Ecuadorian Financial System Exposures: A Network Theory Approach

María Isabel Camacho Cárdenas
Ivonne Stefanía Cilio Mejía
Juan Pablo Erráez Tituana

Abstract

The purpose of this research is to analyze interrelations in the Ecuadorian financial system by means of a network theory approach. The network structure was defined using interbank exposure in absolute and relative terms. A static-comparative graphic analysis of the networks was carried out providing for the deposit and investment exposure of financial institutions in the financial system from December 2012 through December 2015, and the monthly metrics for each financial entity during this period were calculated. Using relative exposures, which consider the capital of each financial institution as collateral against entrusted deposits and investments, a transmission index was developed and a ranking of systemic importance was determined. The calculated metrics show that the stability of the structure of the Ecuadorian financial system as a network and that of its financial institutions has remained unchanged; in this regard, the status of systemically important financial institutions also remains unchanged.

Keywords: network, expositions, systemic risk, regulation.
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María Isabel Camacho Cárdenas <micamachoc@yahoo.com>, Ivonne Stefanía Cilio Mejía <ivonnestefy@hotmail.com> and Juan Pablo Erráez Tituana <jperraez@puce.edu.ec>, all of the Banco Central del Ecuador.

1. INTRODUCTION

One of the ways to define systemic risk is to refer to risk created due to system or market interdependencies. Authors such as Billio, Getmansky, and Lo and Pelizzon (2010) have determined that systemic risk is "any set of circumstances that threaten stability or confidence in the financial system." Accordingly, the failure of an entity or group of entities would cause a cascade effect and a possible collapse of the system or market as a whole as a result of market interrelations.

The construction of a model of the Ecuadorian financial system's interconnections using a network theory approach is an exercise in innovative methodology that permits, among other things, the determination of measures related to financial networks for the purpose of identifying the structure of the interrelations that exist between the entities that make up the financial system. It also allows those entities categorized as systemically important to the system to be monitored, and, in the future, to carry out resistance testing and contagion analysis as a dynamic and timely exercise such as the distribution of losses in certain circumstances, such as shocks. All the aforementioned analyses constitute inputs that, in the field of macroprudential policy, become technical foundations for the analysis of the stability of the financial system as a whole; and therefore for proposing of lines of action that strengthen the capacity to mitigate possible disturbances.

In this context, a comparative analysis of interbank exposures from December 2012 to December 2015[1] was undertaken for the purpose of identifying if the networks' structure,

[1] Due to the availability of the information disseminated by the entities of the Ecuadorian financial system regarding the structure corresponding to minimum liquidity reserves and the internal liquidity ratio, the analyzed period begins in December 2012, since prior to that month the structures about which the information was provided were different and therefore not comparable (Regulation 032-2012 of the Directorio, Banco Central del Ecuador).

configured by the deposits and investments of the Ecuadorian financial system, had changed. Additionally, the financial institution measures were calculated on a monthly basis during the period studied.

Based on the relative exposures, taking into consideration each financial institution's capital used to guarantee deposits and investments, a transmission risk index was built and a rating of systemic importance was determined.

With respect to total interbank exposures, a higher density was seen in the sector of interrelations in the largest private banks, corresponding to amounts of more than 5 million USD. On the other hand, the participation of both private and cooperative banks in the debt market, and the limited interconnectedness between mutuals and financial companies –with the exception of the largest financial entities– with most of the financial system, are notable. There is a noticeable concentration in deposits, especially in private banks: 66% of the total exposure of these assets was concentrated in the banks up to December 2015. Taking into consideration the investment market's interconnections, a large participation by banks and cooperatives as both lenders and borrowers was seen. The banks and cooperatives have more interconnections in the debt market which made up between 56% and 42% of total investments as of December 2015. The structure of the Ecuadorian financial system remained stable during the period under analysis in accordance with the calculated measures, both in network and individual financial entity terms. In this regard, the financial institutions of most systemic importance remained unchanged during the period analyzed.

2. THEORETICAL ASPECTS OF NETWORK ANALYSIS

The theoretical aspects related to network analysis are based on a document published by The Depositary Trust & Clearing Corporation-DTCC (2015).

In terms of the relations between entities in a structure or system, *interconnection* is defined as the relations between

economic agents created by financial transactions or payment arrangements, and this interconnection refers specifically to the links between the following institutions and by means of them: financial entities, financial infrastructure services providers, sellers, and third parties tied to the aforementioned entities. For this reason, interconnection is one of the key factors that must be taken into account when evaluating systemic financial sector risk.

Along the same lines, a *financial interconnection* is the network of credit exposures, exchange channels and other relations and dependencies between financial agents. An interconnection has contrarian aspects, as it can act as a conduit for contagion. The effect of a highly connected entity's failure can spread rapidly and extensively throughout the financial system to the point where it can cause global financial instability. Financial interconnectivity can be direct or indirect.

A *direct financial interconnection* refers to direct ties between entities via financial transactions, debentures, contracts and other agreements or relations that can be documented either explicitly or through indirect observation.

Credit exposures between banks are among the most basic types of direct interconnection. Bank A lends funds to Bank B; the two banks are directly connected and the interbank loan will appear as an asset on Bank A's balance sheet and a liability on Bank B's. Bank A is exposed to Bank B and could suffer losses if Bank B were to become insolvent. Credit exposure can also result from the acquisition of securities issued by other institutions, securities funding transactions, derivatives trading, and other activities beyond the interbank lending market. Finally, credit exposures may also appear in holding companies and other structures where legal entities are connected by property ties.

An *indirect financial interconnection* refers to channels where the expectation is that one entity can affect another entity, including where there is no link between the two. The expectation of an effect between entities where there is no apparent relation between the two can be propagated in many ways, as

for example when there is exposure to common assets. Financial institutions that maintain common assets are indirectly interconnected. Concentrations of common asset holdings have exposed financial institutions to large price fluctuations and elevated risk, above all during periods of market volatility or turmoil. Supply and demand distortions, such as the effect of prices on assets, represent additional vulnerabilities for financial institutions and can move quickly through the financial system in response to an initial market shock, the actions of market participants, and subsequent reactions.

It is relevant to consider that both indirect and direct financial interconnectivity are closely related to financial contagion and its side effects.

On the other hand, *financial contagion* is the process by which an adverse shock in one financial institution can have negative consequences for the rest. Shocks that propagate through indirect interconnectivity can affect a wide range of institutions more or less simultaneously. As a result, market conditions may deteriorate further and affect a growing number of businesses, leading to negative feedback that increases the initial shock and deepens stress throughout the entire system. This can trigger a cascade effect.

2.1 Representing the Interbank System's Network Structure

The relations between the entities that make up a financial system can be represented as a direct network with weights (Cont, Moussa and Santos, 2012), or a defined network such as $I = (N, A, c)$, where:

- N is the set of nodes that correspond to each financial entity,
- A is the adjacency matrix showing the bilateral exposures between the financial entities, for which A_{ij} denotes the exposure of node i to node j as the accounted for the value of entity i's distinct assets in entity j in the case of interconnection, but zero in the case where the entities maintain

no interrelation. In other words, the exposure can be interpreted as node *i*'s loss as a result of node *j*'s problems.

- $c = c(i), i \in N$, where *c(i)* is institution *i*'s capital representing the ability of each financial entity to absorb losses; supposing that, facing any problem in debtors' payment capacities, the capital shall be the tool used to mitigate the loss.

Said network is shown as a graph in which its nodes represent a financial entity and its connections are interpreted as the exposures between them.

Additionally, the in-degree $\left(k_{in}(i)\right)$ of a node i $\left(i \in N\right)$ is defined as its number of creditors and the out-degree $\left(k_{out}(i)\right)$ as its number of debtors, so that the total degree[2] of entity *i*, is defined as $k(i) = k_{in}(i) + k_{out}(i)$ and shows the level of connectivity of entity *i* at any given moment.

On the other hand, financial entity *i*'s assets *S* can be expressed as the following:

$$S(i) = \sum_{j \in N} A_{ij} .$$

While the liabilities *P* of entity *i* can be denoted as:

$$P(i) = \sum_{j \in N} A_{ji} .$$

2.2 Relative Bilateral Exposures

To construct the Ecuadorian financial system's interbank networks, the basis for making the relative exposure calculations is based on the criteria that assumes that the assets of the depository entities are liabilities for the entities that receive them.

Relative bilateral exposures can be expressed as the coefficient of the exposure of entity *i* to entity *j* for *i*'s capital.

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[2] The degree of a node is a measure of connectivity that shows the number of borders that a node has as one of its ends. This translates into the number of a bank's counterparts.

$$\frac{A_{ij}}{c(i)}.$$

This type of exposure allows the level of *i's* exposure in the face of a possible bankruptcy of entity *j* to be verified using its capital as an instrument for responding to the loss. In other words, it indicates at what level the capital of *i* could protect its exposure to entity *j*.

Moreover, the cumulative relative exposure level was calculated in a horizontal fashion, which refers to the ratio of total assets to capital for each entity. For entity *i* it can be defined as:

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} = S(i)/c(i), \text{ where } S(i) = \sum_{j \in N} A_{ij}.$$

This type of exposure identifies the most vulnerable financial institutions taking into consideration their incapacity to use their capital to confront the losses.

