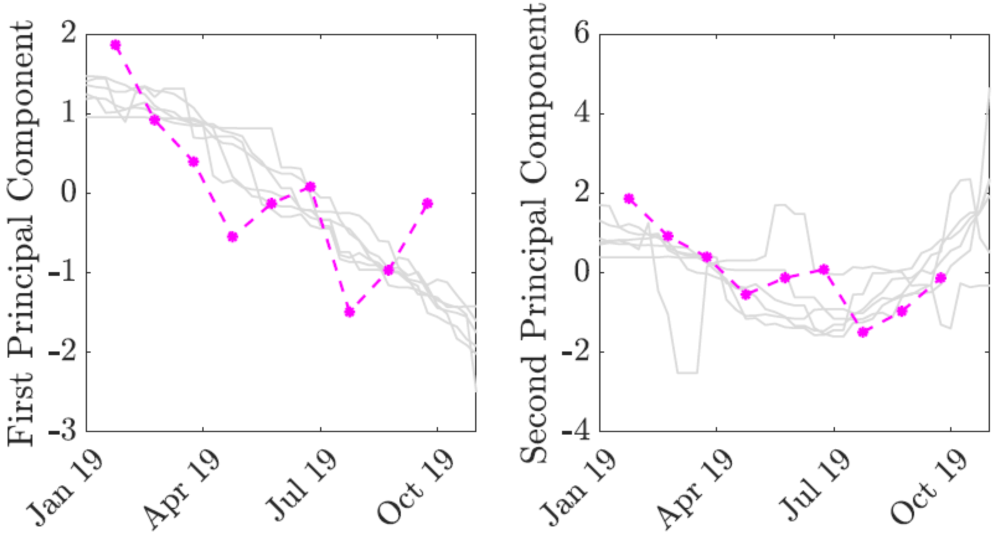
	Dependent variable:	
	Probability of price change	
	All products	Without sales
Unemployment	−0.009***	−0.010***
	(0.0003)	(0.0003)
Observations	685,343	668,624
R^2	0.176	0.154
Adjusted R^2	0.146	0.123
Residual Std. Error	0.107 (df = 661377)	0.124 (df = 644938)

Controls: FE (products & time), clustered errors at the product & time level
Note: *p<0.1; **p<0.05; ***p<0.01

1st and 2nd PCs



PCs and employment



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Working Groups on Central Bank Digital Currencies and Fintech Data Gaps

Working Group on CBDC

- The aim of this group was to deepen in practical experience, design and technology, around Central Bank Digital Currencies (CBDC), to better understand how a central bank must proceed, if. The jurisdictions that participated were **Bahamas, Chile, Colombia, Eastern Caribbean, Ecuador, Jamaica, Perú, Uruguay and Sweden**.

- A Peer Review of CBDC pilots in LAC central banks was conducted having as objective drawing lessons on what technology and an implementation plan implies when rehearsing a CBDC system in a controlled environment.

- The Peer Review summarizes the main findings of pilots from Bahamas, Sweden and Uruguay, with mainly a focus on aspects of design (technological) and implementation (operational).

- The WG identifies key insights on design and implementation of a retail CBDC.

Working Group on Fintech Data Gaps

- The aiming of this group is to identify and evaluate the main problems faced by Central Banks for data collection in Fintech activities and to identify best practices and recommendations. The jurisdictions that participate are: **Brazil, Chile, Costa Rica, El Salvador, Honduras, Jamaica, Mexico, Trinidad and Tobago and Spain**.

- The Fintech industry is still behind the banking sector, but it may have the potential to move credit intermediation away from commercial banks and placed it into institutions that are currently less supervised. For this reason it´s needed to define a framework with the purpose to provide relevant information for central banks about this growing sector.

- The policy report generated provided an overview on the main issues that central banks faces towards including Fintech activities in the regular statistics. The group also revised:
  - Implications on data gaps in areas as monetary policy, financial stability payment systems and economic activity.
  - Implications related to the activity of Bigtechs companies and cybersecurity issues.

- The IFC survey "Central Banks and Fintech Data" was applied to the LAC countries in order to shed light on the current position and developments of regional central Banks regarding Fintech data.