On the other hand, the relative vertical accumulated exposure defines the role the financial entities perform as transmitters in the financial system since their failure would have great consequences for their counterparts. In the case of entity *i* this type of exposure can be defined as:

$$\sum_{j=1}^{N-1} \frac{A_{ji}}{c(j)}.$$

In this way, financial institutions were grouped into four categories:

1) Vulnerable and transmitting entities. This group covers entities whose relative cumulative vertical and horizontal exposure exceeds 100%, which implies that in the face of their counterparts' problems, they run the risk of being weakened and in turn could spread the problem to other entities.

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} > 100\%, \sum_{j=1}^{N-1} \frac{A_{ji}}{c(j)} > 100\%.$$

2) Vulnerable entities. This group covers entities whose relative cumulative horizontal exposure exceeds 100%, implying that in the face of their counterparts' problems they could be affected, as their capital would not allow them to cope with their losses.

3) Immune entities. This group corresponds to entities that could not be affected by their counterparts' problems and also do not meet the role of transmitters, so they are indifferent to failures in the system; that is, their relative cumulative vertical and horizontal exposure is less than 100 percent.

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} < 100\%, \sum_{j=1}^{N-1} \frac{A_{ji}}{c(j)} < 100\%.$$

4) Transmitter entities. This category covers entities whose cumulative relative vertical exposure exceeds 100%, which means that in the face of problems they might have, their counterparts would be affected.

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} > 100\%.$$

2.3 Transmission Risk Index

Depending on the bilateral relative exposure, an index was obtained for each entity in order to be able to identify which are systemically important. In order to establish this index, three aspects were taken into account that show, on the one hand, the number of entities tied to each institution, and on the other, their ability to transmit a shock to other entities, and finally, their position in the network.

- Selection of entities that comply with an exposure relatively greater than 20%,

$$\frac{A_{ij}}{c(i)} \geq 20\% \cup \frac{A_{ji}}{c(j)} \geq 20\% \; \forall \, i.$$

From the selection, and adjacency matrix is obtained with the number of entities that fulfill the previous condition. Thus, we calculate the total degree of each entity *i* and proceed with the transformation between 0 and 1[3] of the total degree of each institution.

In this case, the number of creditor and debtor entities can be observed,[4] with values in the range of 0 to 1, where 0 corresponds to the entity with the lowest total degree and 1 to the entity whose degree adds up to the highest value.

- Core-periphery algorithm[5] that allows the position of the node in the network to be observed and delivers a value of 0 to the entities categorized as being peripheral and a value of one to those categorized as being core.
- The transformation between 0 and 1 of the internodal measurement[6] of each entity *i*, where 0 corresponds to the entity with the lowest internodal measure and 1 to the entity through which pass the highest number of connections, a condition that allows the identification of the capacity of transmitting a shock to a part of an entity.

The final result is to add the obtained valued according to the criteria detailed above in order to have a measure or index with a range from zero to three that permits the establishment of a grade of systematic importance for each entity in the financial system.

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[3] The transformation between 0 and 1 of the X_i is obtained by:

$$\left(\frac{X_i - Min(X_i)}{Max(X_i) - Min(X_i)} \right).$$

[4] In-degree and out-degree.

[5] Measure proposed by Craig and Von Peter (2014) that consists of the division of the network into two subdivisions.

[6] Centrality measure that refers to the number of times a node acts as a tie between two other actors.

3. STRUCTURE AND ANALYSIS OF THE ECUADORIAN FINANCIAL SYSTEM EXPOSURES

The Ecuadorian financial system analyzed in this research was made up of 75 operating financial entities at the close of 2015.[7] Private banks make up the largest participation in the system in accordance with their assets which are: 22 banks comprising 79.4% of all assets; 39 cooperatives,[8] comprising 14.2%; 10 financial societies making up 4.9%, and 4 mutuals at 1.8 percent.

As of December 2015, four large financial institutions accounted for 52.3% of total assets. They were followed by five medium-sized financial entities with a concentration of 23.3%. The largest bank in the Ecuadorian financial sector held 23.4% of all assets, and the second largest bank had 11 percent.

As for the evolution of all regular and term deposits, between December 2012 and December 2015, on average, regular deposits made up 64% of the capital raised by the financial entities under analysis. The data series shows positive annual variation rates up to March 2015 and a consecutive fall with respect to the previous year, ending in December 2015 with the lowest rate (–16%) during the period under analysis. On the other hand, time deposits corresponded to 36% of the financial entities' raised assets and showed positive rates up to August 2015. During the following months, negative variation rates were seen, reaching the lowest point for the period under analysis at –4% in December 2015.

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[7] For the comparative analysis of this research, 80 financial institutions were considered, of which 75 are in operation and five closed (four private banks and one financial company) by December 2015.

[8] The Board of Monetary and Financial Policy via resolution number 038-2015-F issued as "Standard for the Segmentation of Widespread and Supportive Financial Sector Entities" in accordance with the type and amount of its assets. For this reason, the cooperative referred to in the analysis correspond to segment 1 of the mentioned regulation (taking into consideration the largest entities in terms of the size of the assets)

Table 1

STRUCTURE OF THE ECUADORIAN FINANCIAL SYSTEM AS OF DECEMBER 2015

Type of entity	*Number of entities*	*Assets (millions of dollars)*	*Share of assets (%)*
Private banks	22	30,864	79.4
Cooperatives	39	5,529	14.2
Segment 1	22	4,934	12.7
Segment 2	11	517	1.3
Segment 3	6	78	0.2
Mutuals	4	687	1.8
Financial societies	10	1,804	4.6
Total	75	38,885	100.0

Source: Created by the authors.

The evolution of the 80 entities' total loan portfolios, analyzed between December 2012 and December 2015, showed positive but decreasing rates of variation until October 2015. In the last months of the fourth quarter of 2015, negative rates of variation were seen until reaching the lowest point in December 2015 at –4%. Additionally, in Figure 2, the bars correspond to the amount of credit authorized in each segment,[9] and it can be seen that the largest proportion is distributed between consumer and commercial credit with microlending accounting for 12%, housing credit approximately 8% and education lending less than 2% on average during the year under analysis.

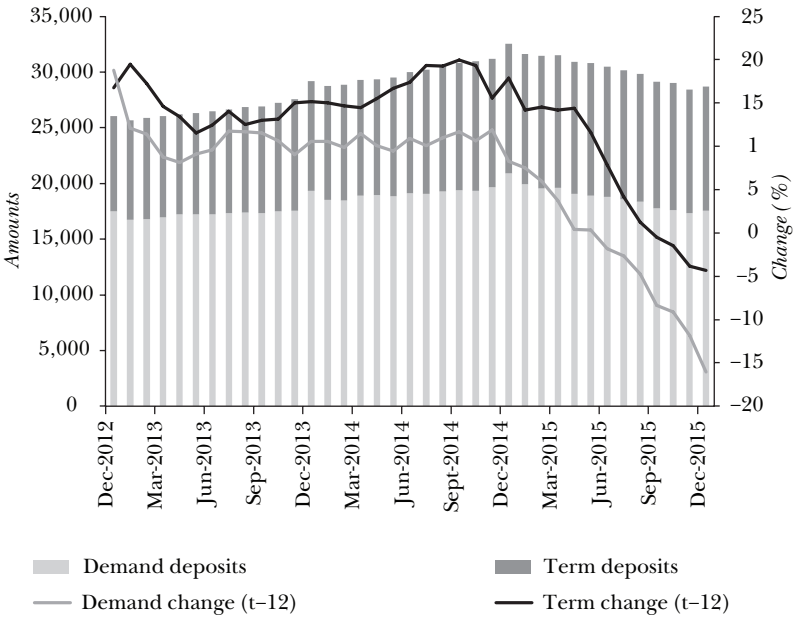
In terms of loan portfolio management, the evolution of the non performing loans ratio per credit segment shows that from December 2012 the total index increases, reaching it highest value in November 2015 at 4.9%. The highest non performing loans ratios correspond to the microcredit and consumer segments at 6.7% and 6.3% respectively, as of December 2015, while the lowest rates correspond to housing and commercial loans at 2.3% and 1.2% respectively.

[9] The credit segments have been grouped for comparative purposes, since new segments began operating in April 2015.

Figure 1

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION AND RATE OF CHANGE OF DEMAND DEPOSITS AND TERM DEPOSITS, DECEMBER 2012 TO DECEMBER 2015

(millions of dollars and percentages)



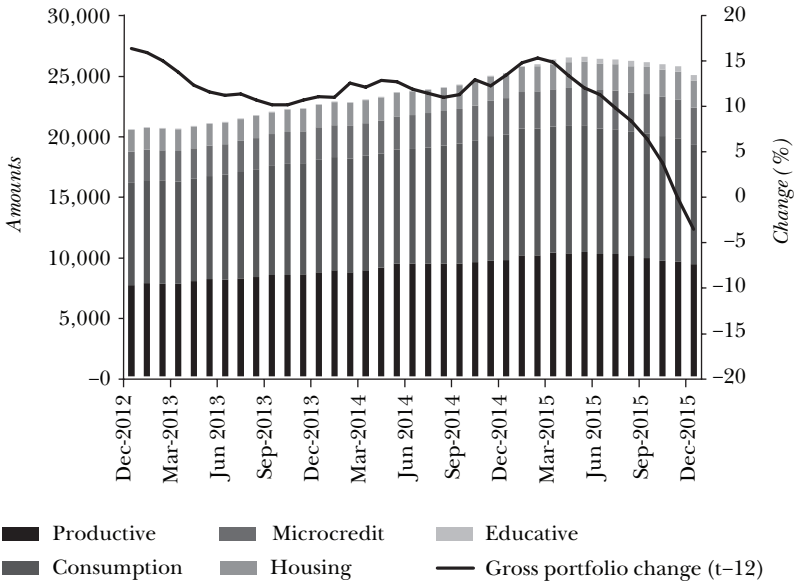
Source: Banco Central del Ecuador.

According to Camacho et al. (2015), given the decline in oil prices since the second half of 2014 and the appreciation of the dollar, the Banco Central del Ecuador undertook a series of counter-cyclical policies to prevent the economic slowdown from sharpening. As a result of resolutions[10] issued by the Board

[10] The Board of Monetary and Financial Policy via resolution number 043-2015-F issued "Norms that Regulate the Segmentation of Credit Portfolios Pertaining to Entities with the National Financial System," and via resolution number 044-2015-F set the "Norms Regulating the Setting of Effective Maximum Active Interest Rates."

Figure 2

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION AND RATE OF CHANGE OF TOTAL LOAN PORTFOLIO BY SEGMENTS, DECEMBER 2012 TO DECEMBER 2015
(millions of dollars and percentages)



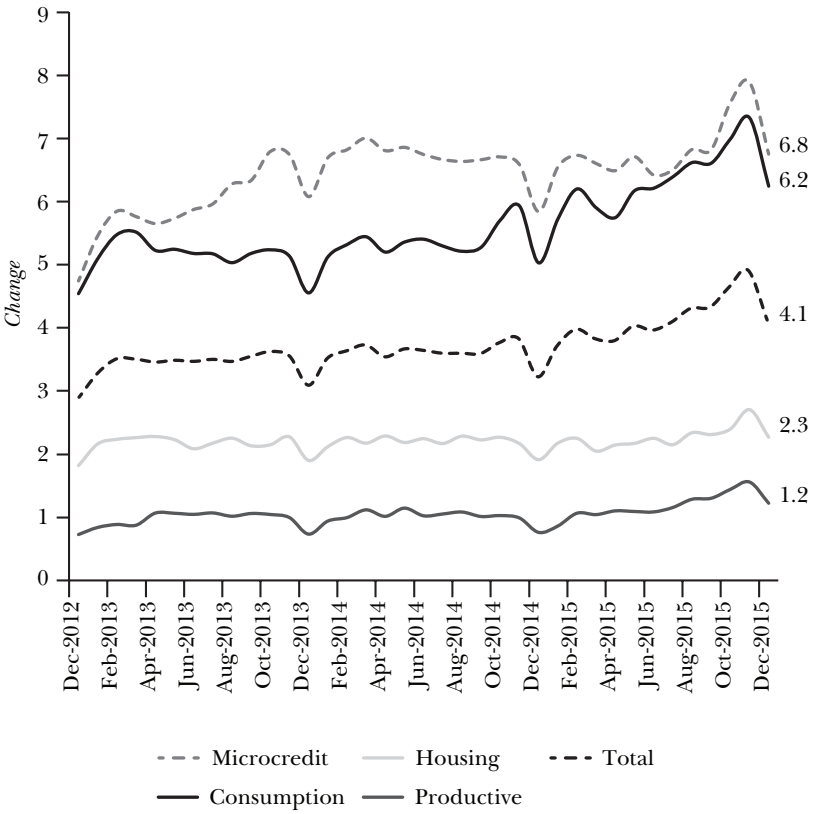
Source: Banco Central del Ecuador.

of Monetary and Financial Policy new credit segments were established accompanied by board rules for setting maximum active interest rates. Credit segments went from 9 to 15 and were in force as of April 2015.

Various analyses were undertaken from the perspective of network theory given the described structure of the Ecuadorian financial system. This innovative methodology permitted, among other things, the determination of financial network measurements, the analysis of bilateral exposure relative to each entity's capital, and the rating of entities of systemic importance to the financial system overall. These analyses provide a technical foundation for the analysis of the financial system's

Figure 3

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION OF NON PERFORMING LOANS RATIO BY CREDIT SEGMENT, FEBRUARY 2012 TO DECEMBER 2015
(percentages)



Source: Banco Central del Ecuador.

Table 2

ECUADOR FINANCIAL SYSTEM: CREDIT SEGMENT CLASSIFICATION BEGINNING APRIL 1, 2015

Credit segment	*Credit subsegment*	*Maximum interest rates in effect since April 2015 (%)*
Business credit	Corporate	9.33
	Business	10.21
	SME	11.83
Ordinary business credit		11.83
Priority business credit	Priority corporate business	9.33
	Priority commercial business	10.21
	Priority commercial SME	11.83
Ordinary consumer credit		16.30
Priority consumer credit		16.30
Education credit		9.00
Public interest housing credit		4.99
Real estate credit		11.33
Microcredit	Retail	30.50
	Simple buildup (no more than 10,000 USD)	27.50
	Extended buildop (more than 10,000 USD)	27.50

Source: Board of Monetary and Financial Policy.

stability overall, and subsequently for proposing courses of action for strengthening the capacity to deal with possible disturbances and creating important inputs for the macroprudential policy environment.

The configuration of interbank exposure networks was determined as the aggregate network of deposits and investments that each financial entity has with others in the financial

Table 3

ECUADOR FINANCIAL SYSTEM: DETAIL OF ACCOUNT BALANCES BY TYPE OF FINANCIAL ENTITY FOR THE ANALYSIS OF THE NETWORKS AS OF DECEMBER 2015

(billions of dollars)

Asset account	*Financial entities*				*Banking network*
Billions of dollars	*PB*	*CO*	*FS*	*MU*	
11 *Available funds*	6,049.5	471.3	198.4	37.1	
1101 Cash	1,153.8	77.5	0.4	6.6	
1102 Deposit reserves	1,679.6	–	34.7	16.4	
1103 Banks and other FEs	2,564.2	390.5	163.3	12.8	
110305 Banco Central del Ecuador	0.1	126.7	–	0.0	
110310 Banks and domestic FEs	828.5	205.5	133.6	12.1	X
110315 Banks and foreign FEs	1,735.7	1.3	29.6	0.7	
1104 Immediate clearing payments	282.6	3.3	0.1	1.3	
1105 Intransit remittances	369.3	0.0	–	0.1	
12 *Interbanking operations*	39.7	2.1	–	–	X
13 *Investments*	4,438.0	519.7	113.9	59.8	
1301 Fair value –private sector	57.9	12.7	0.4	–	X
1303 Available for sale –private sector	1,455.6	404.4	14.4	21.2	X
1305 Held until expiration –private sector	27.3	102.7	8.1	–	X
1302 Fair value–public sector	250.9	–	–	–	
1304 Available for sale –public sector	980.6	0.4	43.3	1.8	
1306 Held until sale –public sector	1,487.7	–	50.3	36.3	
1307 Restricted availability	245.2	0.9	–	0.7	X
1399 Provisions for investment	–67.33	–1.31	–2.60	–0.18	

Source: Created by the authors.

system. Within this framework, a static comparative analysis of the representation of the networks between December 2012 and December 2015 will be undertaken, and monthly measurements for each financial entity will be calculated for the entire period. In addition, relative bilateral exposures in the financial system will be determined in terms of each entity's capital used to guarantee deposits and entrusted investments. A transmission risk index will be created as an instrument for determining a systemic importance rating.

The accounting values that will be used to establish the interrelations are detailed in Table 3.

3.1 Interbank Exposure

For the analysis of interbank exposure, accounts on the books have been classified into two types: interbank deposits and investments (interbank debt market). Table 2 details the six assets that will be considered for creating the interbank network. These assets can be divided into *1)* available local financial institution funds such as assets facing other national institutions, and *2)* repurchase agreements that include the four assets classes that make up marketable securities and debt up to its maturity. These two subnetworks are distributed proportionally by the balance amounts with a slightly larger share of average debt holdings participation throughout the sample. Interbank deposits and repurchase agreements stand out as the main asset classes, so the analysis of the networks will focus on the aforementioned assets.

The information base included 80 deposit institutions both active and liquidated. The size of the network was fixed to control the relevance of changes in network structure resulting from the disappearance of institutions in the sample which are included in the network as disconnected nodes.[11] The re-

[11] Only depositary financial institutions that provide information about minimum liquid reserves and internal liquidity ratio were considered in the sample.

sults comparison was done between December 2012 and December 2015.[12]

Figure 4 shows the interbank network of the Ecuadorian financial system as of December 2015 within which the interconnections of financial entities occurs.[13] The size of the nodes is a function of the degree, while the thickness of the edges depends upon the book value of the assets being considered in the analysis. In this first representation of the interconnectivity, four sets of financial entities and their interconnectivity can be distinguished. In the first group, the majority of the cooperatives have ties with two mutuals and four banks (two of these being very small, one small and the other medium-sized). In the other three groups can be found the four largest banks in the country, and the financial companies evenly distributed; while there are two cooperatives for each grouping of entities. Finally, the two remaining mutuals are present in two of the three groups. It should be mentioned that the interrelations of these sets of entities in practice correspond to the country's financial groups.