Innovation Hub academic activities 2020 -2021

Innovation Hub academic activities in 2020

- Course on Financial Technologies and Central Banking, from 18-20 February, 2020 in Kingston Jamaica.
- III Fintech Forum Meeting, from 18-20 August, 2020.
- Course on RegTech and SupTech from 24 – 28 August 2020.
- Policy Implementation Meeting on Cyber resilience, 3 and 4 November, 2020.
- Course on Machine Learning for Central Banking, from 9-13 November 2020.
- Course on Distributed Ledger and Blockchain Technologies for Central Banking, from 30 November to 4 December, 2020. Four use cases will be developed.

Forthcoming activities

- II Course on Distributed Ledger and Blockchain Technologies for Central Banking, late September 2021.
- II Course on Machine Learning for Central Banking, dates to be confirmed.
- Course on Financial Technologies and Central Banking, November 2021. **New Call for Proposals**.
- Workshop on Cybersecurity, November 2021.

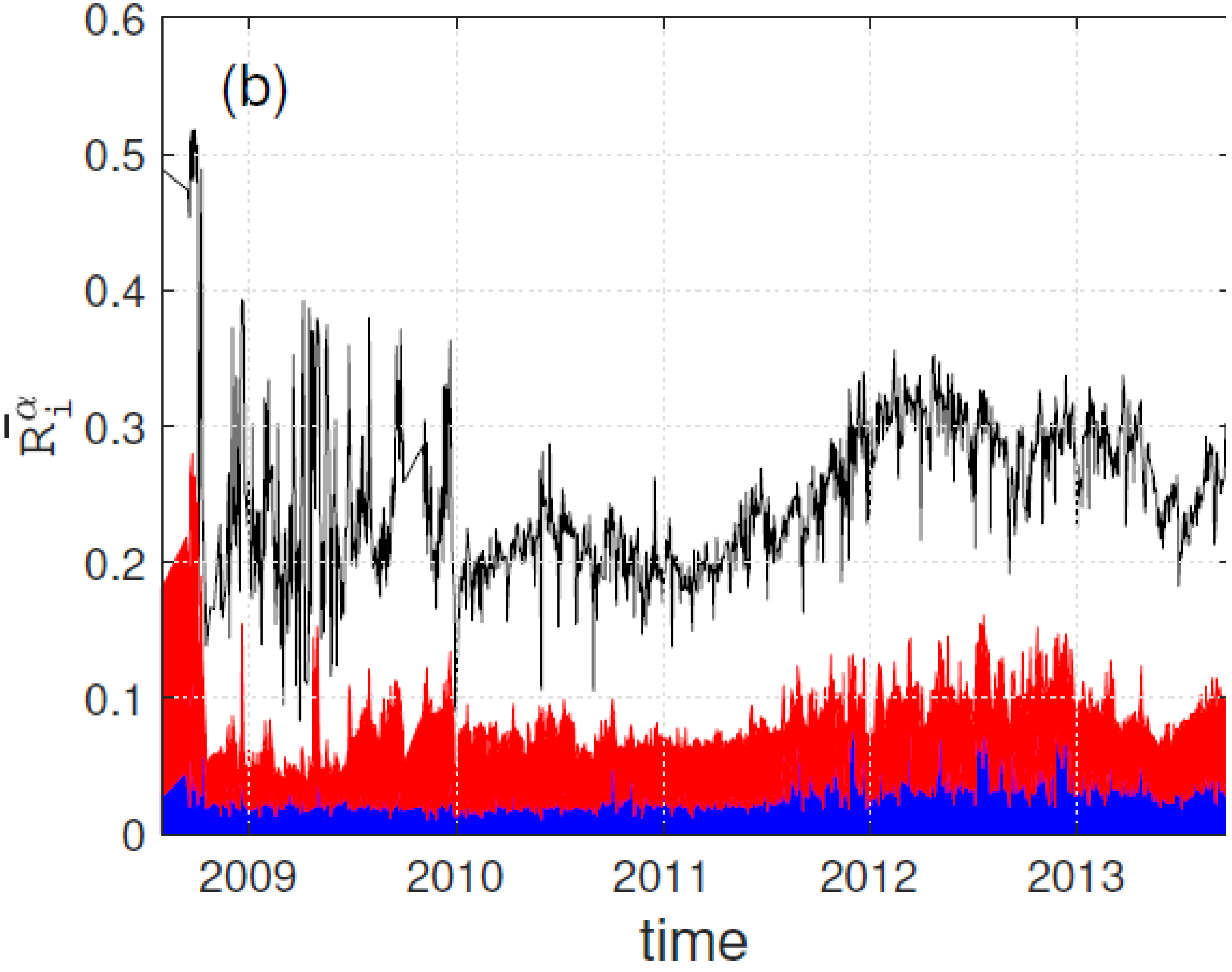
Financial Stability related activities 2020 -2021