The structure of the interconnections is then broken down into a network of deposits and a network of investments in order to observe the interrelations of the financial system in each case. At the same time, the size of the nodes found in both networks is a function of the number of connections, while the thickness of the edges depends on the book value of the deposits and investments (taken separately).

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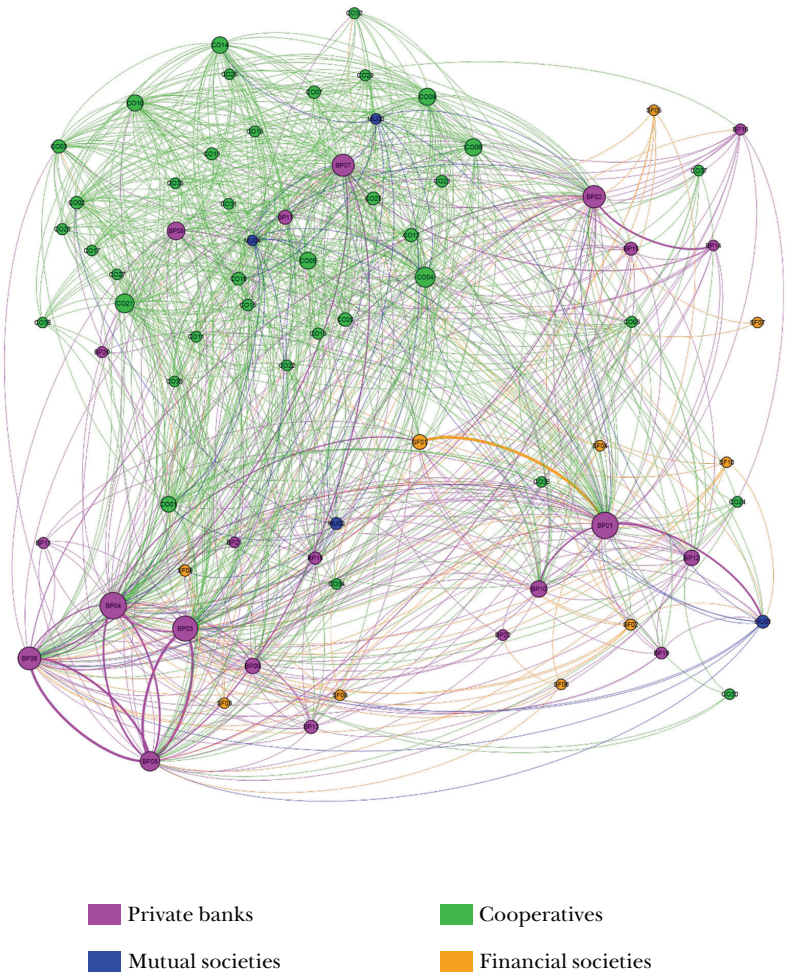
[12] The analysis period, from December 2012 to December 2015, was selected in terms of the comparison that can be made with respect to information structures in which financial institutions must report their minimum liquidity reserves (MLR) and domestic liquidity ratio (DLR) to the Banco Central del Ecuador pursuant to Regulation No. 032-2012 of the Directory of Banco Central del Ecuador.

[13] The network model selected for the analysis refers to the direct interconnection weighted by the book value of the selected assets.

Figure 4

ECUADOR'S FINANCIAL SYSTEM: INTERBANK NETWORK, DECEMBER 2015



Source: Authors' elaboration.

Figure 5 shows the network of interbank deposits as of December 2015. In this case, the position of the nodes is stable and a strong link between the largest banks located in the lower left of the graph can be observed. Equally, a strong interconnection between the cooperatives can be seen. The importance of PB01 can be seen in the number of deposits coming from all types of entities, among which the relation with SF01 stands out. While for its part, this bank only maintains deposits with two entities belonging to the same financial grouping (PB10 and PB12).

On the other hand, Figure 6 shows the relations resulting from interbank investments in the financial system as of December 2015. This network shows an even stronger link between private banks, especially the interconnectivity between the large banks. The case of investments by MU01 in PB01 are notable. Similarly, the cooperatives maintain strong ties among themselves, while the mutuals, as in the case of financial companies, diversify their investments between various types of financial entities.

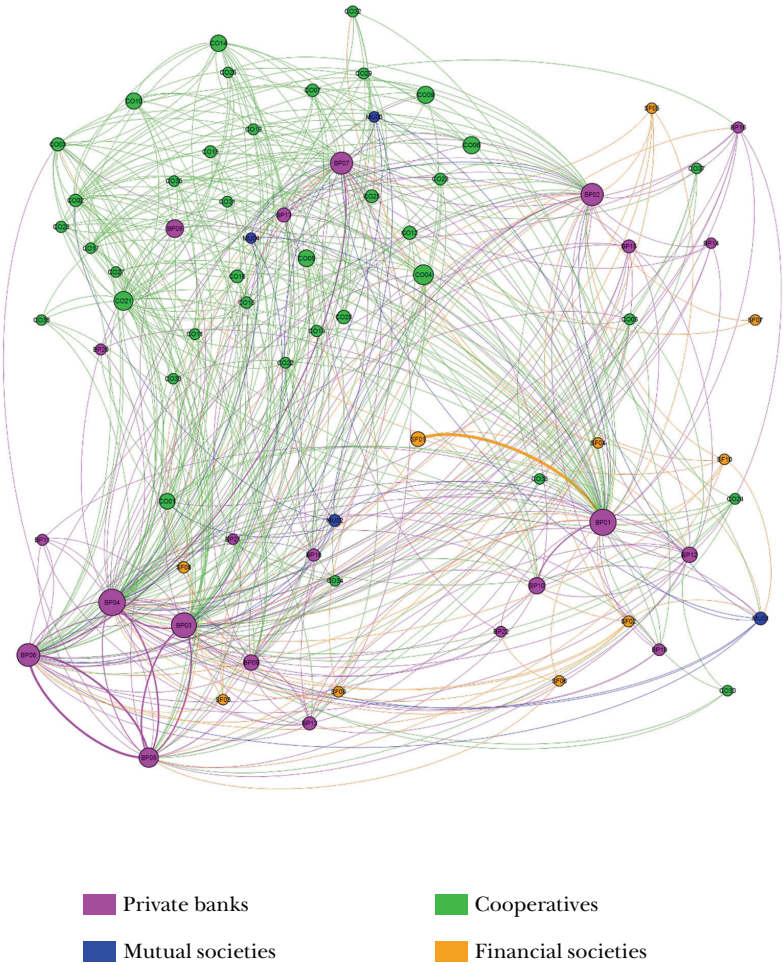
The graphical representation of the interbank network as of December 2015 is a first general view of the structure of the interconnections of the entities of the Ecuadorian financial system. It is, therefore, necessary to identify exposures by asset type, as well as to calculate the network measures for the purpose of describing the network structure, determining the systemic importance of certain entities in the Ecuadorian financial system, and making a comparison to determine if significant changes occurred between December 2012 and December 2015.

Figure 7 shows the interrelations of financial institutions[14] classified by type of entity and ordered according to each financial institution's amount of assets. As a result, the largest financial institutions occupy the first spaces in each type. Bilateral exposure is represented by the intersection of the coordinates

[14] In terms of total amounts deposited and invested in the counterparts of the financial system.

Figure 5

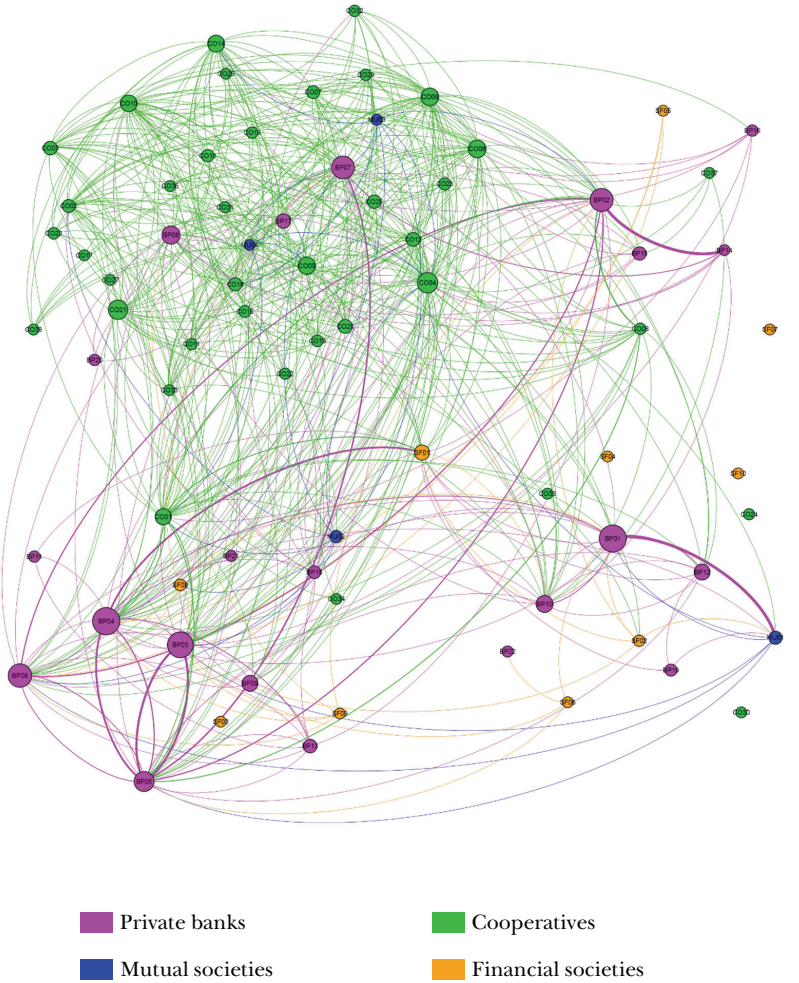
ECUADOR'S FINANCIAL SYSTEM: INTERBANK DEPOSITS NETWORK, DECEMBER 2015



Source: Authors' elaboration.

Figure 6

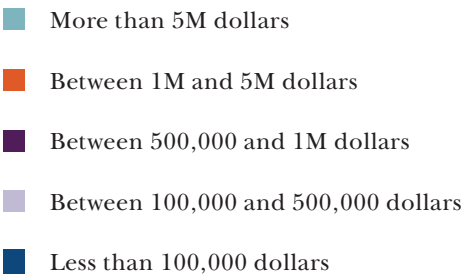
ECUADOR'S FINANCIAL SYSTEM: INTERBANK INVESTMENTS NETWORK, DECEMBER 2015



Source: Authors' elaboration.

Table 4

EXPOSURE AMOUNT RANGES
(dollars)



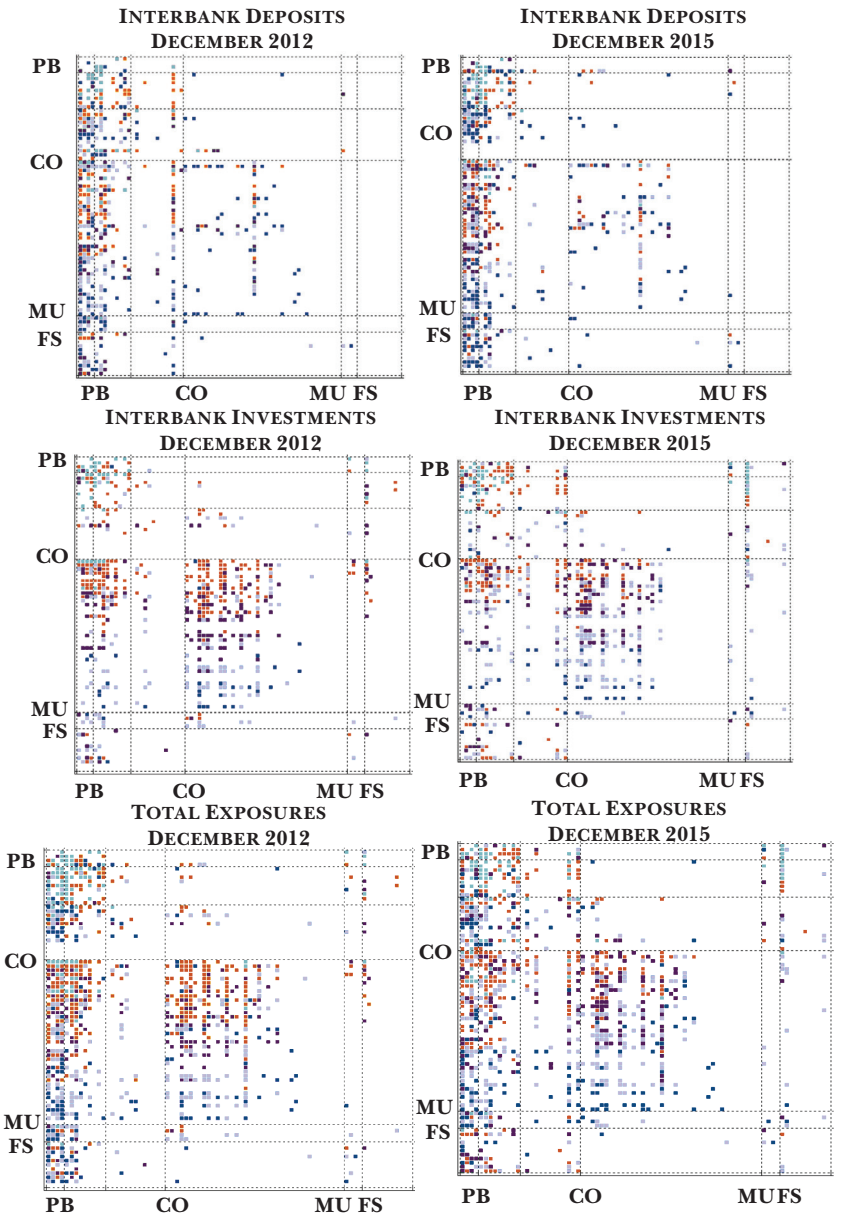
of the financial entities along the axes with a colored square. The amounts of the exposures differed according to the ranges shown in Table 4.

The first row of the figure shows local banks' available funds as well as the interbank operations of the financial institutions. In this case, it can be seen that for both periods the financial entities' deposits are concentrated, especially at private banks: as of December 2012, 70% of total exposure; while as of December 2015, participation decreased to 66%. The largest cooperatives are also receiving amounts of between 100,000 USD an 5 million USD, and only one received an amount greater (December 2015), although to a lesser proportion than the private banks. The mutuals and financial companies have almost no ties to the group and they act as net lenders to the rest of the system. In particular, mutuals and financial companies give their funds to private banks, although certain mutuals do so to some cooperatives. Their interconnectivity is very slight and limited to interactions with the large entities in the financial system.

The second row corresponds to the assets financial entities keep as investments. The financial system's interconnectivity regarding this type of asset demonstrates the large participation of banks and cooperatives as lenders and borrowers in the

Figure 7

ECUADOR'S FINANCIAL SYSTEM: INTERBANK NETWORKS BY ASSET CLASS
(US dollars)



Note: PB: private banks, CO: cooperatives, SF: financial societies, MU: mutual societies.
Source: Authors' elaboration.

debt market. In contrast to the section regarding interbank deposits, the banks and cooperatives have more connections in the investment market, whose total represents 73% and 23% respectively as of December 2012, and between 56% and 42% as of December 2015. This situation creates important channels for the transmission of possible disturbances in this group of institutions. Although the largest exposures are concentrated in the larger cooperatives, even the smallest show a certain degree of interconnection. On the lending side, the largest institutions in each group obtain substantial financing from the private banks, especially through debt securities,[15] which creates an indirect channel for shocks between mutuals and financial societies and via the private banks for the rest of the system.

In the third row two types of assets (interbank deposits and investments) in each year are added, with the general result of a denser network in the sector where the large private banks are located, which also correspond to amounts of more than 5 million USD. On the other hand, the participation of both private and cooperative banks in the debt market, and the lack of interconnectedness between mutuals and financial companies with most of the financial system–with the exception of the largest financial entities–are notable. Between December 2012 and December 2015, there is a change in the financial companies where the interrelations with the financial system in general, and even more with private banks, loses its strength, and the amounts decrease from one period to another which could be explained by regulatory provisions covering these types of financial entities.

[15] Documents representing a payment obligation for capital and interest on the part of the issuing company on a certain due date (Caxia, 2016). Debt securities are negotiable securities that incorporate a credit right in the strict sense, which allows the issuer to finance investments through its placement in the capital market (Comisión Nacional de Valores, 2007).

3.2 Measurements of Ecuadorian Financial System Exposures

While the representations of the structure of the networks during the two periods of time show some changes in the interconnections of the Ecuadorian financial system, it is necessary to analyze the behavior of the principal metrics over time to determine if there have been visible changes in their composition. The evolution of some important metrics of the interbank system of the financial system is represented in Figure 8.

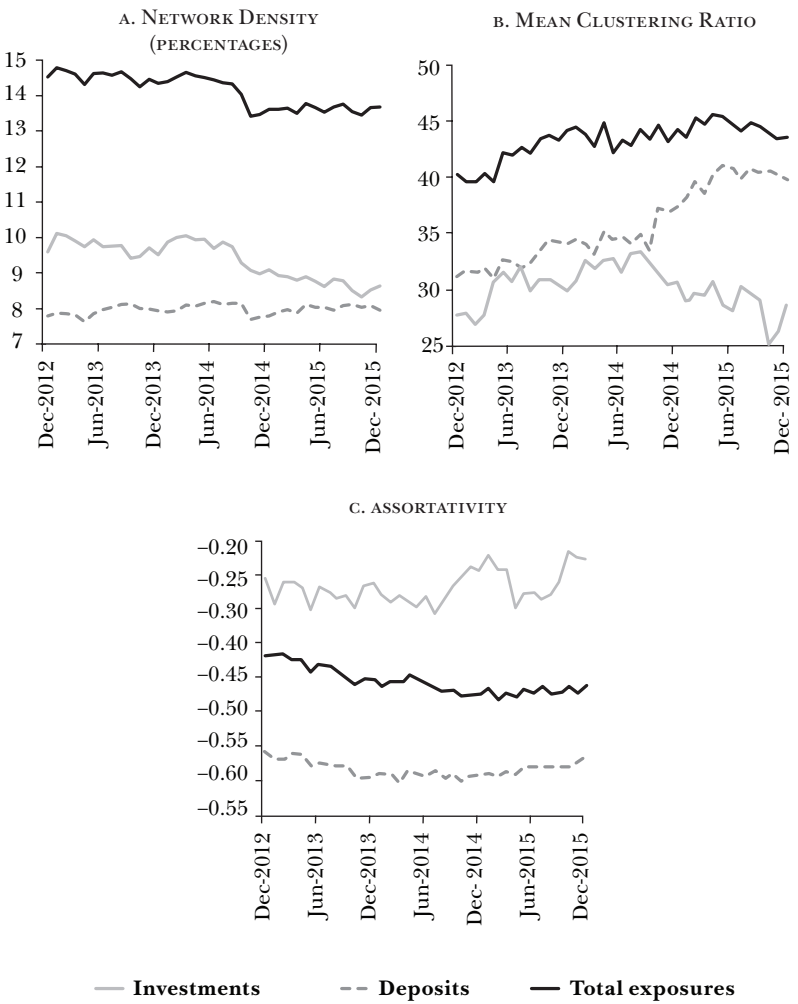
The density of the network is the proportion of links present in a network relative to the total number of possible links. The path of this indicator for the network of total exposures during the period shows a slight decline which probably can be explained by the decrease in the interconnection of the investment market subnetwork. In Figure 8:

- The evolution of the ties present in a network in relation to the total number of possible links is identified. The deposit subnetwork remains at around 8%, while the investment subnetwork decreases from 10% to 8.6% in December 2015, although this subnetwork has a higher density than those of the deposit interrelations.
- The path of the clustering coefficient is shown;[16] this indicator describes the interconnection of the nearest neighbors to some vertex. A high and upward-trending coefficient indicates that most financial institutions, if not directly connected, have common connections with other entities. In the case of the Ecuadorian financial system, interconnections between financial entities display the previously explained characteristic: They are not directly interrelated, but the distance separating their common vertices, to arrive from one to another, is short in the case of any eventual shocks.
- The path of the assortability coefficient refers to the tendency of the central nodes to be linked to others that meet this

[16] Metric of non-local character that calibrates the density of the connections around some vertex.

Figure 8

ECUADOR'S FINANCIAL SYSTEM: INTERBANK NETWORKS METRICS, DECEMBER 2012 TO DECEMBER 2015



Source: Authors' elaboration.

same characteristic, avoiding interlacing with lower grade nodes. The Ecuadorian financial system network presents negative coefficients over time, resulting in the manifestation of weakly connected entities that tend to have ties to entities that are strongly connected.[17]

3.3 Measurements of the Entities that Make Up the Ecuadorian Financial System

Table 5 shows the principal each financial entity's metrics by degree (entry and exit) as of December 2012 and December 2015. In section *a*, the entities with the highest degrees of exit are shown. The cooperatives diversify their relations in greater measure since only a bank appears on the list for each year, PB42 and PB04 respectively.[18] The principal entities based on entry grade are shown in section *b*. In this case, private banks show greater participation, which indicates, in first place, the concentration of assets on the part of the rest of the entities in those that have higher values; and, in second place, imply a large amount of uncertainty in the case of adverse shocks, due to the concentration they have.

Table 6 shows the financial institutions with the highest degree of average proximity. For this measure, the financial entities are the ones that possess a higher indicator and, as a consequence, have neighbors that have high levels of interconnection. For this reason, this would aid in the faster spread of an eventual shock throughout the financial system: Five of the 10 entities that appear on the list as of December 2012 also appear as of December 2015.

Table 7 shows the measures related to *betweenness*. During the period under analysis, there is a marked change among the

[17] If the assortability is negative, it implies that weakly connected nodes join with strongly connected nodes; if assortability is positive, it signifies that strongly connected nodes join with other strongly connected nodes.

[18] Considering that both entities were merged at the end of 2014.

Table 5

PRINCIPAL FINANCIAL ENTITIES BY DEGREE
(number of connections)

a) Exit Degree			*b) Entry Degree*		
Financial entities	*December 2012*	*Decembrer 2015*	*Financial entities*	*December 2012*	*Decembrer 2015*
CO02	29	29	PB04	40	65
CO10	18	26	PB01	68	62
CO14	21	24	PB03	59	58
CO05	21	23	PB06	51	49
CO09	17	23	PB07	43	47
CO03	18	22	PB02	38	47
CO08	26	21	CO04	35	38
CO01	18	20	PB05	38	36
CO11	13	20	CO21	32	33
CO33	19	19	PB08	19	29
CO19	14	19	PB24	48	0
PB04	11	19	PB26	34	0
CO06	20	18			
PB24	22	0			

Source: Authors' elaboration.

financial entities that present many possible contagion routes (centrally located for betweenness). In December 2012, of the ten principal financial entities, six were cooperatives, three banks, and one a mutual. In contrast, as of December 2015, six were banks and four were cooperatives. Finally, three entities maintained their statuses in both periods.

3.4 *Core* or *Peripheral* Entities

Also, when applying the core-periphery algorithm, the presence of financial entities cataloged as core or nuclear, was

Table 6

ENTITIES WITH THE LARGEST AVERAGE DEGREE OF PROXIMITY
(number of connections)

Financial entities	*December 2012*	*December 2015*
FS05	76.0	62.9
FS09	62.0	61.2
FS07	51.3	58.5
FS03	0.0	57.0
MU04	53.1	56.6
CO26	50.4	56.0
PB22	18.4	56.0
CO24	44.4	55.4
CO27	51.3	55.3
CO37	60.3	53.6
CO31	52.0	53.0
PB16	53.9	45.7
CO34	53.0	45.1
FS08	57.0	39.8
PB18	55.3	30.1

Source: Authors' elaboration.

verified. This structure affirms that the core entities serve as nodes between the periphery entities that do not directly interact among themselves but do so with core entities. In addition, the entities of the core interact intensely with each other and are systemically important in the network. This application uses the definition seen in Craig and Von Peter (2014). In the case of the Ecuadorian financial system, the number of entities that are cores or nodes is stable over time (an average of 18 entities for the total exposures network, 10 in the deposits network and 15 in the investments network), and they act as intermediary links between the peripheral entities that do not interrelate directly among themselves.

Table 7

ENTITIES WITH THE HIGHEST BETWEENNESS
Number of short routes

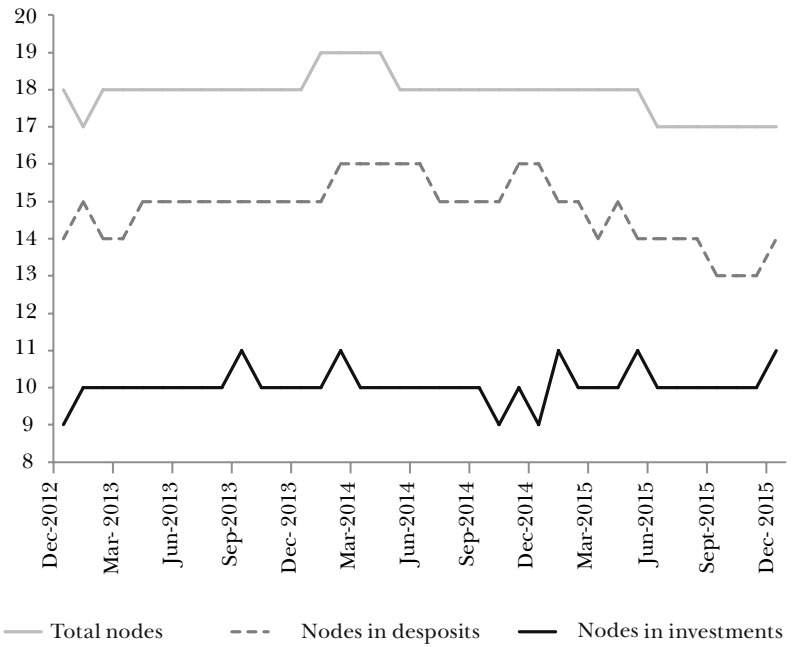
Financial entities	*December 2012*	*December 2015*
PB15	26	1,315
PB18	0	1,270
CO25	1,543	1,158
PB05	1,067	1,137
CO21	181	1,058
PB04	197	882
PB08	173	775
PB17	154	745
CO16	310	711
CO12	0	558
CO10	333	306
PB02	768	286
CO23	297	61
MU01	665	6
CO09	279	3
PB24	694	0
CO17	231	0

Source: Authors' elaboration.

The construction of the networks also made it possible to identify certain entities whose metrics show the importance they play in the financial system. In general, during the period under analysis, there is no change in the structure of these entities and they are stable in terms of their participation in the financial market (Table 8). Large private banks tend to be located at the top of the list, while many other institutions deserve attention from the point of view of systemic risk due to their role in all of the entity groups.

Figure 9

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION OF THE NUMBER OF FINANCIAL INSTITUTIONS CONSIDERED AS NODES



Source: Authors' elaboration.

Table 8

ECUADOR FINANCIAL SYSTEM:
FINANCIAL ENTITIES CATALOGED AS CORE

Order 2015	*Financial entity*	*December 2012*	*December 2013*	*December 2014*	*December 2015*
1	PB01	✓	✓	✓	✓
2	PB02	✓	✓	✓	✓
3	PB03	✓	✓	✓	✓
4	PB04	✓	✓	✓	✓
5	PB05	✓	✓	✓	✓
6	PB06	✓	✓	✓	✓
7	PB07	✓	✓	✓	✓
8	CO01			✓	✓
9	PB08		✓		✓
	PB09	✓			
	PB10		✓	✓	
10	CO02			✓	✓
	PB12	✓			
	CO03	✓	✓	✓	
11	CO04	✓	✓	✓	✓
12	CO05	✓	✓	✓	✓
13	CO06	✓	✓	✓	✓
14	CO09	✓	✓	✓	✓
15	CO10		✓	✓	✓
16	CO14	✓	✓	✓	✓
17	CO21	✓	✓	✓	✓
	PB24	✓	✓		
	PB26	✓			

Source: Authors' elaboration.