Financial Stability Activities 2020-2021

- II Course on Financial Stability, digital format , 16 -20 November, 2020.
- Workshop Climate Risk and the Financial System, digital format, 8, 10 and 15 December, 2020.

- XI Meeting of Heads of Financial Stability, September 2021.
- III Course on Financial Stability, November 2021.
- Conference on Financial Stability, 2021.

Time series for the average DebtRank from 31 July 2008 to 30 September 2013



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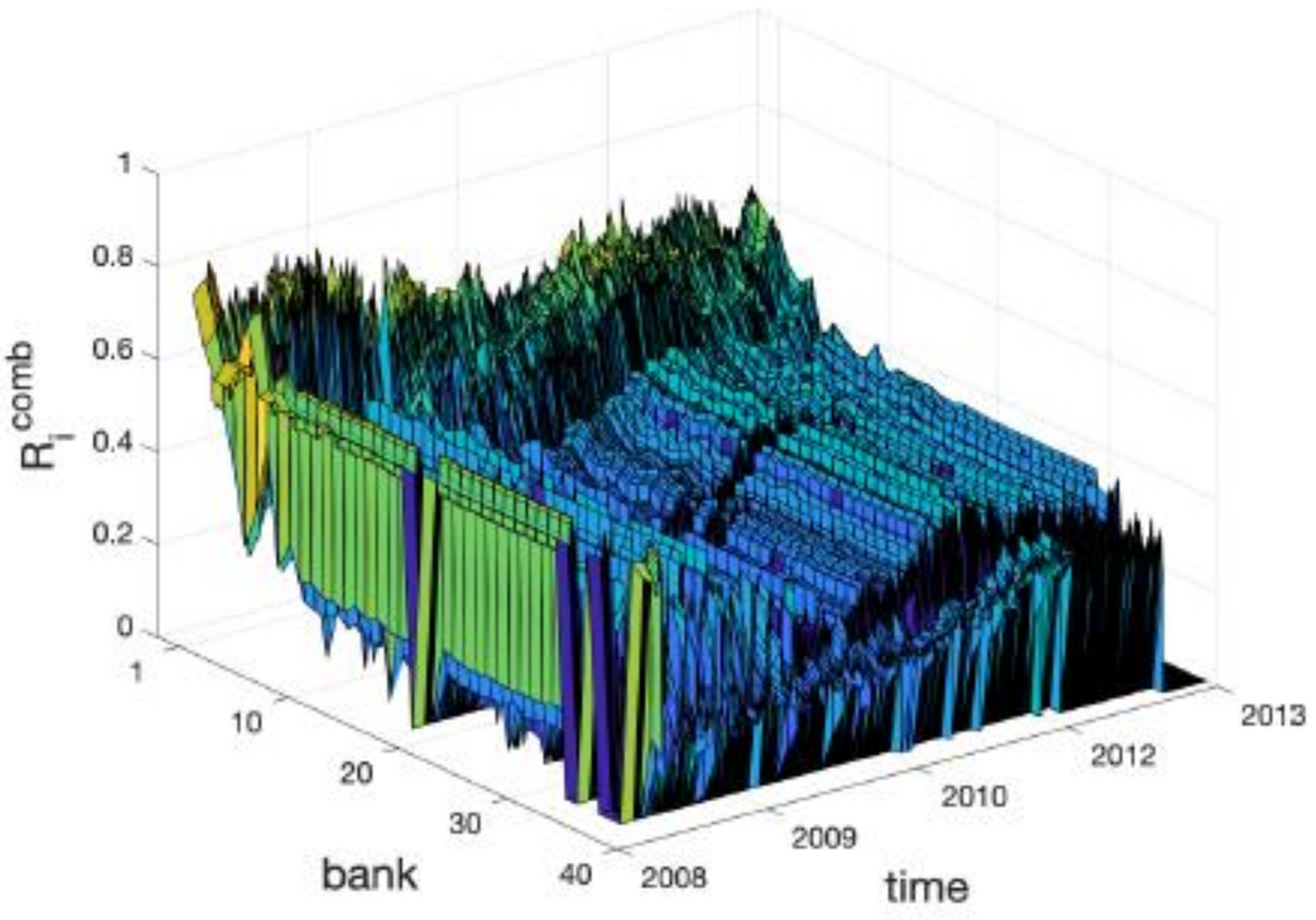
Systemic Risk surface for the combined network from all layers, from 31 July 2008 to 30 September 2013.