In this context, the largest private banks are of fundamental importance according to the measures calculated for the network; so, as a result, there is congruence between network centrality and the size of the assets. The magnitude of the private banks' participation plays an important role and this is transmitted by their market share in the system. Between December 2012 and December 2015, these entities have maintained their importance to both the total exposures environment as well as in each subnetwork (deposits and investments). In the investments submarket, some small private banks and medium-size cooperatives are of fundamental importance due to their active participation in the debt and deposit markets respectively.

The large private banks are also seen as core, and the small banks are the most important in terms of deposits exposures. Only the new cooperatives serve as nuclei and therefore are important in the financial system, while the mutuals and the financial companies do not play relevant roles as cores which implies their role as disrupters of shocks to the system.

3.5 Relative Exposures and Risk of Transmission

With respect to relative exposures, based on the adjacency matrix obtained as a function of the exposures in terms of capital that each financial entity can guarantee to its counterparts—as well as the calculation of the transmission risk index—, illustrations representing the transmission risk index for the years 2012 and 2015 have been created. The transmission risk index values were divided into four ranges that will later serve to establish the rating of systemic importance for each entity. The size of the bubbles representing the financial entities is a function of each entity's assets, while the entities' locations in the quadrants represent the accumulated vertical (abscissa axis) and horizontal (ordinate axis) exposures where each quadrant constitutes one of the four categories of relative exposure.

Table 9

CLASSIFICATION OF ENTITIES ACCORDING TO RELATIVE EXPOSURE CATEGORIES

Quadrant	*Entities*
1	Vulnerable and transmitters
2	Vulnerable
3	Indifferent
4	Transmitters

When comparing the two years of analysis, 2012 and 2015 (Figures 10 and 11), the entities that are high on the transmission risk index are principally located in quadrant 4 (next to entities that have intermediate values). These entities also have a high amount of assets and could be considered as the principal transmitters of any eventual shocks. They are entities categorized as cores, and their location in the network is strategic as well as the number of entities that are linked to them. In addition, the group of transmitter entities (quadrant 4) includes institutions with intermediate values on the transmission risk index and in accordance with the size of their assets, have a representative weighting in the financial system.

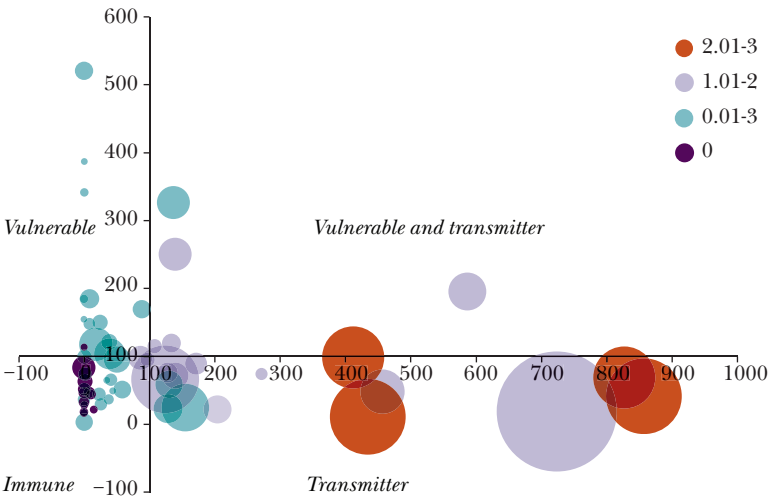
On the other hand, quadrant 3 principally contains entities that score zero on the index. These institutions have fewer assets and also do not represent a threat to the financial system in the case of shocks, so they were categorized as being immune.

Finally, in quadrant 2 which corresponds to vulnerable entities, we find institutions with relatively low values on the transmission risk index as well as having low participation in terms of their shares of assets in the financial system.

The main change between the two periods of analysis is the increase in entities that are located in quadrant 1 (vulnerable and transmitters) and that as of December 2015 are located in quadrant 4 (transmitters), as well as the increase in entities located in quadrant 3 (immunes) for 2015. Likewise, there is

Figure 10

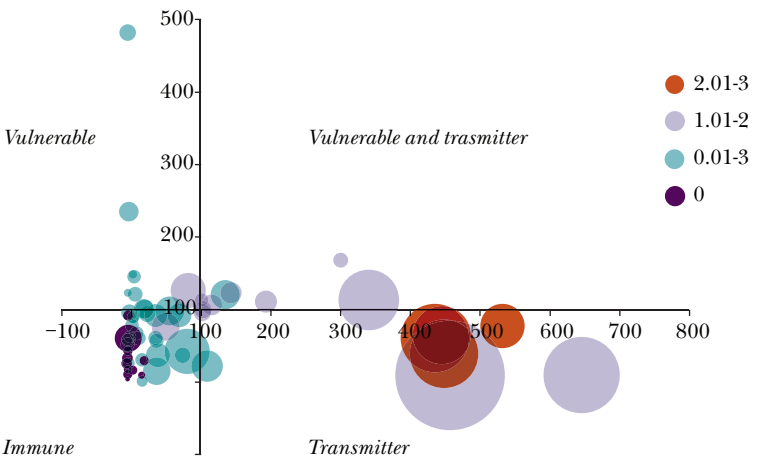
ECUADOR'S FINANCIAL SYSTEM: TOTAL EXPOSURES AND RANGES OF TRANSMISSION RISK INDEX, 2012



Source: Autors' elaboration.

Figure 11

ECUADOR'S FINANCIAL SYSTEM: TOTAL EXPOSURES AND RANGES OF TRANSMISSION RISK INDEX, 2015



Source: Authors' elaboration.

a decrease in the level of accumulated relative exposure both horizontally and vertically between 2012 and 2015.

Figure 12 compares the value of the transmission risk index for each entity between 2012 and 2015. It identifies a greater number of entities that have increased their values on the index in the period under analysis which implies an increase in the number of entities that have become systemically important. In this group of entities, savings and credit cooperatives, as well as financial companies are the most notable. On the other hand, the mutuals are the type of entities that show a decrease in their index value. Consequently, their importance in the financial system is diminished in contrast to the large private banks which have maintained a stable position as risk transmitters in the Ecuadorian private financial system.

The systemic importance of large banks is evident in their high values on the index both in December 2012 and December 2015, while the rest of the entities, in spite of their sizes, do not display an equal relevance.

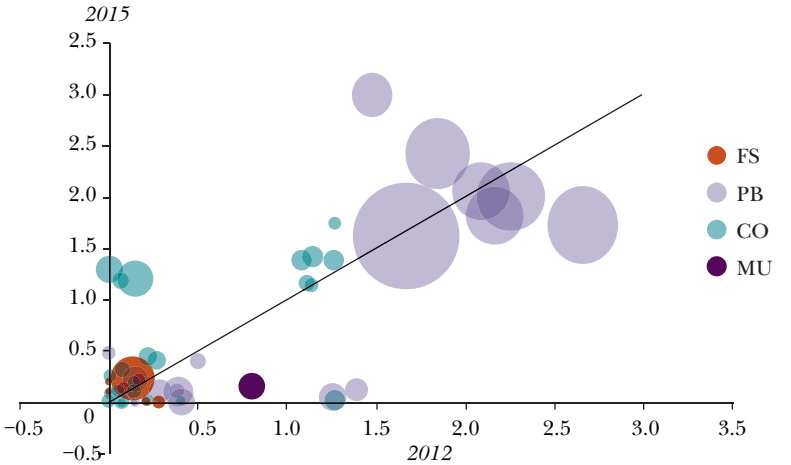
Whenever relative exposures were identified, financial entities were classified in accordance with the proposed categories and the transmission risk index values were calculated for each of them. It is pertinent to simplify the network of relative exposure taking into consideration the entities whose index values for transmission risk are above 20%.[19] The networks in Figures 13 and 14 constitute a simplified financial system structure for the years 2012 and 2015 respectively. In this case, the size of the nodes is a function of the transmission risk index, and the thickness of the borders corresponds to the relative exposure of the entities that make up the financial system. There is a greater number of interrelations among the entities in 2012 compared to 2015[20] because in the first year there was

[19] It corresponds to the 90th percentile of the indexes calculated for 2015 and is a condition applied to the indexes for 2012.

[20] There is a total of 75 connections between 46 financial institutions for the year 2012 and 44 connections between 31 financial institutions for the year 2015.

Figure 12

ECUADOR'S FINANCIAL SYSTEM : VARIATION OF THE TRANSMISSION RISK INDEX, 2012-2015



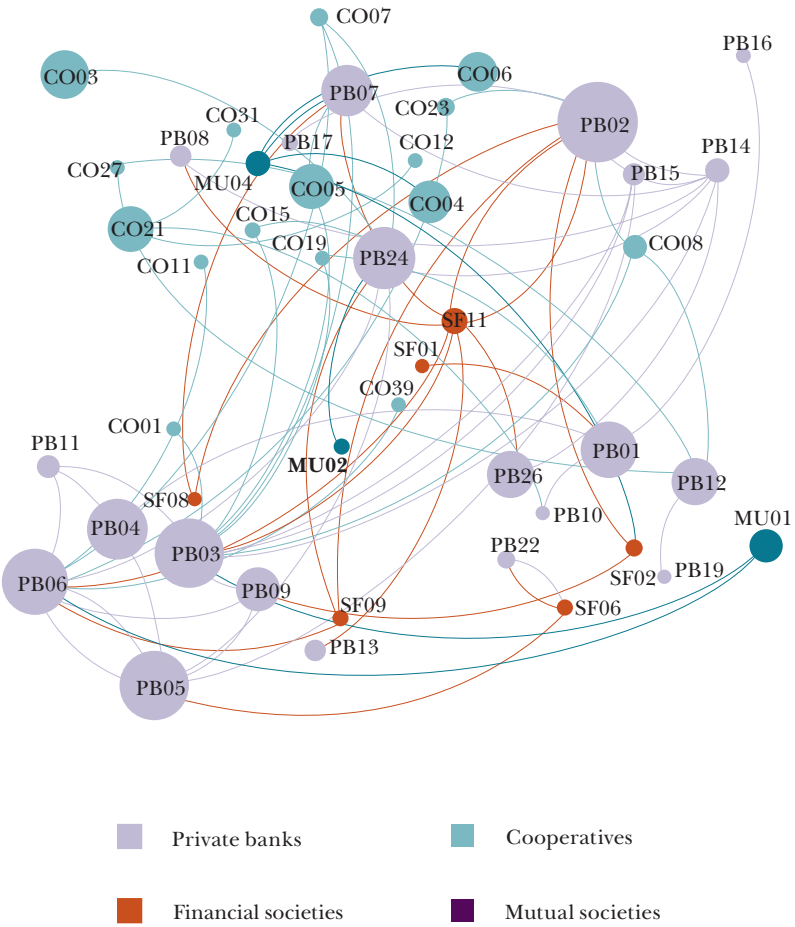
Note: PB: private banks, CO: cooperatives, FS: financial societies, MU: mutual societies
Source: Authors' elaboration.

a denser, more simplified network. Some entities have gained importance in the financial system in terms of their values on the transmission risk index, while others disappeared from the network due to their decreased values on the transmission risk index to less than 20% as was the case with eight private banks, four cooperatives, two mutuals and one financial company. However, the role played by private banks in the financial system, especially large and medium-sized ones, remains stable precisely because of their importance as links between their counterparts.

Regarding the classification of the entities of systemic importance, Table 6 shows the transmission risk index as a rating and verifies that five entities that have the most systemic importance between December 2012 and December 2015 are banks. In 2015, PB07 is notable. It doubled its value on the transmission risk index, showing the most accumulated relative exposure, the highest betweenness (strategic location in

Figure 13

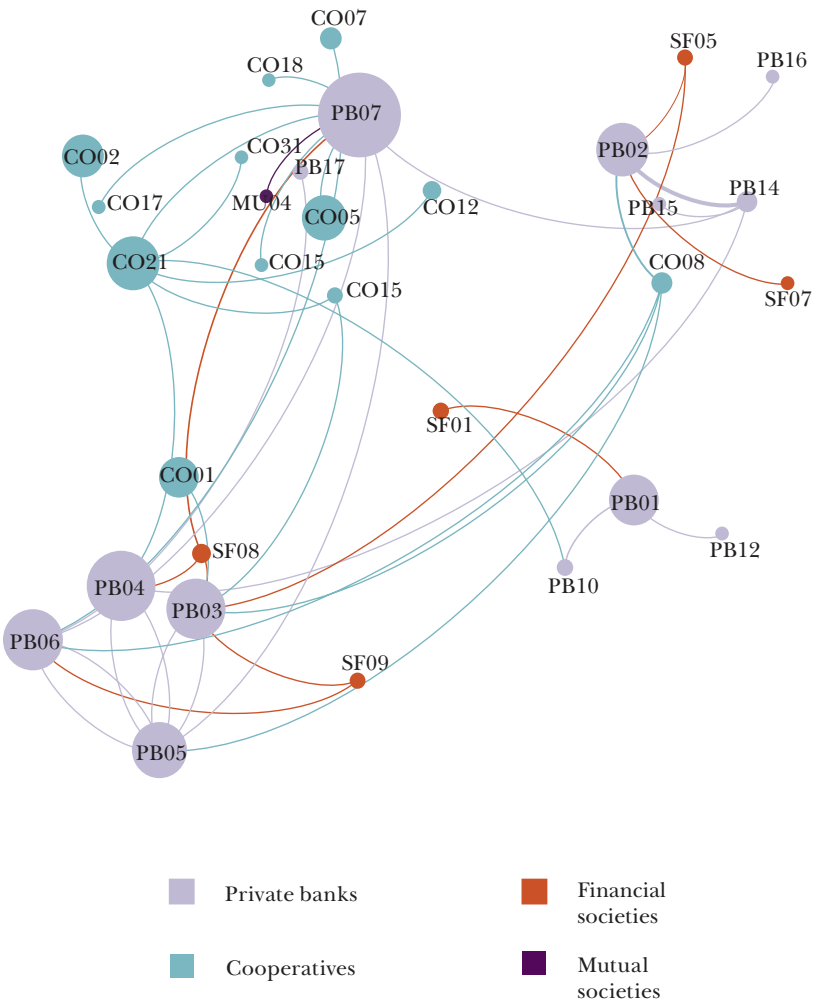
ECUADOR'S FINANCIAL SYSTEM: SIMPLIFIED NET OF RELATED EXPOSURES. INSTITUTIONS WITH RELEVANT EXPOSURE GREATER THAN 20%, DECEMBER 2012



Source: Authors' elaboration.

Figure 14

ECUADOR'S FINANCIAL SYSTEM: SIMPLIFIED NET OF RELATIVE EXPOSURES. INSTITUTIONS WITH RELATIVE EXPOSURE GREATER THAN 20%, DECEMBER 2015



Source: Authors' elaboration.

the network) and it is an entity that is considered core in the network. This financial institution is part of a group of transmitter entities which implies a high probability of triggering a strong shock or detrimental impact in the event that the referred to the institution has a failure.

The most significant variations are in the banks PB24 and PB26 which would respond to mergers between them and others in the financial system, while the cooperative CO03 has lost importance both in terms of its level of accumulated exposures and in the measure of betweenness. On the other hand, three cooperatives have gained systemic importance, which corresponds to their greater volumes of assets as of December 2015.

4. CONCLUSIONS

- With respect to interbank exposures referring exclusively to deposits with financial entities, the entities especially concentrate their deposits in private banks: 70% of the total exposures of these assets is concentrated in the banks as of December 2012, which declined to 66% as of December 2015.
- When considering the interconnections in the investments market, the financial system interconnections show a large participation on the part of the banks and cooperatives as lenders and borrowers in the debt market. In contrast, in the section of interbank deposits, the banks and the cooperatives have more interconnection in the debt market at 73% and 23% respectively as of December 2012, and at 56% and 42% respectively as of December 2015.
- With respect to total interbank exposures, a higher density network was seen in the sector where the largest private banks are located, corresponding to amounts of more than USD 5 million. On the other hand, the participation of both private banks and cooperatives in the debt market, and the lack of interconnectedness between mutuals and financial companies with most of the financial system–with the exception of the largest financial entities–are notable.

Table 10

QUALIFICATION OF FINANCIAL ENTITIES WITH SYSTEMIC IMPORTANCE ACCORDING TO THE TRANSMISSION RISK INDEX

Financial entities	*December 2012*	*December 2015*
PB07	1.47	3.00
PB04	1.86	2.41
PB06	2.10	2.05
PB03	2.23	2.01
PB05	2.17	1.82
CO21	1.26	1.74
PB02	2.64	1.73
PB01	1.66	1.62
CO04	1.15	1.42
CO05	1.26	1.39
CO06	1.08	1.38
CO02	0.00	1.29
CO01	0.15	1.19
CO10	0.06	1.18
CO09	1.11	1.15
CO14	1.13	1.14
PB12	1.38	0.10
PB09	1.26	0.05
CO03	1.27	0.00
PB24	1.87	0.00
PB26	1.32	0.00

Source: Authors' elaboration.

- Regarding networks metrics calculated from December 2012 to December 2015, the series are stable over time which points to a stable network structure over the period under analysis, results that are verified even when demand deposits and term deposits, the loan portfolio and the portfolio management indicators showed deterioration. In this context, the largest private banks are of fundamental importance according to the metrics calculated for the network; so network centrality is consistent with the amount of assets. The magnitude of the private banks' participation plays an important role in the path of estimated metrics, and such participation is transmitted by their market share in the system. This is shown in the 2015 measurement of systemically important entities, considering the risk transmission index based on relative exposures, the betweenness measure, and the core-periphery analysis.
- Between 2012 and 2015 many entities increased their values on the transmission risk index, implying an increase in the number of entities that have become systemically important. Large private banks maintained their position.
- The simplified relative bilateral exposure network for each year shows a denser network in 2012 compared to 2015, where fewer entities have more than 20% relative exposure in terms of the capital guarantees they have for their counterparts.

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