In this figure, we show the daily DebtRanks in the combined network from all layers for each bank from 2008 to 2013.

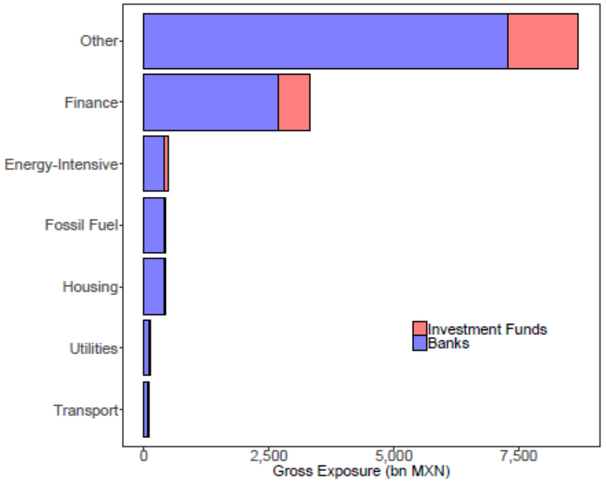
The most systemically important banks do not change too much over time.

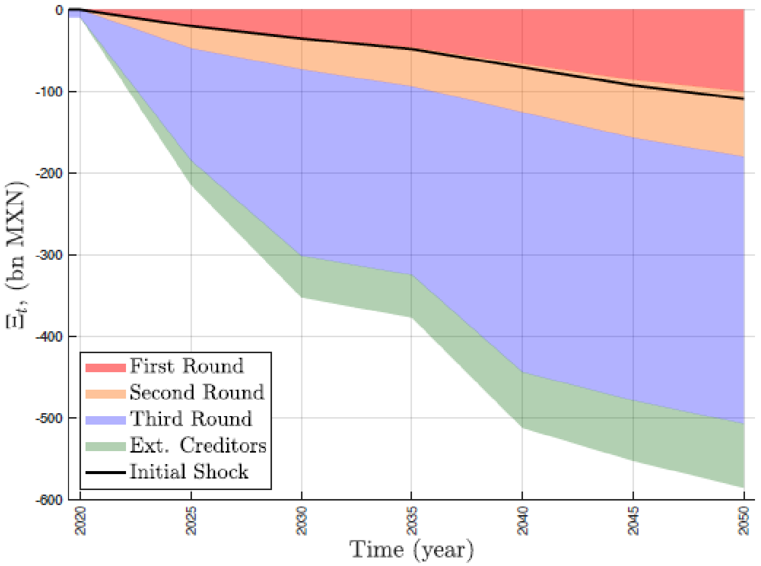
Systemic Risk was higher for almost all banks at the beginning of the measurement period (2008 financial crisis).

After the height of the financial crisis, there is a group of banks that are basically flat in terms of SR and over time.



Climate Change and Financial Stability





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